Drivers and Inhibitors of Countrys' Broadband Performance

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Abstract

- Large differences persist in the diffusion levels of broadband Internet access across triad countries and emerging markets alike. Major industrialised nations are being criticised for allegedly lagging behind in broadband development. This study analyses worldwide broadband Internet access take-up and draws on a wide range of variables to explain each individual nation's current broadband position and anticipate future market developments.
- Depending on data availability, initial correlation results for EU-25, OECD or up to 186 countries worldwide are presented using a time lag design of introducing the influencing variables for the year 2003 and the outcome criteria for 2005/2006.
- Bivariate correlation and reduced-raw-data-regression results show that broadband penetration differences among countries can be traced to (1) economic prosperity, (2) general regulatory quality, and (3) computer literacy. Further, strong effects are identified for (4) English language proficiency, which affects the attractiveness of global Web content for the countries' population, (5) teleworking, which increases the base of potential early broadband adopters, (6) service sector employment that positively correlates with the need for information access, and (7) unemployment, which reduces the spending power of consumers.
- Privatisation, independent regulator, and LLU lead times have a significant positive impact on broadband development, while intra-technology and general market concentration are negatively associated with broadband uptake and inter-technology (e.g., Cable vs. DSL) competition is not significant in the three data samples.

Key words: Broadband, Diffusion, Drivers, Internet, Telecommunications.

1. Introduction

Broadband Internet access ranks high on international policy agendas: In their information society strategy statements, the European Commission positions high broadband availability as one of their core targets (European Commission 2002, 2005, 2006a). Similar objectives and goals are set forth by the United States Congress and the Worldbank. Such examples show that broadband Internet – in 2006 still commonly defined as connections with download capacity equal to or greater than 128 KBit/s (European Commission 2006b) or 256 KBit/s (cf. OECD 2007)[1] – is seen as a means to bolster economic growth and educational opportunities (e.g., Lehr et al. 2006, p. 4-6).[2]

Overall, the number of broadband connections has reached approximately 75m (232m) in Europe (worldwide) compared to an estimated 245m (1,135m) Internet users at the end of 2006 (EITO 2007, pp. 246-247). Globally, the average population penetration in OECD countries stood at 16.9%, indicating that broadband Internet markets were in an early growth stage of their life cycle year-end 2006 (OECD 2007). However, large differences persist between the diffusion levels of broadband Internet access worldwide. Major industrialised nations such as the United States or Germany are criticised for "lagging behind" in broadband development (e.g., Redding 2006; Turner 2005). Broadband penetration ranged from 31.9% (Denmark) to 4.6% (Greece) in the EU 25 countries alone at year-end 2006 (OECD 2007). Such differences or below-expectations levels of broadband deployment may be attributed to inhibiting market characteristics both in terms of demand for and supply of this type of Internet access in a country market. To this end, a wider set of factors such as English literacy and proficiency in computer usage, teleworker density, service sector employment, narrowband-price level and many others that may be driving demand for broadband subscriptions at an aggregate, country-level, has not been reviewed for a larger set of countries so far.

The number of studies that specifically address differences in broadband diffusion across countries is limited but has been increasing recently. Bauer et al. (2003), Cava-Ferreruela/ Alabau-Muñoz (2004), Distaso et al. (2006), Garcia-Murillo (2005), Turner (2006), and Wallsten (2006) analyse broadband diffusion as a function of various economic, societal and country specific circumstances for OECD countries. Others focus on demand drivers within the United States or in one country (see for many Bauer et al. 2002, Chaudhuri/Flamm 2005,

1 The term "Broadband" describes any Internet access method that provides faster data transfer than traditional dial-up connections by using higher bandwidth and some form of packet switching and "always on" capability. Cf. Bauer et al. 2003, p. 4; Gerpott 2007, p. 799; Maldoom et al. 2005, p. 3. Commonly, DSL (Digital Subscriber Line), Cable, Fixed Wireless, Satellite, third generation mobile, and fiber-to-the-home are technologies discussed as broadband Internet access platforms. Cf. Distaso et al. 2006, pp. 89-90; Maldoom et al. 2005, pp. 11-24; Papacharissi/Zaks 2006, pp. 65-67. DSL and (in some countries) cable are by far the dominant broadband technologies today.

2 The benefits of broadband are commonly discussed in a qualitative manner in any publication on this topic (cf. Bauer et al. 2003, p. 3; Frieden 2005, pp. 596-599; Maldoom et al. 2005, pp. 8-11) but are seldomly quantitatively qualified (cf. Lehr et al. 2006).

Gerpott 2007)[3]. However, a time lag between dependent ("broadband performance") and independent ("broadband drivers") variables that is critical to evaluate the causal relation more consistently is not common in these studies (see Cava-Ferreruela/Alabau-Muñoz (2004) as an exception). Further, European countries or worldwide demand patterns have not been compared in comprehensive empirical analyses. A larger number of studies is available in the potentially related field of mobile telecommunications diffusion across countries, which attribute penetration differences both to characteristics of the competitive environment and to general country parameters (cf. Gruber/Verboven 2001; Koski/Kretschmer 2005; Liikanen et al. 2004; Rouvinen 2006; Sundqvist et al. 2005). Larger and more economically prosperous countries and mobile markets with higher competitive rivalry achieve faster service diffusion and higher penetration rates (Dekimpe et al. 2000; Koski/Kretschmer 2005; Liikanen et al. 2004).

The aim of this study is to present empirical explanations for broadband achievement differences based on a wholistic conceptual model. The main research questions is (1) why some countries have outperformed others in terms of diffusion levels reached for broadband Internet access.

Broadband Internet access take-up is analysed for three data subsets (Europe, OECD, world) using a wide range of explanatory variables that help understand each individual nation's current broadband position and anticipate future market developments. First, a conceptual framework is presented to reflect upon all relevant dimensions to explain a country's broadband development, pertinent literature is reviewed and hypotheses are formulated in chapter 2. Second, variable measurements, the empirical setting and samples are described in chapter 3. Third, results of the empirical analyses are presented in chapter 4. Finally, a summary, limitations, and analyses in progress are discussed in chapter 5.

2. Conceptual Framework and Literature Review

A wide range of factors was taken into account in order to determine which conditions support broadband development. General and societal country characteristics, broadband market specific variables, and regulation are the four main constructs presented as potential influencing factors for a country's broadband development in the conceptual framework in Figure 1. While only some of the underlying variables can be actively influenced by policy makers or market players, it is nevertheless important to also review external factors that have to be taken as fixed in the short to mid-term timeframe. Otherwise, a full understanding of market effects and parameters that may predetermine a higher/stronger (= "better") broadband diffusion in some countries over others may be precluded.

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[3] A comprehensive summary of the literature is provided in Gerpott 2007, pp. 801-805; additional references are cited in Bauer et al. 2003, pp. 9-10.

General country characteristics

General economic conditions provide the basis for the need and for the purchase potential of broadband. First, more developed and prosperous countries are more reliant on information and long-distance data communication for private and professional requirements than less developed nations. Second, both residential and business customers have more resources to afford a broadband subscription or Internet access under such circumstances. At the highest aggregation level, the economic prosperity of a country (i.e., commonly measured by purchasing power adjusted gross national income per resident) reflects these basic conditions (cf. Garcia-Murillo 2005, p. 89). Economic prosperity is affected by underlying conditions, of which the level of unemployment, the share of service sector activity, and urbanisation also may be reviewed separately as broadband indicators because they directly influence the extent to which a larger or smaller share of the population will have the means and/or need for broadband connectivity.[4] Especially the creation of knowledge intensive services (e.g., information provision services, logistics, transaction processing, or consulting) requires access to information that is increasingly non-local and readily available only through the Internet (or secured proprietary company Intranets).

Economic prosperity only had a weak positive association with broadband development in one study of 2001 data (Bauer et al. 2003, pp. 15-16, see also Garcia-Murillo 2005, pp. 96-102) but was significant in OECD countries in 2004 (Turner 2006, pp. 9-10). Also in 2002, broadband adoption was significantly more common among economically more wealthy countries (Garcia-Murillo 2005, pp. 96-102). Further, a positive effect of economic prosperity was found on Internet penetration in general (Chinn/Fairlie 2007, pp. 30-35).

Normalising for timing differences due to deviating commercial launch dates for broadband services, telecom operators may be able to attract a higher share of the population for broadband services more quickly in more densely populated countries (Cava-Ferreruela/Alabau-Muñoz 2004, p. 3; Frieden 2005, p. 598; Garcia-Murillo 2005, p. 89). Ultimately, this association would be a result of lower efforts required to cover the relevant market with broadband services, i.e., the roll-out of broadband access to the population ("coverage") is less costly and faster in more densely populated areas (Papacharissi/Zaks 2006, p. 70). In addition, communication and distribution instruments can be leveraged more effectively if the population is concentrated regionally.[5]

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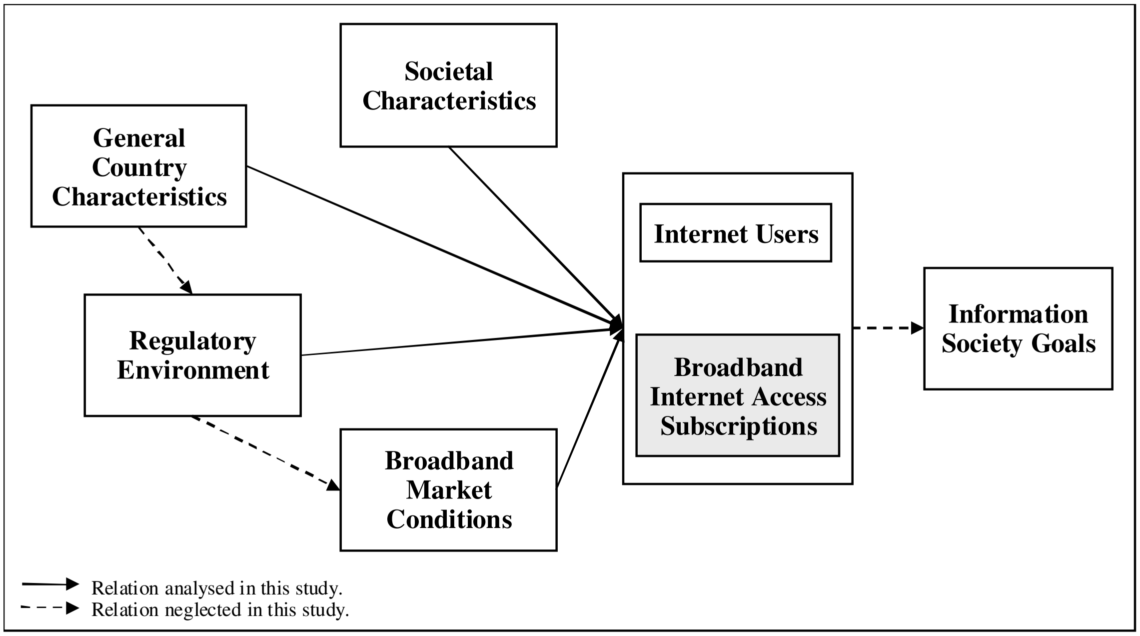
4 In turn, broadband is also hoped to positively impact economic development (cf. the discussion of broadband benefits by Bauer et al. 2002; Chinn/Fairlie 2007; Lehr et al. 2006, pp. 4-6; European Commission 2006a).

5 General diffusion concepts further increase the proposed relevance of such a "spatial agglomeration" effect: Population density increases interaction between individuals and enables quicker adoption of innovations.

Figure 1: Conceptual framework of antecedents and consequences of broadband Internet access



Further, unemployment and non-urban residence potentially make a paid subscription for broadband less central to the everyday requirements and budget distribution objectives of individuals or households. Not only the overall penetration level achievable at a given time, but also the initial adoption timing for broadband by a country may be affected by these economic circumstances.

Empirical findings indicate a positive relation of population density to broadband penetration (Bauer et al. 2003, pp. 14-17; Cava-Ferreruela/Alabau-Muñoz 2004, p. 6-10; Turner 2006, pp. 7-8): Countries with higher concentration of residents were able to attract more users faster. However, for Internet penetration in general, a weak negative association was found (Chinn/Fairlie 2007, pp. 30-35).

Operators will be more interested and pushing to enter the most attractive/prosperous countries first because they promise the highest and quickest return on investment. As an additional effect, countries with earlier broadband introduction will be further advanced on the diffusion curve and exhibit higher broadband penetration at any given snapshot in time.

To sum, based on the arguments and findings from the pertinent literature, we expect to find a higher level of broadband penetration in more prosperous and industrialised countries, i.e., nations that have higher income per resident, and also exhibit less unemployment, more service sector activity, and more urbanisation.

Societal country characteristics

Besides the economic conditions, societal and cultural antecedents may affect the extent to which users are prepared or attracted to use broadband services. Readiness in terms of computer usage skills, English literacy, teleworking, and cultural mindset affects both the potential market size and therefore the achievable penetration level relative to the overall country size (of residents or households) and the drive towards earlier and/or faster adoption of broadband at the country level.

The first antecedent of a broadband subscription by an individual or household is basic knowledge of working with a personal computer, i.e., "digital literacy" (Frieden 2005, p. 599). If customers are not confident to use the technical hardware that is required as interface to use broadband-enabled services, they will naturally be reluctant to subscribe or have no need to do so. Interconnected with such skills will be the penetration with personal computers (PCs) in a country (Chinn/Fairlie 2007, pp. 25-30). Therefore, a higher level of PC penetration is perceived to be instrumental for higher broadband take-up as well (Cava-Ferreruela/Alabau-Muñoz 2004, p. 3; Chinn/Fairlie 2007, pp. 25-30; Garcia-Murillo 2005, p. 90; JP Morgan 2006, p. 44). These conditions are coined "preparedness" by Bauer et al. (2003, pp. 13-14), which find that this indicator (measured as an index that is not fully transparent but includes factors such as openness for technical innovation and availability of complementary products such as personal computers) is positively associated with broadband penetration. The analysis by Cava-Ferreruela/Alabau-Muñoz (2004, p. 7) also found a positive effect of PC penetration on broadband development. PC penetration will likely have a positive feedback relation to broadband development, i.e., higher levels of either will positively influence the other variable.

Second, English literacy is relevant, because English language content is much broader than content of any other local language on the Web. Rough estimates point out that more than 50% of the 15 billion web pages currently indexable are supplied in English. The attractiveness of broadband access increases with the users capability of understanding/appreciating the diverse English language contents on supply globally. Since it is often argued that rich content is required to attract potential users for broadband services (e.g., Garcia-Murillo 2005, pp. 87-89), the vast amount of information and entertainment readily available worldwide in English must be interpreted keeping this in mind. To date, no empirical analysis has specifically addressed this relationship except for the significant positive bivariate correlation presented in Arthur D. Little (2007) between English literacy and broadband penetration for a sample of European countries.

Third, teleworking, i.e., the percentage of the population that works from home, affects the initial market potential of customers that are prone to subscribe to broadband services. A significant positive bivariate correlation was presented in Arthur D. Little (2007); other empirical reference points for this relation are lacking.

Fourth, cultural factors may affect the openness of societies towards new technologies. One cultural dimension that has been used in previous studies relating to new product adoption or technology diffusion is "uncertainty avoidance", which refers to the level of a country's population striving for reliability, rituals, rules, and institutionalisation. Potential broadband subscribers that are reluctant to accept technical uncertainty, newness or innovation, will adopt new services later or wait until the service is fully established. In turn, telecom operators will introduce new services later in countries with higher uncertainty avoidance and/or broadband take-up will be delayed/slowed down. For mobile telecom services, one study found uncertainty avoidance to be associated with imitation, i.e., later adoption across countries (Sundqvist et al. 2005, p. 109).

Overall, more developed computer skills and English literacy, a larger teleworking base at the country level as well as more culturally innovation-minded and risk taking societies are expected to be associated with earlier and stronger broadband Internet take-up.[6]

General and telecommunications specific market regulation

The regulatory environment indirectly affects broadband development by providing rules for the playing field (see Figure 1). Both general and telecommunications specific rules determine how competition and market dynamics can evolve in a country. Therefore, regulatory indicators should be covered in studies of broadband performance (Bauer 2003, p. 2). Examples of market regulation that may affect broadband development are the consolidation restrictions in the German cable market (cf. Maldoom et al. 2005, p. 54) or the extent to which individual segments of telecommunication markets are subject to regulatory interventions. The appropriate level and form of regulatory intervention to support broadband investment and penetration growth is subject to ongoing controversial debate and is documented in a large body of literature.

The general regulatory environment is related to the overall efficiency and attractiveness of a country for outside investors, which could increase broadband push. Overall regulatory quality within a country had a significant positive association with Internet penetration (Chinn/Fairlie 2007, pp. 30-41). For broadband take-up, an additional key focus may be expected for the dimension labelled "voice and accountability" in Chinn/Fairlie (2007) that mainly covers personal freedom and free media. Citizens of countries with higher levels of personal freedom and free media may find broadband Internet access to be more useful as a means of communicating and informing themselves for private and business purposes. Fur-

6 Socio-demographic factors that are cited in micro-level studies of broadband adoption (e.g., age, gender, residence area, ethnic group, income, or education, cf. Chaudhuri/Flamm 2005; Gerpott 2007) could also be compared at an aggregate level across countries (see in parts Cava-Ferreruela/Alabau-Muñoz 2004, pp. 6-10; Chinn/Fairlie 2007, pp. 30-35). The present study will not focus on an extensive set of generic measures of which some may show only limited variance at the country level or be highly correlated to other indicators that are accounted for and would provide little added value.

ther, overall regulatory quality and voice and accountability are of importance to (foreign) investors that are considering to enter the telecoms sector of any country.

The formal opening of the telecommunications sector, i.e., general market liberalisation was a critical change for the telecommunications industry that took place in the 1990s in most countries with a few earlier exceptions (e.g., US and UK) and also various emerging markets as late(r) followers. Countries with longer lead time since market liberalisation may have developed a more market-oriented and diverse competitive landscape that may in turn provide a better nurturing ground for new broadband markets. Broadband performance studies mostly neglect liberalisation lead time. Clustering of countries by higher or lower regulatory market openness did not yield significant results in an OECD sample for the year 2001 (Bauer et al. 2003, pp. 15-16).

Related to general liberalisation, privatisation of incumbent operators, i.e., the transfer of ownership to private investors by the state, may help to increase or revive infrastructure investment and therefore also imply more attractive broadband services and a stronger push for broadband adoption in the market (Garcia-Murillo 2005, pp. 86-87).

Development support via public infrastructure funding/government initiatives is another related factor that is cited as driver of broadband take-up (cf. Frieden 2005, pp. 599-610; Miralles 2006, pp. 12-22; Papacharissi/Zaks 2006, p. 71) and has been qualitative reviewed in a wide range of commentaries and articles. However, there is no common pattern of initiatives but a rather heterogenous set of strategies that are tested by public institutions and governments to improve broadband development at the country or region level. Initiatives range from tax reductions both for operators and consumers, sponsorship, information and online government services, to public-private partnerships or government investments (Miralles 2006, p. 20-22). Due to incompatible or incomplete data, empirical studies largely omit testing correlations between public infrastructure funding or government initiatives and broadband development. Nevertheless, multiple case studies and evidence from markets such as South Korea or Japan indicate a substantial effect of supportive government policies (cf. Frieden 2005, pp. 599-610; Papacharissi/Zaks 2006, p. 71).

Further, substantive arguments support the proposition that platform competition, which can be intra-modal (i.e., meaning that multiple providers compete using one common technical platform, e.g., DSL-operators and local loop unbundling-service providers) or inter-modal (i.e., meaning that multiple broadband access technologies like Cable and DSL compete against each other in a market) has a positive effect on broadband development (cf. Distaso et al. 2006, pp. 92-103; Maldoom et al. 2005, p. 33; Polykalas/Vlachos 2006, pp. 20-24).

The reasons for a positive effect of intra- and inter-modal competition match: Both have the potential to increase price pressure and service quality/diversity along with stronger promotion and distribution activities of firms competing either on facilities- or access-basis. Market and regulation idiosyncracies have made local loop unbundling (LLU, see detailed review in OECD 2003) or associated means of access-based or intra-modal market entry prosper in some countries, while other countries have a strong inter-modal or facilities-based market, i.e., a variety of platforms provided by different operators competing for the broadband consumer. The ongoing high-level discussion among industry representatives, political country mandates, and academic scholars of high-speed access regulation (e.g., VDSL in Germany) and the effects on intra- and inter-modal competition shows that the overall effects on market outcomes and therefore also the situation-specific suitability of a certain regulation approach are far from clear or undisputed.

LLU is argued to be "driving effective price and bandwidth competition" by some commentators (JP Morgan Chase 2006, p. 44). The analysis by Garcia-Murillo (2005, p. 96-102) supports this statement by finding a significant positive LLU effect for broadband availability and a weaker association for the broadband subscriber level. Further, neglecting other factors, Turner (2005, p. 14) cites as evidence that the average broadband penetration in 30 OECD countries deviated by more than 130% between countries with or without LLU or line sharing at year-end 2003.

However, studies that do not find a strong empirical LLU-effect in samples reflecting market developments until approximately mid-year 2004 are more numerous (Cava-Ferreruela/ Alabau-Muñoz 2004, p. 6-10; Distaso et al. 2006, pp. 100-103; Wallsten 2006, pp. 10-18; Wallsten 2007, pp. 10-12). These studies rather focus on inter-modal competition (measured by a concentration index) between different technological platforms for broadband services (e.g., cable versus DSL), which is found to significantly positively affect broadband penetration (cf. Distaso et al. 2006, pp. 100-103).

Broadband market environment

As an outcome of regulatory policy and market evolution, i.e., competitive strategies followed in the country, broadband competition, price level of telephone calls, the price-spread between narrow- and broadband Internet access capture the main market conditions relevant to broadband service providers. Each may have a unique effect on broadband diffusion levels reached by a country. To wit, broadband competition will influence broadband pricing, network coverage, and bandwidth (down- and upload capacity available to subscribers) that will in turn affect the attractiveness of broadband services and hence impact the penetration level achievable by a country relative to other markets.

First, overlapping with the distinction between intra- and inter-modal competition, general competition between broadband providers irrespective of technology used, which would correspond with the traditional view of measuring competition or market concentration (and may be identical in some cases) is also expected to positively affect broadband development. A crude measure of broadband competition did not show significant correlations to broadband penetration in OECD countries in 2001 (Bauer et al. 2003, pp. 15-17), while a somewhat more fine-grained measure of competition was significant both for broadband availability and for higher subscriber levels in OECD countries in 2002 (Garcia-Murillo 2005, pp. 96-102). The evidence cited for inter-modal and intra-modal competition can also be abstracted to general competitive intensity.

Second, higher prices for traditional fixed voice telephony services may be positively associated to broadband development, because subscribers search for lower cost telephony alternatives as represented for example by voice over IP services like Skype. A first empirical indication of this correlation was found in one recent study (Distaso et al. 2006, pp. 100-103), showing some link between fixed voice telephony service pricing and broadband pull-incentives from the subscriber perspective.

Third, related to the telephony cost, which is related to dial-up, i.e., narrowband Internet charges, broadband pricing *per se* (Cava-Ferreruela/Alabau-Muñoz 2004, p. 3) and especially a higher price-spread between narrow- and broadband Internet access charges arguably reduces incentives to switch or upgrade (despite narrow- and broadband Internet not being substitutes but exhibiting a vertical relation, see Maldoom et al. 2005, p. 5-7). A high price-spread, indicating a higher "cost of upgrading" is seen as inhibitor to switch from narrow- to broadband Internet access (Arthur D. Little 2007; Papacharissi/Zaks 2006, pp. 71-72). Also, related to user prices, high LLU prices (input prices) were found to correlate with lower broadband take-up (Distaso et al. 2006, pp. 100-103). However, previous studies only found weak indications of higher broadband penetration with lower broadband prices and higher dial-up prices (Arthur D. Little 2007; Bauer et al. 2003, pp. 15-16; Cava-Ferreruela/Alabau-Muñoz 2004, p. 6-10).

Further, coverage or spatial technical availability of broadband services for the population of a country is a prerequisite to such services' mass market diffusion (Cava-Ferreruela/Alabau-Muñoz 2004, pp. 2-3), The low coverage of cable, i.e., limitations of inter-technology competition reach, has been identified as inhibitor of overall broadband penetration. The most prominent European case is Germany, with cable broadband development significantly hampered by restrictive policies and mislead strategic moves in the marketplace (Arthur D. Little 2007).

The causal interrelation between Internet use and broadband subscriptions (e.g., to disentangle the relevance of alternative means of getting access to Internet services – i.e., at work, at friends, official and unofficial Internet cafés) is not further reviewed in this study. Most studies identify a positive relation between broadband subscriptions and Internet use without further discussion of causality (cf. Arthur D. Little 2007; Turner 2006, pp. 10-11).[7]

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[7] The expected positive outcome effects of broadband diffusion, i.e., information society goals depicted in Figure 1 as a next step of analysing broadband Internet are also not reviewed in the present study (cf. Bauer et al. 2002; European Commission 2006a; Lehr et al. 2006).

3. Research model and method

To disentangle causal relations between antecedents of broadband development and its indicators, correlation and regression analyses were conducted incorporating a time lag between independent and dependent variables. In addition, alternative indicators and data sources were considered to achieve a coherent view on the topic – the focus was on using more fine-grained and transparent indicators than previous studies (cf. the request by Bauer et al. 2003, p. 21).

Definitions, sources and descriptive statistics of the study variables are presented in Table 1. Data availability issues prevent analysis of broadband markets at the global level for a substantial number of variables discussed in the conceptual section of this paper.[8] Therefore, three levels of analysis are considered, namely (1) the full data set, covering worldwide markets to varying degree per variable, (2) the 30 OECD countries, and (3) the 25 European Union (EU) countries.

In addition to commonly used data sources such as ITU and OECD reports (cf. Cava-Ferreruela/Alabau-Muñoz 2004, pp. 13-14; Chinn/Fairlie 2007, p. 44 and the mobile diffusion studies cited in chapter 1), a variety of secondary statistics was leveraged to collect information on indicators like English literacy, service sector activity, lead times or price-spread that have not received significant research attention previously. All data sources are documented in Table 1.

Dependent variables

Broadband development/indicators are captured with three indicators in the present study: (1) Broadband penetration, i.e., the ratio of broadband subscriptions to total population at year-end 2005 (for all three samples) and 2006 (for OECD and EU-25 only), (2) the ratio of Internet users to total population at year-end 2005 and (3) the time of initial broadband introduction (see variables I-IV in Table 1). These variables are not comprehensive in the sense that they could cover in detail the quality of broadband subscriptions (i.e., bandwidth, type of services) or the overall usage/demand satisfaction percentage. However, they provide an indication for the most common broadband indicator – broadband penetration,[9] as well as a proxy for broadband usage as approximated by the Internet user ratio, and the country adoption/introduction push embodied in the broadband launch lead time. The broadband penetration ratios are highly correlated with the Internet user ratio (r = 0.87, $p < 0.001$, n = 117 and r = 0.78, $p < 0.001$, n = 30). Following the diffusion curve logic, commercial broadband intro-

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8 Analysis of public infrastructure funding and government initiatives was omitted due to unreliability of data caused by incomplete reports of investments and qualitative, hence difficult to quantify measures.

9 Alternative definitions of penetration especially drawing on different baselines, e.g., households or people aged 14 to 65, are highly overlapping (correlations exceeding r = 0,98). Therefore, the inclusion of additional broadband indicators common but only slightly differentiating in meaning adds only marginal value to the analysis and is ommited for this reason.

Table 1: Indicators, measurement, descriptive statistics, and data sources

	Indicators	Measurement and Descriptive Statistics[a]
Broadband Development/Indicators	**Ia. Broadband Penetration 2005**[b]	• Ratio of total broadband subscriptions to total population at year-end 2005 • F[118]: 5.62% (7.87). P[30]: 14.04% (7.97). E[25]: 12.06% (6.92)
	Ib. Broadband Penetration 2006[c]	• Ratio of total broadband subscriptions to total population at year-end 2006 • P[30]: 18.37% (8.54). E[19]: 17.48% (8.11)
	II. Internet User Ratio 2005[b]	• Percentage of the population that were regular Internet users at year-end 2005 • F[188]: 18.80% (20.51). P[30]: 48.35% (18.30). E[25]: 43.89% (14.58)
	III. Broadband Launch Lead Time[d]	• Months since first commercial introduction of broadband services (DSL or Cable) in a country until year-end 2005 (alternative factual and estimated variables) • Factual: F[41]: 67.9 (19.4). P[29]: 72.7 (16.9). E[19]: 68.5 (13.5) • Estimate: F[148]: 47.4 (22.8). P[30] = 71.2 (18.2). E[25]: 65.2 (17.8)
General Country Characteristics	**1. Economic Prosperity**[e]	• Purchasing power parity adjusted gross domestic product per capita in a country in 2003 in USD • F[158]: 9,254.1 (10,364.1). P[30]: 26,048.3 (10,702.2). E[24]: 23,831,1 (11,125.1)
	2. Prosperity Growth[e]	• Percentage growth of gross domestic product per capita in a country from 2002 to 2003 • F[172]: 2.39% (4.56). P[30]: 1.52% (1.70). E[25]: 2.13% (2.80)
	3. Unemploy-ment[e]	• Percentage of the total laborforce that are unemployed at year-end 2002 • F[141]: 9.91% (7.14). P[30]: 7.88% (4.57). E[25]: 8.92% (4.23)
	4. Service Sector Activity[f]	• Employment in services as percentage of total employment in 2003 • F[112]: 56.78% (15.65). P[30]: 64.71% (9.27). E[25]: 64.25% (8.63)
	5a. Urbani-sation[e]	• Percentage of population living in urban areas in a country in 2003 • F[201]: 56.21% (23.59). P[30]: 76.68% (11.53). E[25]: 73.40% (13.14)
	5b. Population Density[e]	• Residents per square kilometer in a country in 2003 • F[204]: 305.4 (1605.3). P[30]: 136.7 (131.7). E[25]: 176.7 (246.2)
	C1. Population[e]	• Total population of a country at year-end 2003 • F[191]: 33.6m (128.0m). P[30]: 39.1m (59.3m). E[25]: 18.4m (23.6m)

a) The study design is to introduce dependent variables with a time lag of 2 to 3 years into the analyses. Therefore, the indepedent criteria are collected for the year 2003 or the closest year for which data was available. F = Full data set = World sample; P = Partial data set = OECD sample; E = EU-25 data set = European sample. The number of countries for the respective indicator and sample is given in square brackets. Main figure = Mean. Figure in parenthesis = Standard deviation.
b) Variables I and III were taken from the ITU World Telecommunication Indicators Database 2006.
c) Variable II was taken from OECD 2007. URL: http://www.oecd.org/document/7/0,3343,en_2649_34223_38446855_1_1_1_1,00.html, viewed June 19, 2007.
d) Variable IV was collected from OECD Communications Outlook 2005 and OECD 2001. A larger data set was derived by estimating commercial launch timing from ITU World Telecommunication Indicators Database 2006 and Analysys 2006 subscriber data.
e) Variables 1-3, 5a-5b, and C1 were taken from the Worldbank World Development Indicators Database 2005. For coding of variable 3 some additional information was drawn from the International Labour Office Bureau of Statistics website at URL: http://laborsta.ilo.org, viewed July 1st, 2007.
f) Variable 4 was collected from data provided by the International Labour Office Bureau of Statistics website at URL: http://laborsta.ilo.org, viewed July 1st, 2007. Some additional information was drawn from the Worldbank World Development Indicators Database 2005.

Table 1: Indicators, measurement, descriptive statistics, and data sources (continued)

Indicators		Measurement and Descriptive Statistics[a]
Societal Country Characteristics	**6a. Computer skills**[b]	• Percentage of the population aged 16 to 74 that have basic computer skills in 2003 • P[15]: 67.67% (19.23). E[18]: 61.78% (16.84)
	6b. Personal Computer Penetration[c]	• Personal Computers per 100 inhabitants at year-end 2003 • F[158]: 13.42% (18.09). P[29]: 39.15% (19.71). E[25]: 34.01% (17.98)
	7. English Literacy[d]	• Percentage of the population speaking English as a foreign language in 2005 • F[28]: 45.0% (28.4). P[20]: 48.5% (29.8). E[25]: 45.2% (26.7)
	8a. Share of Teleworkers[e]	• Percentage of the population that were teleworkers (i.e., worked at home or at a distance from their official place of work) in 1999 • P[11]: 8.64% (5.18). E[10]: 8.50% (5.44)
	8b. Home Office[f]	• Proportion of workforce that worked from home at least one day per week in 2004 • P[19]: 2.08% (2.22). E[25]: 1.72% (2.04)
	9a. Uncertainty avoidance (Hofstede)[g]	• Uncertainty avoidance index from the Hofstede survey, indicating a strive for reliability, rituals, rules, and institutionalisation • F[51]: 65.94 (24.67). P[24]: 65.50 (24.50). E[14]: 66.14 (28.55)
	9b. Uncertainty avoidance (Globe)[h]	• Uncertainty avoidance index from the Globe study. Scores for “societal cultural practices scales”, i.e., current society practices • F[58]: 4.13 (0.60). P[24]: 4.35 (0.66). E[16]: 4.35 (0.72)
General & Telecoms Regulation	**10. Regulatory Quality**[i]	• Index measuring the “ability of the government to formulate and implement sound policies and regulations that permit and promote private sector development” (Kaufmann et al. 2006, p. 4) • F[193]: -0.04 (1.01). P[30]: 1.32 (0.45). E[25]: 1.33 (0.35)
	11. Voice and Accountability[i]	• Index measuring the “extent to which a country’s citizens are able to • participate in selecting their government, as well as freedom of expression, freedom of association, and free media” (Kaufmann et al. 2006, p. 4) • F[195]: -0.05 (1.01). P[30]: 1.15 (0.37). E[25]: 1.18 (0.19)
	12. Liberalisation Lead Time[j]	• Number of months since official telecommunications market liberalization until year-end 2005 • F[60]: 88.2 (53.4). P[29]: 101.3 (53.3). E[21]: 87.1 (50.2)
	13. Independent Regulator Lead Time[i]	• Number of years since an independent regulator was established in a country until year-end 2005 • F[130]: 9.0 (8.3). P[27]: 13.5 (12.9). E[25]: 9.2 (5.1)

a) The study design is to introduce dependent variables with a time lag of 2 to 3 years into the analyses. Therefore, the indepedent criteria are collected for the year 2003 or the closest year for which data was available. F = Full data set = World sample; P = Partial data set = OECD sample; E = EU-25 data set = European sample. The number of countries for the respective indicator and sample is given in square brackets. Main figure = Mean. Figure in parenthesis = Standard deviation.
b) Data for variable 6a was collected from the Eurostat Database 2007 accessible at URL: http://epp.eurostat.ec.europa.eu, viewed January 15, 2007.
c) Data for variable 6b was taken from the ITU World Development Indicators Database 2006.
d) Variable 7 was drawn from the European Commission 2006 Report „Europeans and their Languages“. For Ireland, United Kingdom, and USA English skills were assumed for 100% of the population.
e) Variable 8a was taken from the Empirica ECaTT-Report „Benchmarking Telework in Europe 1999“.
f) Data for variable 8b was collected from the PWC et al. 2004 Report „Technical assistance in bridging the “digital divide”: A cost benefit analysis for broadband connectivity in Europe”.
g) Variable 9a is based on the Hofstede-Survey as documented in Hofstede 2001, p. 151.
h) Variable 9b is based on Globe-Study and is documented in De Luque/Javidan 2004, p. 622.
i) Data for variables 10, 11, and 13 was collected from URL: http://www.govindicators.org.
j) Data for variable 12 was taken from URL: http://www.itu.int/ITU-D/treg/index.html (March 17, 2005).

Table 1: Indicators, measurement, descriptive statistics, and data sources (continued)

	Indicators	Measurement and Descriptive Statistics[a]
General & Telecoms Regulation	**14. Incumbent Privatisation Lead Time**[b]	• Number of months since a significant (i.e., > 25%) share of the incumbent was sold to the public or private investors until end 2005 • F[30]: 94.3 (76.0). P[17]: 128.9 (58.6). E[10]: 127.8 (48.0)
	15. Broadband Regulation Scorecard[c]	• ECTA index of 11 variables mainly measuring local loop unbundling (LLU) conditions and market transparency at year-end 2005 • P/E[16]: 0.61 (0.22)
	16. Regulatory Scorecard Index[c]	• ECTA index of 99 variables covering e.g. speed, transparency, effectiveness, and independence of regulation as well as general and sub-sector specific market access conditions at year-end 2005 • P/E[16]: 0.58 (0.12)
	17. Intra-Technology Concentration[d]	• Hirschman-Herfindahl-Index: Sum of squared subscriber market shares of DSL providers in a country at year-end 2003 • F[38]: 77.61 (24.58). P[26]: 74.51 (25.01). E[22]: 84.56 (19.56)
	18a. LLU Lead Time[e]	• Number of months since local loop unbundling (LLU) was introduced until year-end 2005 • F[26]: 70.7 (25.8). P[25]: 72.3 (24.9). E[18]: 68.9 (25.3)
	18b. Unbundling Variants[e]	• Count of available unbundling types (Full LLU, Line Sharing, Bitstream Access, and Sub-Loop Unbundling) at mid-year 2003 • F[30]: 1.97 (1.43). P[30]: 1.97 (1.43). E[19]: 2.42 (1.43)
	19. Inter-Technology Concentration[d]	• Hirschman-Herfindahl-Index: Sum of squared subscriber market shares of different technological platforms for broadband access in a country at year-end 2003 • F[40]: 58.96 (16.39). P[26]: 58.40 (14.87). E[22]: 57.67 (17.03)
Broadband Market Environment	**20. Market Concentration**[d]	• Hirschman-Herfindahl-Index: Sum of squared subscriber market shares of all broadband providers (irrespective of technological platforms used) in a country at year-end 2003 • F[40]: 48.74 (22.43). P[26]: 46.05 (22.27). E[22]: 47.35 (18.05)
	21a. DSL Coverage[f]	• DSL coverage of the population in percent at year-end 2003 • F[29]: 74.5% (22.5). P[29]: 74.5% (22.5). E[18]: 74.9% (21.1)
	21b. Cable Coverage[g]	• "Upgraded", i.e., Broadband-Internet-access ready cable coverage of the population in percent in the third quarter 2006 • P[14]: 33.86% (24.26). E[11]: 31.09 (25.66)
	22a. Local Call Prices[h]	• Average cost of local telephone call (US$ per three minutes) in 2003 • F[99]: 0.09 (0.12). P[18]: 0.18 (0.22). E[17]: 0.19 (0.22)
	22b. International Call Prices[i]	• Residential users international telephone call basket (OECD basket methodology) at year-end 2003 • F[27]: 1.62 (1.31). P[21]: 1.29 (0.94). E[25]: 1.65 (1.35)
	23. Price Spread[i]	• Difference between 40 hour peak-time local call basket (proxy for dial-up Internet) and cheapest ADSL Internet price at year-end 2003 • P[17]: 32.92 (65.66). E[15]: 17.89 (20.74)

a) The study design is to introduce dependent variables with a time lag of 2 to 3 years into the analyses. Therefore, the indepedent criteria are collected for the year 2003 or the closest year for which data was available. F = Full data set = World sample; P = Partial data set = OECD sample; E = EU-25 data set = European sample. The number of countries for the respective indicator and sample is given in square brackets. Main figure = Mean. Figure in parenthesis = Standard deviation.
b) Data for variable 14 was drawn from the OECD Communications Outlook 2005.
c) Variables 15 and 16 were aggregated from the ECTA 2005 Regulatory Scorecard Report.
d) Data for variables 17, 19, and 20 was computed from Analysys 2006 broadband market share statistics.
e) Variables 18a-18b stem from OECD 2003 „Development in Local Loop Unbundling", pp. 16-19.
f) Data for variable 21a was collected from the OECD Communications Outlook 2005.
g) Variable 21b was collected from the JP Morgan Chase 2006 Report „The Fibre Battle".
h) Variables 22a stem from the ITU World Telecommunication Indicators Database 2006.
i) Variables 22b-23 draw on the 2004 and 2005 Reports prepared by Teligen for the European Commission.

duction lead time had a strong correlation both to broadband penetration rates and to the Internet user ratio ($0.39 < r < 0.67$, $p < 0.031$, $28 < n < 144$). The factual and estimated commercial broadband introduction lead time variables correlated strongly with $r = 0.81$ ($p < 0.001$, $n = 41$), indicating that the estimated indicator, which is available for a larger data set, can be used as a reliable reference variable.

Independent variables

General country characteristics are captured with five variables, namely economic prosperity, prosperity growth, unemployment, service sector activity, and urbanisation/population density (see variables 1-5b in Table 1). While most of these indicators are common in macro-level studies of country factors impacting attractivity of market entry, unemployment and service sector activity received less research attention in related research studies.

Societal country characteristics are reflected by the four indicators computer skills/computer abundance, English literacy, teleworking, and uncertainty avoidance, with three of these criteria also being analysed using alternative variables due to data availability/scope (see variables 6a-9b in Table 1).

General and telecommunication-specific market regulation are covered with ten indicators. Regulatory quality and voice and accountability are the two general characteristics tested, while liberalisation lead time, independent regulator lead time, incumbent privatisation lead time, broadband regulation scorecard, regulatory scorecard index, intra-technology concentration, LLU lead time, unbundling variants, and inter-technology concentration cover the broadband-relevant telecoms regulation circumstances in a market in detail (see variables 10-19 in Table 1). This is especially important, since it has previously been pointed out that measuring regulatory conditions for broadband is challenging and that more fine-grained measures are called for (Bauer 2003, p. 2 and 19). The general regulatory criteria were previously used to explain PC and Internet penetration (Chinn/Fairlie 2007, p. 44). The concentration measures were used in one recent study (Distaso et al. 2006, pp. 94-95), while the lead time indicators are new.

The broadband market environment is described using four indicators: Market concentration, DSL and cable coverage, average local call prices and average international call prices during the year 2003, and the narrow-to-broadband-price-spread at year-end 2003 (see variables 20-23 in Table 1).

There is substantial overlap within the set of explanatory variables and it is difficult to distinguish effects of each indicator. Therefore, further tests and consolidation of variables are ongoing. This work in progress version of the paper provides initial correlation analyses and a reduced regression analysis.

4. Results

To test the study propositions, bivariate correlation analyses and reduced-form multivariate regression analyses were conducted on the set of dependent and independent variables. Tables 2 (World sample), 3 (OECD sample), and 4 (EU-25 sample) provide the correlation results. Taking associations as relevant that have both a significant Pearson and a significant Kendall correlation and given that a time lag of two to three years between dependent and independent variables was used by design, most of the indicators have a strong significant causal effect on broadband development.

The results are very similar across the three sample universes, with only some notable deviations to be discussed in further detail. General country characteristics play a strong role for explaining both the broadband subscription and Internet user penetration reached in a country: Economic prosperity, service sector activity, and urbanisation had a strong positive effect on the broadband market development worldwide as well as in OECD and EU-25, while prosperity growth and unemployment had a negative effect. Broadband launch lead time was significantly higher in more prosperous countries in the world sample, but not so in the OECD and EU-25 samples, which indicates a larger disparity at the world level and similar broadband starting conditions in developed countries.

Results for societal country characteristics provided support for the study propositions. PC penetration as an indicator of computer skills at global level (see Table 2) as well as a computer skills assessment for OECD and EU-25 countries (see Tables 3 and 4) was strongly associated with broadband and Internet developments. However, this variable is highly overlapping with economic prosperity, making a realistic assessment of the effect of computer skills, independent of available income of a market's inhabitants uncertain.

English literacy also had a strong positive association with broadband and Internet development – lending support for the assumption that use of such services is more attractive and therefore more widespread if (freely accessible) global web content is useful for subscribers.

The share of teleworking or home office employees also correlated with broadband and Internet take-up but not with broadband launch lead time (see Tables 3 and 4). The base of these users may not be large enough in relation to the full market to make earlier introduction feasible for operators compared across countries. Nevertheless, as indicated by the significant correlations this target group contributes to more rapid take-up and overall stronger penetration levels at the macro level.

Results for uncertainty avoidance are inconclusive: While the Hofstede-based index correlates negatively, the Globe-study index has a positive association with broadband development (see discussion of these criteria in a different study context in Jakopin 2006, pp. 224-225). Results for the Hofstede-index, despite being more than 25 years older than the Globe-

Table 2: Correlation analyses: Explaining broadband development (World sample)

	Ia. Broadband Penetration 2005		II. Internet User Ratio 2005		IIIa. Broadband Launch Lead Time (Estimate)	
Variables[a]	*r*	*t*	*r*	*t*	*r*	*t*
1. Economic Prosperity	0.84 ***	0.77 ***	0.86 ***	0.70 ***	0.63 ***	0.49 ***
2. Prosperity Growth	-0.19 +	-0.16 *	-0.11	-0.05	-0.16 +	-0.13 *
3. Unemployment	-0.26 *	-0.11	-0.25 **	-0.14 *	-0.32 ***	-0.14 *
4. Service Sector Activity	0.39 ***	0.25 ***	0.48 ***	0.32 ***	0.24 *	0.17 *
5a. Urbanisation	0.50 ***	0.50 ***	0.56 ***	0.47 ***	0.56 ***	0.41 ***
5b. Population Density	0.22 *	0.22 ***	0.12	0.19 ***	0.16 +	0.05
6b. Personal Computer Penetration	0.89 ***	0.77 ***	0.90 ***	0.75 ***	0.58 ***	0.48 ***
7. English Literacy	0.49 *	0.39 **	0.52 **	0.41 **	0.35 +	0.26 +
9a. Uncertainty Avoidance (Hofstede)	-0.39 *	-0.23 *	-0.35 *	-0.16	-0.21	-0.12
9b. Uncertainty Avoidance (Globe)	0.55 ***	0.35 ***	0.50 ***	0.28 **	0.34 **	0.24 *
10. Regulatory Quality	0.76 ***	0.69 ***	0.80 ***	0.60 ***	0.65 ***	0.48 ***
11. Voice and Accountability	0.65 ***	0.57 ***	0.68 ***	0.51 ***	0.50 ***	0.38 ***
12. Liberalisation Lead Time	0.32 *	0.21 *	0.33 *	0.22 *	0.34 **	0.30 **
13. Independent Regulator Lead Time	0.36 ***	0.23 **	0.25 **	0.07	0.34 ***	0.29 ***
14. Incumbent Privatisation Lead Time	0.55 **	0.46 ***	0.69 ***	0.49 ***	0.70 ***	0.51 ***
17. Intra-Technology Concentration	-0.38 *	-0.29 *	-0.37 *	-0.29 *	-0.52 ***	-0.42 ***
18a. LLU Lead Time	0.51 **	0.34 *	0.58 **	0.44 **	0.65 ***	0.51 ***
18b. Unbundling Variants	0.31 +	0.17	0.25	0.13	0.20	0.17
19. Inter-Technology Concentration	-0.21	-0.12	-0.26	-0.17	-0.18	-0.13
20. Market Concentration	-0.37 *	-0.22 +	-0.44 **	-0.27 *	-0.47 **	-0.35 **
21a. DSL Coverage	0.70 ***	0.49 ***	0.58 ***	0.27 *	0.58 ***	0.27 *
22a. Local Call Prices	0.20	0.16 +	0.34 ***	0.15 *	0.01	0.00
22b. International Call Prices	-0.46 *	-0.38 **	-0.46 *	-0.35 **	-0.33 +	-0.27 +
C1. Population	-0.05	-0.01	-0.04	-0.09 +	0.10	0.17 **

a) For each dependent variable, Pearson (= r) and Kendall (= τ) correlations are shown in the first (second) row. The number of cases ranges from 25 to 118 for dependent I, 25 to 186 for dependent III, 27 to 146 for dependent IVa (compare number of cases given in Table 1).

+ $p < 0.10$ * $p < 0.05$ ** $p < 0.01$ *** $p < 0.001$ (two-tailed test)

Table 3: Correlation analyses: Explaining broadband development (OECD sample)

Variables[a]	Ib. Broadband Penetration 2006		II. Internet User Ratio 2005		IIIb. Broadband Launch Lead Time (Factual)	
	r	*t*	*r*	*t*	*r*	*t*
1. Economic Prosperity	0.56 ***	0.49 ***	0.61 ***	0.41 ***	0.17	0.12
2. Prosperity Growth	-0.44 *	-0.30 *	-0.23	-0.12	-0.07	-0.02
3. Unemployment	-0.46 *	-0.33 **	-0.28	-0.28 *	-0.22	-0.01
4. Service Sector Activity	0.37 *	0.22 +	0.59 ***	0.44 ***	0.17	0.08
5a. Urbanisation	0.53 **	0.41 ***	0.60 ***	0.41 ***	0.37 +	0.26 *
5b. Population Density	0.28	0.09	0.17	-0.06	-0.08	-0.08
6a. Computer Skills	0.76 ***	0.59 **	0.79 ***	0.52 **	0.00	-0.05
6b. Personal Computer Penetration	0.80 ***	0.60 ***	0.82 ***	0.62 ***	0.31	0.21
7. English Literacy	0.55 *	0.48 **	0.56 **	0.43 **	0.33	0.29 +
8a. Share of Teleworkers	0.80 **	0.55 *	0.81 **	0.70 **	0.29	0.19
8b. Home Office	0.72 ***	0.56 ***	0.70 ***	0.53 **	0.29	0.27
9a. Uncertainty Avoidance (Hofstede)	-0.50 *	-0.27 +	-0.53 **	-0.36 *	-0.21	-0.17
9b. Uncertainty Avoidance (Globe)	0.60 **	0.45 **	0.48 *	0.34 *	0.17	0.12
10. Regulatory Quality	0.65 ***	0.50 ***	0.64 ***	0.50 ***	0.35 +	0.27 *
11. Voice and Accountability	0.62 ***	0.58 ***	0.56 ***	0.46 ***	0.27	0.17
12. Liberalisation Lead Time	0.40 *	0.47 ***	0.55 **	0.56 ***	0.24	0.32 *
13. Independent Regulator Lead Time	0.21	0.35 *	0.32	0.29 *	0.57 **	0.38 **
14. Incumbent Privatisation Lead Time	0.32	0.21	0.52 *	0.31 +	0.25	0.24
15. Broadband Regulation Scorecard	0.55 *	0.42 *	0.42	0.37 *	0.31	0.20
16. Regulatory Scorecard Index	0.58 *	0.46 *	0.42	0.46 *	0.25	0.12
17. Intra-Technology Concentration	-0.52 **	-0.40 **	-0.67 ***	-0.52 ***	-0.46 *	-0.30 *
18a. LLU Lead Time	0.41 *	0.27 +	0.51 **	0.40 **	0.45 *	0.33 *
18b. Unbundling Variants	0.33 +	0.22	0.25	0.13	0.21	0.18
19. Inter-Technology Concentration	-0.28	-0.13	-0.20	-0.11	-0.17	-0.27 +
20. Market Concentration	-0.43 *	-0.19	-0.50 **	-0.27 *	-0.30	-0.17
21a. DSL Coverage	0.70 ***	0.48 ***	0.58 ***	0.27 *	0.42 *	0.19
21b. Cable Coverage	0.64 *	0.37 +	0.50 +	0.23	0.33	0.30
22a. Local Call Prices	0.10	0.10	0.23	0.09	-0.30	-0.10
22b. International Call Prices	-0.64 **	-0.49 **	-0.57 **	-0.49 **	-0.35	-0.09
23. Price Spread	0.15	-0.15	0.05	-0.22	-0.06	0.03
C1. Population	-0.12	-0.19	0.06	-0.19	0.28	0.11

a) For each dependent variable, Pearson (= r) and Kendall (= τ) correlations are shown in the first (second) row. The number of cases mostly ranges from 23 to 30 (only two variables have sample sizes < 15, compare number of cases given in Table 1).

+ $p < 0.10$ * $p < 0.05$ ** $p < 0.01$ *** $p < 0.001$ (two-tailed test)

Table 4: Correlation analyses: Explaining broadband development (EU-25 sample)

	Ib. Broadband Penetration 2006		II. Internet User Ratio 2005		IIIb. Broadband Launch Lead Time (Factual)	
Variables[a]	*r*	*t*	*r*	*t*	*r*	*t*
1. Economic Prosperity	0.47 *	0.50 **	0.53 **	0.32 *	0.05	0.19
2. Prosperity Growth	-0.64 **	-0.44 **	-0.24	-0.19	-0.46 *	-0.24
3. Unemployment	-0.45 +	-0.28 +	-0.28	-0.26 +	-0.27	-0.05
4. Service Sector Activity	0.37	0.28 +	0.50 *	0.35 *	-0.13	-0.15
5a. Urbanisation	0.63 **	0.51 **	0.38 +	0.19	0.40 +	0.29 +
5b. Population Density	0.36	0.17	-0.04	-0.08	0.16	0.07
6a. Computer Skills	0.71 **	0.51 *	0.73 ***	0.46 **	0.08	0.09
6b. Personal Computer Penetration	0.77 ***	0.59 ***	0.81 ***	0.63 ***	0.16	0.12
7. English Literacy	0.58 **	0.52 **	0.39 +	0.31 *	0.13	0.18
8a. Share of Teleworkers	0.82 **	0.55 *	0.81 **	0.64 *	0.34	0.26
8b. Home Office	0.72 ***	0.56 ***	0.65 ***	0.44 **	0.33	0.29 +
9a. Uncertainty Avoidance (Hofstede)	-0.62 *	-0.46 *	-0.63 *	-0.52 **	0.17	-0.08
9b. Uncertainty Avoidance (Globe)	0.76 ***	0.63 ***	0.67 **	0.49 **	0.50 +	0.41 *
10. Regulatory Quality	0.79 ***	0.68 ***	0.64 ***	0.47 ***	0.42 +	0.36 *
11. Voice and Accountability	0.89 ***	0.78 ***	0.58 **	0.39 **	0.41 +	0.29 +
12. Liberalisation Lead Time	0.62 **	0.76 ***	0.49 *	0.46 **	0.49 *	0.46 **
13. Independent Regulator Lead Time	0.40 +	0.37 *	0.10	0.13	0.55 *	0.42 *
14. Incumbent Privatisation Lead Time	0.18	0.27	0.20	0.32	0.17	0.05
15. Broadband Regulation Scorecard	0.55 *	0.42 *	0.42	0.37 *	0.31	0.20
16. Regulatory Scorecard Index	0.58 *	0.46 *	0.42	0.46 *	0.25	0.12
17. Intra-Technology Concentration	-0.59 **	-0.46 **	-0.43 *	-0.36 *	-0.33	-0.15
18a. LLU Lead Time	0.59 **	0.56 ***	0.52 *	0.56 ***	0.49 *	0.35 +
18b. Unbundling Variants	0.42 +	0.33 +	0.36	0.25	0.16	0.06
19. Inter-Technology Concentration	-0.26	-0.06	-0.09	-0.03	0.05	-0.12
20. Market Concentration	-0.27	-0.10	-0.23	-0.10	-0.10	-0.05
21a. DSL Coverage	0.67 **	0.51 **	0.47 *	0.29	0.66 **	0.36 *
21b. Cable Coverage	0.74 **	0.44 +	0.47	0.15	0.25	0.30
22a. Local Call Prices	0.18	0.31	0.58 *	0.30	-0.38	-0.14
22b. International Call Prices	-0.65 **	-0.54 ***	-0.47 *	-0.36 *	-0.30	-0.04
23. Price Spread	-0.49 +	-0.31	-0.54 *	-0.33 +	-0.19	0.14
C1. Population	-0.05	-0.04	-0.05	-0.13	0.30	0.21

a) For each dependent variable, Pearson (= r) and Kendall (= τ) correlations are shown in the first (second) row. The number of cases mostly ranges from 18 to 25 (only three variables have sample sizes < 15, compare number of cases given in Table 1).

+ $p < 0.10$ * $p < 0.05$ ** $p < 0.01$ *** $p < 0.001$ (two-tailed test)

study database, are more intuitively appealing: Broadband development is slower or less widespread if a society is rather uncertainty avoiding. In contrast, the Globe-study correlations suggest that countries with an uncertainty avoiding population both introduce broadband earlier and have stronger take-up.

General and telecommunications specific market regulation affects broadband and Internet development. Firstly, regulatory quality and voice and accountability, which strongly overlap with economic prosperity, are positively related to broadband penetration, Internet user ratios, and introduction lead time. Liberalisation, independent regulator, and incumbent privatisation lead times all significantly positively correlated with the three dependent variables – supporting the general diffusion curve logic and providing evidence for the positive effect of all three government actions that were carried out in the 1990s in the majority of countries.

The broadband regulation scorecard, as well as the aggregate regulatory scorecard index correlated positively with broadband take-up – indicating that there is some face validity for these indices in capturing regulatory actions that should by design be useful for market development.

Intra-technology concentration and LLU lead time were significant, and indicated that higher diversity of service offers within one technological platform and earlier LLU introduction coincided with better broadband development. The number of unbundling variants available to alternative operators did not have significant coefficients.

Inter-technology competition, i.e., a less uneven dispersion of subscribers across cable, DSL or other broadband platforms was not driving broadband take-up significantly. This result is mainly explained by the relative predominance of DSL – despite some of the more advanced countries also showing higher cable broadband usage, which however does not seem to be a general trend.

Market outcomes and strategy related macro indicators provided mixed results. Market concentration, i.e., a lower number of competitors with higher subscriber market shares had a significant negative effect on broadband timing. While significant for broadband development at world scale, higher concentration proved non-significant in the EU-25 sample. To wit, market concentration should not be referred to as one of the main drivers of (too) low/slow broadband development.

DSL and cable coverage, i.e., technical availability of such services to the population was strongly associated with broadband take-up. Higher local call prices had a weak positive effect on broadband and Internet development, while higher international call prices exhibited a stronger negative correlation. The results pattern, given the other relevant explanatory variables and relatively recent introduction of voice over IP/Internet-based telephony, is difficult to interpret correctly and may rather stem from other underlying factors than from a real effect of telephony price levels on Internet take-up. International call price associations may be more a result of the specific overall economic and telecoms market development situation of the countries characterised by high international call prices than a voice over IP substitution effect or of the lack of such an influence.

Finally, based on the the available data set, initial analyses provided little evidence for the assumed price differential effect between narrow- and broadband Internet that may prevent or promote switching to broadband subscribtions.

As bivariate correlations can only serve as first indication – that needs to be confirmed with multivariate analyses (Bauer 2003, p. 12; Wallsten 2007, p. 2-4), additional initial regression analyses were conducted on the full data set. Due to multicollinearity of the data, which is indicated by high Variance Inflation Factors/Condition Indices, and low sample sizes for some variables, the initial regressions on the raw variables were reduced to a minimum set of variables. The reduced specification included eight explanatory variables and reached highly significant adjusted R^2s of 0.58 for broadband subscriptions and Internet user ratio and 0.49 for broadband launch lead time (see. Table 5). In general, coefficients tended to be considerably smaller, but corresponded to bivariate results presented in Tables 2-4.

Mirroring the economic prosperity effect, prosperity growth had a negative relation to take-up and introduction timing, reflecting the overall economic position effect rather than the relevance of broadband for economic development at the country level.

As expected, unemployment remained significantly negative for broadband development in multivariate analyses, while the positive correlation of higher service sector activity levels disapperated. Urbanisation had a positive coefficient, while population density lost significance. Concentration of residents in main cities is therefore more important for broadband development than the mere spatial concentration at the country level.

Voice and accountability, which may be translated to mean higher freedom of expression on the Internet and is highly correlated with general economic prosperity and regulatory quality, had strong significant positive effects on the broadband development criteria. Finally, while a longer history of independent telecoms regulation was not critical for Internet take-up in general, it was significant for broadband penetration.

Overall, the main implication of the study is to refrain from to narrow normative categorisation of market developments without referring to the various influencing effects that contribute to the stage of market development that a country can reach at a certain point in time. Simple comparison of broadband penetration rankings is not enough. Regulators and commentators should be more aware and concious about the specific economic and societal situations of countries being compared or benchmarked against each other. Operators considering an entry into a foreign broadband market should take into account a broader range of indicators to identify attractive opportunities and when attempting to appropriately predict broadband development speeds and penetration thresholds.

Table 5: Initial regression analyses on broadband development factors

Variables[a]	Ia. Broadband Penetration 2005	II. Internet User Ratio 2005	IIIa. Broadband Launch Lead Time (Estimate)
2. Prosperity Growth	-0.14 +	-0.07	-0.22 *
3. Unemployment	-0.17 *	-0.16 *	-0.21 *
4. Service Sector Activity	-0.04	0.15	-0.19 +
5a. Urbanisation	0.22 *	0.27 **	0.44 ***
5b. Population Density	0.11	0.00	0.04
11. Voice and Accountability	0.51 ***	0.52 ***	0.37 ***
13. Independent Regulator Lead Time	0.24 **	-0.05	0.14
C1. Population	0.01	0.06	0.13
Adjusted R-Square	**0.58** ***	**0.58** ***	**0.49** ***
F-value	13.68	14.57	10.73
n	76	81	81
Durbin Watson Statistic	1.73	1.76	2.19
Maximum Variance Inflation Factor	1.72	1.72	1.72
Maximum Condition Index	14.67	14.67	14.67
Maximum Cook's D	0.17	0.13	0.50

a) Standardised beta coefficients are shown. Substantial multicollinearity prevents introducing a larger set of study variables. Alternative variables and highly correlated indicators were ommited from the analyses in an iterative procedure. One case was excluded from regression analyses due to Cook's D > 1.

+ p < 0.10 * p < 0.05 ** p < 0.01 *** p < 0.001 (two-tailed test)

6. Conclusions

This study analysed indicators that may explain international broadband development differences in a three-layered sample covering 186 countries at the worldwide level, 30 countries at the OECD and 25 countries at the European level of analysis. Explanatory variables were collected for the year 2003, while the dependent variables refer to the year 2005 or 2006 to introduce a time lag, which is better suited to allow causal interpretation of results. The main areas covered by the variables are general economic conditions, societal and cultural antecedents, general and telecommunications-related regulatory environment, and broadband market conditions. Findings indicate that most of the 24 indicators are significantly related to broadband development, i.e., the broadband subscriber penetration, Internet user ratio and commercial introduction timing of broadband.

Therefore, analysts and regulators should refrain from citing simple country broadband penetration rankings, but also take into account the specific situations faced by each individual country before to single minded comparison. Operators reviewing foreign broadband market entry opportunities are well advised to pay attention to a broader range of variables and criteria to evaluate their stakes and options, as well as the planning outlook.

The present analyses point towards five open research questions and future areas of advancement: (1) Conditionality of effects, (2) broadband outcomes, (3) variable aggregation, (4) interacting/moderating and mediating effects, and (5) non-linearity of association patterns.

1. Conditional effects were not explicitly discussed in the present study. However, underlying variables could constitute an interrelated set of conditions required to be present to achieve superior broadband development. Bauer (2003, p. 17) points out that a high price level is never associated with high broadband take-up while low prices can either coincide with high or low broadband penetration and therefore only constitute a necessary but not a sufficient condition. However, no common set of sufficient conditions to explain high broadband penetration emerged from earlier analyses (Bauer 2003, pp. 17-18). Future studies should further sharpen the understanding of necessary conditions under which follower broadband markets may be able to prosper and catch up with advanced countries.

2. The effects of broadband on economic development or other "Information Society Goals" as described in Figure 1, were not taken into account in the present paper. However, the main reason for the heated debate about broadband development differences emanates from the presumed positive relation between broadband and desired outcomes like economic growth, higher employment levels, lower unequality and others (cf. discussion in Bauer et al. 2002; European Commission 2006a; Lehr et al. 2006). Therefore, future studies should simultaneously capture incoming and outgoing effects associated with broadband Internet access, i.e., in simulatenous equation models.

3. In the present draft, we did not attempt to further consolidate the vast number of variables. To enable advanced consolidation of the various indicators proposed in this work, the data will be transformed into a common scale in relation to the sample universe. The resulting common-scale variable values will be aggregated according to the usual reliability testing procedure for reflective constructs that form indices that may then be used for regression analyses. The use of formative partial least squares constructs to aggregate overlapping variables and omit multicollinearity problems is another option to consider in this context. Formative constructs should be used, when indicators can have varying degree of influence on a construct. Formative indicators can but must not necessarily be highly intercorrelated. Further, such multivariate modelling can be used at low sample sizes.

4. Interactions and moderating effects were not reviewed in the present paper. However, as indicated in Figure 1, some of the variables and constructs may not impact broadband development directly, but have a moderating effect on other potential broadband affecting criteria (e.g., regulation on market conditions). Therefore, future work should explicitly test interactions of the main study variables.

5. Non-linearity, i.e., u-shaped or other curvilinear patterns of association between the explanatory variables and broadband development indicators were neglected in the present

study. While an initial review of the study variables suggests that they all should have a monotonous and not curve-shaped effect on broadband development, it may still be useful to further review arguments towards such relation patterns and test them empirically.

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