Is high-speed Internet an infrastructure of general interest?*

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Abstract

The Digital Agenda for Europe from 2016 has set ambitious aims for high-speed Internet connections. Though availability has increased as demanded, economic growth did not accelerate as hoped. In contrast to the introduction of DSL, the uptake of higher speeds is still rather low. The low usage might be driven by too expensive contracts compared to basic speeds. I approach the question of high-speed Internet adoption by investigating whether high-speed and basic Internet are substitutes. Substitutes are derived from a mixed-logit discrete choice model, which is heavily applied in the market definition literature. I use a cross-sectional setting in Austria, where regional differences with respect to active providers are exploited. I find that high-speed and basic Internet are no substitutes. Hence, users who do not need higher speeds will always choose the relatively cheap basic speed alternative independent of high-speed availability.

Keywords: substitution; high-speed Internet; discrete choice; mixed-logit; NetTest data

JEL-Codes: L96; L13; L51

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1 High-speed Internet: coverage aims and usage

Policy makers across Europe increasingly care about the quality of broadband Internet connections. The Digital Agenda for Europe from 2016 aims at connecting all (50 percent) households to broadband Internet with at least 30 Mbps (100 Mbps) by 2020. Only five years later, full household coverage with 100 Mbps or more shall be attained across Europe.[1] According to the Digital Single Market report, the coverage rates indicate that Europe is on a good way to succeed. The coverage rates for these bandwidths aims already achieved 79.0 percent (55.1 percent) in 2017, compared to 55.3 percent (39.9 percent) in 2013.[2] However, coverage is only the one hand side. On the other hand side, usage is needed for a technology to have an impact. However, usage of high-speed Internet remains low. European household's subscription of at least 30 Mbps (100 Mbps) was at 27 percent (11 percent) in 2017.[3] Hence, only one third (fifth) of the households with higher speeds available also subscribed such a contract. In contrast, the introduction of DSL at basic bandwidths accelerated economic growth (among others Czernich et al. (2011) and Kolko (2012)). However, economic growth only occurred because DSL at basic bandwidths was subscribed heavily. Now, it is the European Commission's hope that higher speeds again go along with economic growth. However, the European Commission's goals are broader than economic growth. European citizens with high ICT skills and confidence were declared as a goal as well. Additionally, broadband Internet should facilitate businesses to go online and citizens to shop online. Therefore, this paper's evaluation is also broader. Instead of analyzing a specific goal, I investigate the usage side of high-speed broadband Internet.

Basic speeds are still the main focus when analyzing the effects of broadband Internet. More recent papers on higher speeds apply availability and miss the role of adoption therefore. Nevertheless, there is still a lack of papers investigating high-speed Internet of more than 100 Mbps. Also, in the market definition literature there is still a lack of studies analyzing higher speeds (more than 100 Mbps). Therefore, this paper analyzes high-speed Internet adoption in Austria and takes especially contracts of more than 100 Mbps into account. High-speed Internet adoption depends on the substitutability across bandwidths and between stationary fixed-line and mobile technologies. Only if basic and higher speeds are seen as substitutes, high-speed Internet will broadly be adopted. Otherwise, there is only a certain type of Internet user with a high utility from high-speed Internet. Other users do not have such a high utility and will always choose a cheaper basic contract. In this case, the adoption rate will remain low as the high prices do not reflect the low utility most users receive from

[1] https://ec.europa.eu/digital-single-market/en/broadband-strategy-policy
[2] https://ec.europa.eu/digital-single-market/en/connectivity
[3] https://ec.europa.eu/digital-single-market/en/european-digital-progress-report

higher bandwidths. I approach the question of high-speed Internet adoption by investigating whether high-speed and basic Internet are substitutes.

The methodology applied in this paper is heavily used in the market definition literature where different technologies or bandwidths are analyzed with respect to their substitutability when deciding whether they form a single market or different markets. I apply a cross-sectional setting for Austria with regional differences with respect to the active providers on the level of municipalities and to high-speed coverage on a finer grid-level. Own- and cross-price elasticities of demand are derived from a mixed logit discrete choice model. While own-price elasticities show how price-sensitive consumers are, cross-price elasticities define substitutes.

I find that high-speed and basic Internet are no substitutes. Hence, there exists a certain type of users who needs higher speeds and uses such a contract. Thus, an increase of high-speed Internet availability only increases high-speed Internet usage if such users live in the area which might get an upgrade. In contrast, users who do not need higher speeds will always choose the relatively cheap basic speed alternative independent of high-speed availability. However, I find that for lower speeds fixed-line and mobile technologies are substitutes. Contrarily, for higher speeds these technologies do not work as substitutes. Moreover, the derived own-price elasticities indicate that demand is generally very elastic.

This paper uses innovative and novel data. One major data base comes from usage data where the realized speed is tested on the regulation authority's website (RTR-NetTest). The number of Internet users testing their speed increased sharply in recent years (Figure A.1), which makes new methods like the one presented in this paper feasible. The increase of speed tests is not caused by higher Internet penetration in Austria.[4] Rather, the increase in tests shows that users are not anymore satisfied by merely being connected to the Internet but care about the speed they have available. This data makes it also possible to track the increased average download speed (Figure A.2).

I exploit extensive data on around 150,000 Austrian stationary broadband Internet tests, performed between April and November 2016. I observe the provider chosen and the measured download and upload speed and can conclude the chosen contract from this information. Additionally, I observe the chosen contract's price as well as the competitive environment in the household's locality, which allows me to define choice sets for every user in the sample.

This paper contributes to two literature strands. Starting with the literature on the effect of broadband Internet on economic outcomes, the estimated utilities and price elasticities of

[4] In 2013, already 98 percent of households had a broadband coverage of at least 2 Mbps and four out of five Austrians had the possibility to access the Internet from home, meaning that the households did have a valid Internet subscription.

demand from this analysis show limitations in the usage for high-speed Internet, which is necessary before finding economic effects of higher speeds. Czernich et al. (2011) identifies an effect of broadband infrastructure annual per capita growth for OECD countries. For the US, Kolko (2012) finds a positive relationship between broadband expansion and local economic growth. He applies the slope of the terrain as an instrument for broadband expansion and detects growth in population, employment, the average wage, and the employment rate. Focusing on labor market effects, Atasoy (2013) discovers that gaining access to broadband services in a county is associated with approximately a 1.8 percentage points increase in the employment rate. This is in contrast to Czernich (2014) who finds no effect on the unemployment rate for Germany. On the firm level, Akerman et al. (2015) identify different broadband Internet effects depending on the skill level of workers on labor market outcomes and productivity for Norway. For Germany, Bertschek et al. (2013) detect broadband Internet effects on the firms' innovation activity but not on their labor productivity. Colombo et al. (2013) find that the productivity performance of small and medium enterprises in Italy is not influenced by basic broadband applications. However, depending on the industry advanced broadband applications influence productivity. On broadband adoption Grimes et al. (2012) discover an increase in firm productivity. All these studies apply basic DSL with lower speeds than in this paper.

More recent studies analyze various broadband speeds. Ford (2018) compares 10 Mbps and 25 Mbps in the US and finds no economic payoff with respect to jobs, personal income, and labor earnings on the county-level. Similar results are shown in a correction of Bai (2017) by Whitacre et al. (2018). For Germany, Briglauer et al. (2019) evaluate the Bavarian state aid program for speed upgrades in broadband Internet availability. They detect no effect on the employment rate. However, 16 Mbps and more is the highest category. Therefore, I investigate whether there might exist not enough users with a high utility from high-speed Internet.

Methodologically, this paper builds on the literature on market definition in the broadband market. So far, the literature has focused on investigating potential technology-level boundaries. Early papers by Crandall et al. (2002), Rappoport et al. (2003) and Flamm and Chaudhuri (2007) analyze demand for dial-up, DSL and cable modem in the US and focus on the substitution between narrowband and broadband. Flamm and Chaudhuri (2007) analyze cross-price elasticities of demand and find that dial-up and broadband are substitutes. Similar results are found by Pereira and Ribeiro (2011) for Portugal.

In one of the more recent studies Cardona et al. (2009) also analyze the Austrian broadband market applying a nested logit model. They find a strong substitution for DSL and cable, where cable exists, and suggest adding cable to the DSL market. Additionally, they exploit the fact that about half of Austria is connected to the cable network. They detect higher elasticities in areas connected to the cable network than in areas without the possibility to access the cable network. Mobile was not yet very important in the market. Therefore, the authors leave it, expecting it to become more important, to further research to discuss substitution pattern between fixed-line and mobile Internet. Other more recent evidence, increasingly focusing on whether fixed and mobile technologies are substitutes, has been presented by Srinuan et al. (2012) and Grzybowski et al. (2014) for Sweden and Slovakia, respectively. The price elasticities derived point towards high price-sensitivity for all technologies, indicating them to be close substitutes. They all use survey data and while the first study applies a nested logit model, the latter study applies a mixed logit model. Here, this paper contributes by providing substitution patterns across speed and technology as first signs for future market definitions for the broadband Internet market in Austria.

The remainder of this paper is organized as follows. After this introduction, Section 2 defines the discrete choice model, the mixed logit regression and how elasticities are derived. Broadband coverage in Europe and the case of Austria are explained before the data sets I use and merge are introduced in Section 3. Section 4 presents estimation results as well as price elasticities of demand while the paper concludes in Section 5.

2 Discrete choice model

I apply a discrete choice model based on McFadden and Train (2000), which is the standard method in the market definition literature. Internet subscribers choose a contract with a certain provider, bandwidth, and price. All available contracts are defined as the choice set's alternatives. The alternatives form an exhaustive and mutually exclusive discrete choice set.

The most basic regression method in this context would be a multinomial logit model. However, it imposes the independence of irrelevant alternatives (IIA) property. As IIA might not be guaranteed, I apply a more general approach, a mixed logit regression, which relaxes IIA by allowing for correlation of choices across the alternatives. This model allows for unobserved heterogeneity among the individuals, which might apply in this case as I observe only very few individual characteristics of the Internet subscribers. Furthermore, Internet subscribers consider in their choice not only the speed but also other characteristics, especially the price. A random coefficient for the price is, therefore, applied for the unobserved heterogeneity among Internet subscribers.

Choice set

The choice is defined by the contracts selected by the Internet subscribers. The alternatives are represented by speed categories for fixed-line and mobile providers separately. In total, there exist seven alternatives: surfing with (i) at the most 20 Mbps, (ii) 40 Mbps (iii) 80 Mbps or (iv) more than 80 Mbps using a fixed-line provider and (v) at the most 20 Mbps (vi) 80 Mbps or (vii) more than 80 Mbps using a mobile provider. Importantly, within each alternative I do not distinguish between providers or technologies.

Utility

The utility V_{ij} is defined for each Internet subscriber i and for each contract category j. It depends on test- and alternative-specific valuations (β_j and γ) and the Internet subscriber's price sensitivity $\widetilde{\alpha_i}$. Hence, it is given by:

$$V_{ij} = \widetilde{\alpha_i} p_{ij} + \beta_j x_i + \gamma z_{ij} + u_{ij},$$

where x_i is a vector of test-specific variables and β_j are fixed, alternative-specific coefficients on x_i. Additionally, γ will be estimated on z_{ij}, a vector of alternatives-specific variables. Finally, u_{ij} is the logit error term, which is, as suggested by theory, identically and independently distributed across contracts according to the Type I extreme value distribution. The random price coefficient $\widetilde{\alpha_i}$ accounts for the heterogeneity among the individual Internet subscribers, which is unobserved. It cannot be estimated directly, but only by estimating the parameters of $f(\tilde{\alpha})$. Assuming a normal distribution ($\tilde{\alpha} \sim N(\alpha, \Sigma)$), $\widetilde{\alpha_i}$ is calculated as follows:

$$\widetilde{\alpha_i} = \alpha + \sigma_\alpha v_i, \tag{2.1}$$

where α is the price coefficient's mean valuation, σ_α refers to its standard deviation and v_i is a random variable, following a standard normal distribution ($v \sim N(0,1)$).

Choice probabilities

It is assumed that each Internet subscriber maximizes her utility. With the previous defined utilities, individual choice probabilities for each category can be calculated as:

$$l_{ij}(\widetilde{\alpha_i}) = P(V_{ij} = \max_{k \in C_i} V_{ik}) = \frac{\exp(\widetilde{\alpha_i} p_{ij} + \beta_j x_i + \gamma z_{ij})}{\sum_{k \in C_i} \exp(\widetilde{\alpha_i} p_{ij} + \beta_j x_i + \gamma z_{ij})},$$

where C_i is the choice set for each Internet subscriber i as defined above. The last equation follows from the distributional assumptions of the logit error term u_{ij}. The mixed logit model with unobserved heterogeneity requires integration over the distribution over $\widetilde{\alpha_i}$, the random coefficient, which has to be simulated.:

$$s_{ij} = \int_{\widetilde{\alpha_i}} l_{ij}(\widetilde{\alpha}) f(\widetilde{\alpha}) d\widetilde{\alpha}.$$

The estimate $\widehat{s_{ij}}$ is then applied to the maximum likelihood estimation:

$$\mathscr{L}(\theta) = y_{ij} \sum_i \sum_j \log(\widehat{s_{ij}}),$$

where y_{ij} equals 1 if individual i has chosen alternative j and 0 otherwise.

Price elasticities of demand

I am interested in own- and cross-price elasticities for the choice set averaged on the country-level. These elasticities are based on the regression's outcome, the choice probabilities, which were derived before, and the prices. From the mixed logit regression, the random coefficient for the price $\widetilde{\alpha_i}$ is simulated according to equation (2.1). The regression output is applied as well for the choice probabilities $\widehat{s_{ij}}$. The individual own-price elasticities of demand are then defined as follows:

$$\epsilon_{ij}^{indv} = \frac{\delta s_{ij}}{\delta p_{ij}} p_{ij} = \widetilde{\alpha_i} s_{ij} (1 - s_{ij}) p_{ij}. \tag{2.2}$$

As in Grzybowski et al. (2014), I calculate elasticities of demand instead of semi-elasticities of demand, i.e. I am not just averaging over individual's price elasticities but weighting these by the individual's choice probabilities. Hence, following the individual's own-price elasticity (equation (2.2)), the country level elasticity is:

$$\epsilon_{ij}^{country} = \frac{\sum_i \widetilde{\alpha_i} s_{ij} (1 - s_{ij}) p_{ij}}{\sum_i s_{ij}}. \tag{2.3}$$

The cross-price elasticities are accordingly calculated from the individual cross-price elasticities:

$$\epsilon_{ik}^{indv} = \frac{\delta s_{ij}}{\delta p_{ik}} p_{ik} = \widetilde{\alpha_i} s_{ij} s_{ik} p_{ik}, \ for \ k \neq j.$$

3 Data on broadband alternatives

I start with the context of broadband coverage in Europe and explaining the situation in Austria before I describe the applied data in this analysis. Beginning with the individual data sets I use, I then explain how these data sets are merged, before the definition of the estimation data for the discrete choice model closes this section.

3.1 Broadband coverage in Europe and the case of Austria

Coverage data for Europe shows that different countries have a different mixture of technologies for their Next Generation Access (NGA) to provide users with high bandwidths. These technologies include copper-based (VDSL), fiber (FTTP) and coaxial cable (DOCSIS 3.0) technologies. Overall, Table A.1 shows an NGA coverage of 80.1 percent in 2017 (46.9 percent in rural areas).[5]

This paper examines Austria because it is a representative country with respect to coverage rates. The coverage of households connected with at least 30 Mbps (100 Mbps) is slightly above the European average with 81.1 percent (57.2 percent). The NGA coverage, in general, rose from 69.5 percent in 2012 to 90.0 percent in 2017 and more than trebled for rural areas in this period. This increase was mostly driven by the expansion of VDSL and DOCSIS 3.0.[6] Although the availability of FTTP in Austria is below the EU average, above average coverage for connection speeds of at least 30 Mbps and at least 100 Mbps has been achieved. Moreover, Austria has a strong mobile net and therefore a high demand for stationary mobile contracts. This should make Austria even more an interesting case. Hence, I consider Austria as a good representative for this study.

[5] In particular, Europe has coverage with VDSL of 53.4 percent (32.5 percent), with FTTP of 26.8 percent (11.3 percent) and with DOCSIS 3.0 of 44.7 percent (10.8 percent).

[6] The coverage with VDSL increased from 50.5 percent to 82.2 percent and from no availability to 22.1 percent for its rural areas. The expansion of the DOCSIS 3.0 was moderate and similar in size for both rural and urban areas. FTTP still plays a minor role in the provision of fast broadband access to Austrian households. The coverage rate of FTTP rose from 6.3 percent to 13.5 percent and from 1.2 percent to 5.4 percent for rural areas, which is a small fraction compared to the EU 28 average of 23.7 percent.

3.2 Spatial broadband data

I apply usage data from the national regulatory via speed tests, network providers and coverage data from the *Breitbandatlas*, and broadband Internet contracts collected by *AK-Tarifwegweiser*. While it is true that prices do not vary a lot over time, there are changes in the offered contracts with respect to the download (and upload) speed. Taking the time frame from April to November 2016, there are no new contractual bandwidths introduced and only very few changes in the prices. Therefore, tests can be assigned to the contracts easily.

Usage data

From RTR-NetTest, I derive information on broadband usage across Austria from around 150,000 speed tests.[7] Besides the exact timing of each test (date and time), importantly, the data provides the exact (geo-coordinates of the) test location and the network provider, establishing the Internet connection. Information on measured upload as well as download speed is included, too. Finally, it provides a rich set of additional information, such as the type of Internet connection (WLAN / LAN).[8]

I restrict the data to tests of stationary Internet connections.[9] This includes tests of fixed-line as well as mobile network quality. Yet, tests of stationary Internet connections that are established via mobile networks are restricted to offers, designed for the use *at home* rather than standard smartphone contracts. While the former offers typically include non-constraint broadband usage at a particular bandwidth, smartphone contracts are limited with regards to the consumable volume and bandwidth.

I handle the issue of selection into the sample. This problem might occur if only users with an incorrect working Internet connection perform the test. However, this case is handled by reducing the sample to tests close to an existing contract. Though, I know the date of the tests, this might not be the dates when testers signed their contract. However, I assume that if the test was not performed because something had been wrong with the Internet connection, most of the tests were performed close after the contract had been signed to assure that the provider keeps up to the contractual speed. If there is a great number of tests

7 The data is publicly available for download on the web page of the Austrian regulatory agency's (RTR - Rundfunk und Telekom Regulierungs-GmbH): https://www.netztest.at/en/. By providing a web browser tool and mobile applications (for Android and iOS), RTR enables users to test the quality of their current mobile and stationary Internet connections.

8 If the test was performed via LAN the applied browser is transmitted and if the test was performed via WLAN the model of the used device is transmitted.

9 Additionally, if a tester performed multiple tests in one session, only the last test is taken and the others are removed from the data. I only observe the network provider rather than actual service providers, meaning that providers with no own infrastructure are not shown in the data. For instance, A1 Telekom Austria, the Austrian incumbent operator is required to grant access to its network for service providers, e.g. via local loop unbundling.

with new signed contracts, my results are not representative for all contracts but explain the behavior of a subgroup of Internet users who have signed a new contract recently. For policy makers, however, this subgroup might be the relevant group for which one is interested in their behavior.

Broadband coverage & network providers

From the Austrian *Broadband Atlas*, I use fine-grained (100 × 100 meters) data on the maximum available download speed in the middle of 2015 via fixed-line networks which is provided by the Ministry for Transport, Innovation and Technology (bmvit).[10] Similarly, data on mobile coverage is made available as geodata indicating which Austrian regions are covered by a particular bandwidth.[11] While high-speed Internet access via fixed-line concentrates in rather urban areas, mobile broadband is distributed allover Austria.

Apart from data on available bandwidths across the country, the *Broadband Atlas* lists all network providers on municipality level. From these, I consider the fixed-line providers A1 Telekom, kabelplus, Tele2, UPC, Salzburg AG, and LIWEST. It is important to notice that these providers have different network technologies and most of them are only in specific regions active. Whereas A1 Telekom, as the incumbent, owns the copper network all over Austria, kabelplus, Tele2 and UPC are active in specific regions with their coaxial networks. The same is true for the fiber networks of Salzburg AG and LIWEST. From the mobile providers, only Hutchinson Drei, A1 Telekom Mobile and T-Mobile offer stationary contracts and are therefore considered in the analysis. These fixed-line and mobile providers account for about 90 percent of all tests from the usage data.

Contract data

From *AK-Tarifwegweiser*, I gather contract data. The data includes monthly information on all contracts offered by major network providers which were named above as well as service providers without their own network.[12] Apart from the price, the data includes information on maximum download bandwidth, maximum capacity[13], and duration. I complement this data with information on maximum upload bandwidth from the providers' website and the Internet archive *Wayback Machine*.[14] For each contract, I apply the minimum price per

[10] The maximum attainable bandwidth is assigned to a particular grid-cell, once at least one provider can technically realize the bandwidth in at least one household in that cell.

[11] Yet, actual attainable bandwidths, especially via mobile networks, may significantly deviate from the theoretical availability, depending on the number of users and the intensity of usage within a particular mobile cell.

[12] MMC, A.K.I.S., Comteam, CNet, DIC, Telematica and TeleTronic, among others

[13] All contracts considered are unlimited except for the ones from Salzburg AG, which contain a *fair use* policy.

[14] https://archive.org/web/

month and take the mean over the whole time period. I consider only unlimited capacities or with *fair use* specified and of at least 150 GB.

In Table A.2 and A.3, the contract information for the above stated providers can be found. These include price (in euros) and upload speed (in Mbps) for each offered download bandwidth (in Mbps). The contract data is made visible in Figure A.3 for the case of A1 Telekom, where each line represents one download speed.

The contractual maximum download speed varies between 8 and 250 Mbps. However, offered bandwidths depend on the provider. For instance, only UPC and kabelplus offer contracts with 250 Mbps. This contract offered by kabelplus is rather expensive, whereas the one by UPC lies in the price range of contracts offered by other providers, such as A1 Telekom or LIWEST, with a contractual download speed of 100 Mbps and 150 Mbps respectively, which cost slightly less than 60 Euros. In general, prices vary between 17.8 and 99.9 Euros.

Spatial merge

I merge the different data sets by exploiting the fact that all data is geographically referenced. The linkage is illustrated in Figure 1. First, the municipalities, with their information on active providers and the providers' tariff plans, are matched to the fixed-line coverage grid via a geo-information software (Figure 1a). Then, each particular test is related to its grid and the information assigned above (Figure 1b), resulting in a data set at the household (actually test-location) level. This data not only includes information on the contract chosen, i.e. the provider and bandwidth, but also on the maximum available bandwidth. Furthermore, it identifies potential alternative providers other than the one servicing the household.

Unfortunately, the level of precision in the data with regards to the related information deviates from an ideal setup. Preferably, I would want to know i) which providers a household could connect to rather than the providers that are active in the household's municipality and ii) which bandwidth each provider can offer in the grid than the maximum available bandwidth of all providers collectively. A minor issue is iii) that the coverage is not available for the household location but rather for a small area of the household.

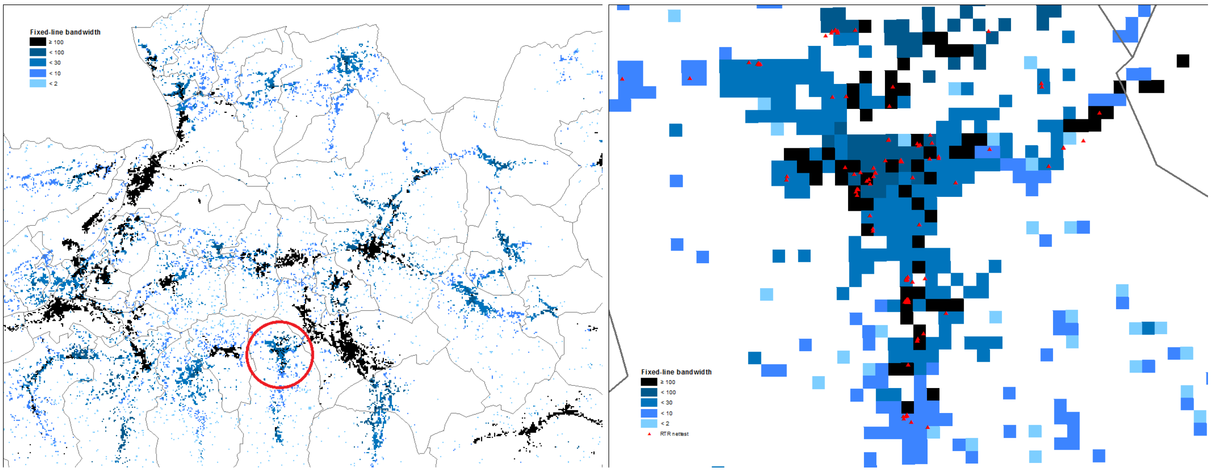
Limiting coverage and providers serving different bandwidths

Comparing the distribution of download speed by fixed-line coverage (Figure A.5), until a maximum fixed-line coverage of 50 Mbps the median measured download speed is rather close to the maximum fixed-line coverage. However, for higher maximum fixed-line coverage (100 Mbps or >100 Mbps), median measured download speed does not increase anymore.[15]

[15] Until a maximum coverage of 30 Mbps, the median measured download speed is at least 50 percent of the maximum coverage. For 10 Mbps, it is even more than 70 percent. For a maximum coverage of 100 Mbps, the median measured download speed is only 26 percent of the maximum coverage anymore.

Figure 1: Illustration of the spatial merge

(a) Municipalities and fixed-line coverage (b) Fixed-line coverage and tests in one municipality



Note: The figure illustrates municipality borders (gray lines), broadband coverage on grid level (blue cells) and household test locations (red dots). Data provided by GfK GeoMarketing GmbH, Ministry for Transport, Innovation and Technology (bmvit), RTR

Hence, it seems that until 50 Mbps many consumers are restricted by the maximum fixed-line coverage such that they would sign contracts with higher download speeds if these were available. However, many consumers are not signing contracts with more than 50 Mbps download speed, even if they were available.

A comparable choice set is needed for the regression. Therefore, tests which were performed in a grid with less than the maximum fixed-line coverage (at least 100 Mbps) in 2015 are removed. Eventually, the data comprises to 64,182 tests. Table A.4-A.6 show in more detail how the sample shrinks when it is reduced for reasons of measurement or limited fixed-line coverage, especially with respect to the number of tests from each provider. Summary statistics comparing the selected observations and the removed ones can be found in Table A.7. Figure A.6 shows the distribution across chosen providers. Most of the A1 tests fall in the lowest bandwidth alternative, whereas most of the UPC tests fall in the two highest bandwidth alternatives. The distribution reflects the prices from Table A.2: UPC offers the cheapest high bandwidth contracts, whereas they are more expensive in lower bandwidth contracts compared to other providers. A1 Telekom might still have market power within lower bandwidths. However, market share declines heavily for higher bandwidths.

Choice & choice set

The mixed logit model requires a choice variable and a choice set containing all alternatives.

The choice is assigned based on the information on download and upload speed as well as the network provider chosen and the location where the test was performed.[16] The choice is defined as the closest contract with respect to the measured upload and download speeds from the displayed provider.[17]

The choice set is defined as four alternatives for fixed-line and three for mobile contracts.[18] The lowest alternative allows for at the most 20 Mbps download bandwidth and the highest alternative contains contracts of more than 80 Mbps download bandwidth, which in fact are contracts with a three-digit download bandwidth ($\geq$ 100 Mbps). Therefore, the more than 80 Mbps alternative can be considered as the very high bandwidth alternative. Alternatives are formed from several contracts as it is unlikely that a consumer considers all available contracts as alternatives. These alternatives make it possible to answer questions on substitution patterns within fixed-line tariffs and between them and mobile tariffs. For chosen alternatives, I apply the price from the tariff plan. The mean price and its standard deviation is 31.13 and 10.84 Euros respectively. For alternatives, I take a weighted average price over available contracts for each alternative. I take the weights from the number of times a choice was taken in the area starting with the same zip-code digit such that I can account for regional variations in available fixed-line providers and in the taste for mobile providers.

Filtering the noise

Determining the choice is complicated by the fact that the test data contains noise. Thus, a measured speed might deviate dramatically from the one assigned in the contract.[19] The noise in the data becomes visual in Figure 2a and 2b showing a heat map and a scatter plot for A1 Telekom tests with a measured download speed below 8 Mbps and a measured upload speed below .75 Mbps. These values refer to the lowest A1 Telekom contract in my data

[16] I update information on active providers and coverage from the usage data. If a test was performed with a transmitted provider not shown in the *Breitband Atlas* in this municipality, the municipality data is updated to include this provider. Similarly, if a test was performed with a higher download speed than covered in this specific grid, the grid information is updated for all tests in this grid.

[17] Contracts have at least to allow the measured speeds in upload and download. An exception is made if the measured speed is above the maximum contract a provider offers. In these 2,105 cases, the test is assigned to this maximum tariff plan. Closest is defined by the lowest Euclidean distance. Regarding the problem that for A1 Telekom tests I cannot distinguish between fixed-line and mobile tests, the tariff plans for mobile and fixed-line are different enough that I can follow the described procedure.

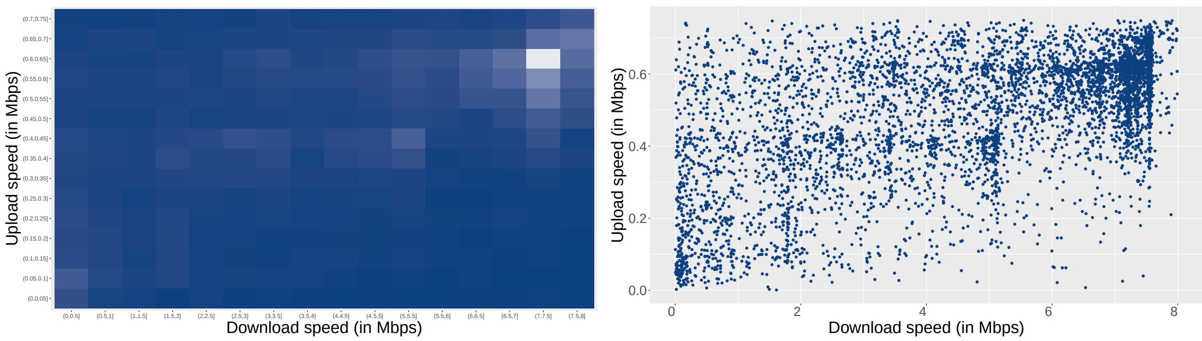
[18] As explained in Section refsec:model, the alternative borders start at 20 Mbps and double two times, resulting in alternative borders at 40 Mbps and 80 Mbps for the fixed-line contracts. Importantly, all different fixed-line technologies appear in each fixed-line alternative. As there exist less mobile contracts, borders for the alternatives are drawn differently: The lowest alternative border is at 20 Mbps (containing contracts of 10 Mbps and 20 Mbps) and the middle alternative border is at 80 Mbps (containing contracts of 30 Mbps, 40 Mbps and 50 Mbps).

[19] While a particular tester may not surf the Internet at a higher speed than the contractually assigned maximum bandwidth, in many cases she will surf with a speed below the latter. For example, unfortunate location of broadband routers may result in actual download and upload speeds lower than the contractually assigned ones when using WLAN instead of a LAN connection.

(Table A.3).[20] The heat map depicts a bright hot spot just below the contractual bandwidths. Additionally, a horizontal tail shows that there are many tests within a certain upload speed corridor but with very different download speeds. However, a similar vertical tail cannot be found. Therefore, it is more important to consider the upload bandwidth when filtering the noise, although the download bandwidth is presumably more important to the consumer. Moreover, the figure display why it is important to filter the noise: There are many tests above 5 Mbps download speed and below .5 upload speed. It is very likely that there exists an old contract with these contractual speeds. However, I have no information on the price of this contract. Therefore, it is better to remove these tests than assigning a wrong contract to them.

Figure 2: Measured download and upload

(a) Heatmap (b) Scatter plot



Note: The figure depicts the distribution of download and upload speeds of performed A1 Telekom tests. The tests are restricted to a low bandwidth for clarity. Data from RTR-NetTest from the Austrian Regulatory Authority for Broadcasting and Telecommunications.

In pursuit of most possible cleanliness of the data, the data is restricted to tests with a realized download and upload speed within a certain corridor below an offered contract. This corridor is defined differently for fixed-line and mobile providers. Additionally, it reflects the assumption that the measurement of the upload speed is more trustworthy than the measurement of the download speed.[21] Figure A.4 contains only the remaining tests and illustrates hereby the corridors. The left column shows all tests for each provider. In the right

[20] The data in these figures was reduced to A1 Telekom tests and with respect to the download and upload speed due to higher visibility.

[21] For fixed-line providers, the corridors are either a deviation of 15 percent in the download speed and 30 percent in the upload speed or 15 percent in the upload speed and 50 percent in the download speed. Saying that when the download speed was measured precisely, the upload speed is allowed to differ more and vice versa. For mobile providers, a deviation of 40 percent either in upload or in download from the tariff plan is allowed. This broader restriction is necessary as mobile tests vary more in both upload and download speed. However, it is still legitimate as there are fewer different mobile contracts, and therefore, a more precise assignment of choices is still possible.

column, observations with a measured download or upload speed which does not fall into one of the corridors are removed. In these tests, the speeds were measured imprecisely.

4 Different types of Internet users

The results of the alternative specific mixed-logit regression are discussed shortly, before focusing on the elasticities of demand to analyze the substitution patterns. I show that there are different types of broadband users: Consumers with a high (low) utility from high-speed Internet, which have a contract in the second highest (lowest) fixed-line category, will upgrade (downgrade) their contracts to the highest (lowest) category if the price of their contract is increased. Hence, an increase in broadband availability will only slightly increase high-speed usage. Moreover, mobile users are rather different from fixed-line users. However, this holds stronger for higher speeds than for the lowest category, where users might substitute between mobile and fixed-line.

4.1 Price sensitivity and substitution patterns

Regression results

I reduce the data to tests with an available fixed-line coverage of at least 100 Mbps at their location grid in 2015 prior to the regression. Furthermore, all regressions contain weights with respect to the number of mobile and fixed-line contracts all over Austria and robust standard errors are applied. As described in Section 2, the price for the alternatives is the weighted mean of all contracts from all providers in one alternative. The weights are defined by the number of chosen providers within a region (first zip-code digit). Specifications with the unweighted mean and without weights will be provided as robustness checks.

In the main specification, I control for whether the device, from which the test was performed, was connected via wireless LAN or LAN. Furthermore, the first zip-code digit and the mobile upload coverage from the *Broadband Atlas* are applied as geographic covariates. In later regressions, I apply further control variables on zip-code level for robustness. There, variables control for population size, education, gender and age distribution, share of newborns, and (un-)employment / retirement status for each zip-code area.

Table 1: Mixed-logit regression results

	(1)	(2)	(3)	(4)
price	-0.176***	-0.194***	-0.196***	-0.196***
	(0.000635)	(0.000621)	(0.000606)	(0.000606)
sd(price)	0.104***	0.127***	0.127***	0.128***
	(0.000354)	(0.000392)	(0.000399)	(0.000400)
basic control	X	X	X	X
further zip-code level controls			X	X
all zip-code level controls				X
sample	whole	reduced	reduced	reduced
Observations	449,274	234,514	234,514	234,514
Cases	64,182	33,502	33,502	33,502

Note: The regression table shows the results for the whole (first column) and the reduced sample (second to fourth column) with four fixed-line and three mobile alternatives. The sample is reduced to tests which had full fixed-line coverage (at least 100 Mbps) in 2015 to make sure that all alternatives are eligible and that the results are comparable. Weights with respect to the number of mobile and fixed-line contracts all over Austria and robust standard errors are applied. It is controlled for whether the device, from which the test was performed, was connected via wireless LAN or LAN. Furthermore, the first zip-code digit and the mobile upload coverage from the *Broadband Atlas* are applied as geographic covariates. In the third column, population size, gender, (un-)employment, retirees, and age structure on zip-code level are added. In the last column, education level and share of newborns on zip-code level are added. Standard errors are shown in parentheses. * $p<0.05$, ** $p<0.01$, *** $p<0.001$

In Table 1, the main specification for the whole (first column) and the reduced sample (second column) is presented. The random coefficient has a mean valuation of $\hat{p} = -0.176$ and -0.194 and a standard deviation of $\hat{\sigma}_p = 0.104$ and 0.127 (all highly significant). A lower standard deviation (in absolute values) than the mean is revealed, which yields a negative $\widetilde{\alpha_i}$ for most of the observations, meaning that consumers are price-sensitive. In Column 3 & 4, further control variables are added. However, adding more control variable does not change the results. Therefore, I focus on the second column as this model is sparser. The coefficients for the choices will be presented with a focus on the socio-economic implications later.

Price elasticities of demand

I present the own- and cross-price elasticities, which are calculated according to equation (2.3), for the reduced sample applying the estimates of the second column from Table 1. Table 2 shows the means over 100 repetitions of an each newly simulated random coefficient.

Table 2: Own- and cross-price elasticities

	≤ 20 Mbps	≤ 40 Mbps	≤ 80 Mbps	> 80 Mbps	mobile ≤ 20 Mbps	mobile ≤ 80 Mbps	mobile > 80 Mbps
≤ 20 Mbps	-2.992	1.204	.931	1.187	.283	.698	.092
≤ 40 Mbps	1.323	-4.542	.994	1.202	.31	.808	.191
≤ 80 Mbps	1.039	.988	-5.562	1.744	.26	.66	.179
> 80 Mbps	.969	.883	1.308	-7.105	.25	.711	.227
mobile ≤ 20 Mbps	1.025	1.008	.841	1.079	-3.691	1.191	.759
mobile ≤ 80 Mbps	.666	.701	.577	.839	.314	-4.251	1.582
mobile > 80 Mbps	.109	.207	.196	.324	.256	2.011	-4.549

Note: The own- and cross-price elasticities are simulated 100 times with the regression coefficients of the reduced sample (Table 1, second column) and according to equation (2.3).

Own-price elasticities show demand changes after a price increase for a specific choice, whereas cross-price elasticities detect movement patterns between the alternatives. The cross-price elasticity is defined as the demand increase of each contract if the price of the alternative in a specific row is increased by 1 percent. Hence, for each row it can be seen how the demand of the contract in that specific row is affected by a price increase. Cross-price elasticities can also be interpreted column by column. For each alternative, one can detect the alternative from which the highest demand increase comes from.

The diagonal in Table 2, the own-price elasticities, shows that all alternatives are elastic, with values starting from -2.99 for the lowest fixed-line alternative. Consequently, an increase in price by 1 percent reduces the demand by 2.99 percent for the lowest fixed-line alternative. For other alternatives, the demand decreases even stronger. The own-price elasticity for other fixed-line choices increases with the bandwidth to a value of -7.11, which is driven partly conceptually by higher prices.[22] The own-price elasticities for the mobile alternatives are comparable to the respective fixed-line alternatives. Similar elasticities are found in the literature for substitution between technologies. For instance, Grzybowski et al. (2014) finds elasticities between -1.5 and -4.9, Cardona et al. (2009) finds that elasticities are -2.5 for all three technologies.

To detect patterns in substitution changes, as stated above, cross-prices elasticities are more important. However, one has to take the correlation within columns into account. The correlation indicates a generally higher preference for specific alternatives, like the fixed-line > 80 Mbps alternative, which has always higher values than the fixed-line ≤ 80 Mbps alternative.

Same technologies are principally more likely to be substitutes. If the price of one of the fixed-line alternative is increased, the other fixed-line alternatives rather than the mobile alternatives are more demanded. The same holds for mobile alternatives vice-versa. The

[22] Therefore, this value should not be interpreted as a demand decrease of 7.11 percent after a price increase of 1 percent for mobile contracts with at least 80 Mbps.

substitutes within fixed-line or mobile are the alternatives with the closest bandwidth. For each technology, for the alternative with the lowest (highest) possible bandwidth, the next higher (lower) alternative has the highest cross-price elasticity. The alternatives inbetween show the relevant substitution patterns for this analysis. For the ≤ 80 Mbps alternative for both technologies, the cross-price elasticity points upwards and for the fixed-line ≤ 40 Mbps alternative downwards. This shows that between these alternatives users are different in their utility, they receive from high-speed Internet. The lowest two fixed-line alternatives and the highest two fixed-line alternatives are closest substitutes within each other. Therefore, it makes sense to define the low speed user for fixed-line ≤ 40 Mbps contracts and mobile ≤ 20 Mbps contracts.

For mobile alternatives, the cross-price elasticities of the other mobile alternatives are always, but for the lowest mobile alternative, higher than the ones of any fixed-line alternative. This indicates that for mobile users, substitution within the technology is higher than across bandwidths. A reason might be that the installation for mobile routers is easier and that the realized bandwidth with mobile contracts is more volatile.

For the lowest mobile alternative, substitution also exists between technologies. The next higher mobile alternative is a good substitute, whereas the highest mobile alternative is less interesting. On the other side, middle speed fixed-line alternatives are good substitutes as well. Hence, consumers tend either to upgrade speed and keep the same technology or change the technology and only slightly increase speed. The lowest mobile alternative might belong to a different kind of user than the higher mobile speed user.

As there is substitution from the lowest mobile alternative to basic fixed-line technologies, one user type for lower speed is defined for all technologies. The highest two mobile alternatives are clearly the closest substitutes, both indicated column- and row-wise. Increasing the price for one of these alternative, the highest fixed-line alternative gets a higher demand increase than the lowest mobile alternative. For higher speeds, fixed-line and the mobile contracts are signed by different users.

4.2 Robustness and heterogeneity

Robustness

First robustness checks show that the results are not driven by the researcher's choices when defining the sample and the estimation specifications. For the whole sample, elasticities look very similar (Table A.8) compared to the reduced sample elasticities. Also, adding more control covariates on zip-code level does not change elasticities a lot (Table A.9 & A.10). On the zip code level, I control for population size, gender, (un-)employment, retirees, and age distribution (as in Table 1, third column). I also add share of newborns and educational level as controls (as in Table 1, fourth column). I apply weights when calculating mean prices to account for how often providers are chosen. Taking the unweighted mean might make less frequently chosen providers too important. Nevertheless, I present elasticity results for the unweighted mean prices with the reduced sample in the Appendix (Table A.11). Again, the elasticity results are very similar as before.

I also apply regression weights with respect to fixed-line and mobile contracts. The sample contains only tests and might not be representative for technologies. One can imagine that mobile networks might react strongly on seasons, weather, and most importantly on the correct position of the router. Therefore, tests with stationary mobile contracts might occur more frequently in my data. Nevertheless, elasticity results without weights with respect to fixed-line and mobile contracts are shown in Table A.12. Elasticities are a bit lower. However, the patterns stay the same. Moreover, one might think that A1 Telekom might be signed more often due to its incumbent position. Adding a preference for incumbent choice increases elasticities a little (Table A.13). Nevertheless, results still look very similar to the baseline results.

As it was shown that the results are not driven by researcher's choices, I continue with further robustness checks and heterogeneous effects. I apply several random data splits: into two halves (Table A.14 & A.15) and a randomly selected five percent subset (Table A.16). With the smaller samples, I can show that results do not depend on my choices, what is already shown above, but also hold in smaller randomly selected samples. Additionally, as the sample is rather big, I can show that significant estimates do not come from a huge number of observations N but are persistent even in smaller samples. In all subsets the results look very similar.

Next, the number of tests per municipality is restricted. I present elasticities for municipalities with more than 10, 20 and 50 tests (Table A.17-A.19). In these municipalities, a few tests can already produce an outlier. These might also be rather small municipalities, which correspond with more rural and poorer locations. One can see that elasticities are getting only slightly higher if the municipalities with fewer tests are removed. However, substitution patterns in the cross-price elasticities are still very robust. The same is true when the municipalities with very high numbers of tests are removed (Table A.20 & A.21), which might be very dense and urban locations. Then, elasticities become a little bit lower. These small changes could be explained with stronger competition in more urban areas. Nevertheless, results with respect to substitution patterns in the cross-price elasticities are again very robust.

Heterogeneity

Heterogeneous effects are observed in a regional and a time dimension. With respect to regional differences, first, I analyze Vienna separately and compare it to the rest of Austria. Vienna is Austria's capital and with 1.9 million inhabitants the biggest city in Austria. Moreover, Vienna is noticeably bigger than the next biggest city Graz (less than 300.000 inhabitants). Due to a higher number of active providers, competition is higher in Vienna. Thus, one can see that own-price elasticities in absolute terms are higher as well: People are more price sensitive. However, substitution patterns in the cross-price elasticities stay the same. Hence, I observe the same substitution pattern in Vienna (Table A.22) and the rest of Austria (Table A.23). For the rest of Austria, I compare the bigger cities (Graz, Linz, Salzburg, and Innsbruck), which have each more than 100,000, and the remaining regions. For the cities together (Table A.24), again, own-price elasticities are higher compared to the regions without bigger cities (Table A.25) as with less competition, there is less substitution. This might potentially be even more true for the not included regions with less coverage.

Next, the data is split along the test date. I divide the data into four groups, each containing data for two consecutive months. In the Tables A.26-A.29, a decline in the own-price elasticities can be detected. However, own-price elasticities are not falling under a certain level of unimportance and can still be explained by random variation. Only the last table for October and November has again higher values. In these months, more tests were performed. A longer time horizon is necessary to get a clearer picture from these time trends. Therefore, this might be a point to dig deeper and observe these trends over a longer time horizon.

Finally, I examine utilities across the controls. Table A.30 shows the estimates for all applied covariates for all alternatives. Estimates are referring to the base alternative (fixed-line $\leq$ 20 Mbps). Before I come to socio-economic characteristics, the base controls (mobile upload, first digit of zip-code, and wireless LAN) are interpreted. The higher the mobile upload is, the higher is the utility of a mobile alternative (first row, fourth to sixth column). Next, utilities for different regions are observed. The estimate for the first digit of the zip-code is interpreted with respect to the baseline, which is Vienna, for each alternative. Therefore, it is not surprising that most estimates are negative and that especially for the highest fixed-line alternative the estimates are highly negative. Internet users with a high utility from higher speeds are more present in Vienna. For mobile alternatives, this image is less clear and for some regions also positive estimates can be found for some mobile alternatives. This shows that in certain regions stationary mobile contracts are more popular than in Vienna. Also, if a test was performed via wireless LAN instead of LAN, estimates for mobile and for the highest fixed-line alternative are negative, whereas for medium fixed-line speeds, estimates are positive with respect to the lowest fixed-line alternative.

Coming to the socio-economic characteristics, in smaller cities higher speeds both for fixed-line and for mobile have highly negative estimates. Medium sized cities show high utilities for medium speed fixed-line and for all mobile alternatives, especially though for these with higher speeds. In contrast, bigger cities show high utilities for high fixed-line speeds but less utility for mobile alternatives. Therefore, it seems that mobile alternatives are more demanded in rather rural areas, independent of the region defined by the first digit of the zip-code. However, one has to keep in mind that the sample only contains areas where high fixed-line speeds are available. Areas with a higher percentage of newborns also show higher utilities for high-speed fixed-line Internet. A higher male share also corresponds with higher utilities for higher speeds. Education characteristics seem not to matter a lot. However, for lower educations higher speeds show a lot less utility. The age distribution matters a lot. Younger people clearly prefer higher speeds both in fixed-line and mobile. Older people prefer mobile alternatives. However, they do it less than younger people. It has to be mentioned that all these estimates are not causal and show only indicative views.

5 Conclusion

It was shown that Internet in Austria is demanded by three different groups of user. Basic Internet is demanded via fixed-line and mobile. For higher speeds, fixed-line and mobile are demanded from different users. Especially, high-speed fixed-line Internet (100 Mbits and more) is only demanded by a certain group of users. Hence, an expansion in the availability of such speeds does not necessarily expand its usage as well. However, a high usage is necessary for a technology to have a broad (economic) impact. If the usage of high-speed Internet does not change, there is no need for a government to foster its rollout as demanded by the European Commission.

In the next years, 5G mobile Internet might become very important and influence substitution between fixed-line and mobile technologies. This will probably affect predominately technological substitution within higher speeds. While this paper analyzes data before the introduction of 5G, the results still work as a baseline for future changes. Also, as 5G might not immediately dominate the stationary mobile Internet, this paper is important for current technological substitution. Moreover, a lack of substitution between fixed-line and mobile technologies for high-speed Internet before the introduction of 5G does not necessarily imply that after its introduction substitution does not exist. Lower high-speed mobile Internet quality compared to fixed-line high-speed quality might be the reason for the lack of substitution. With 5G high-speed mobile Internet quality will increase and therefore substitution might become more likely.

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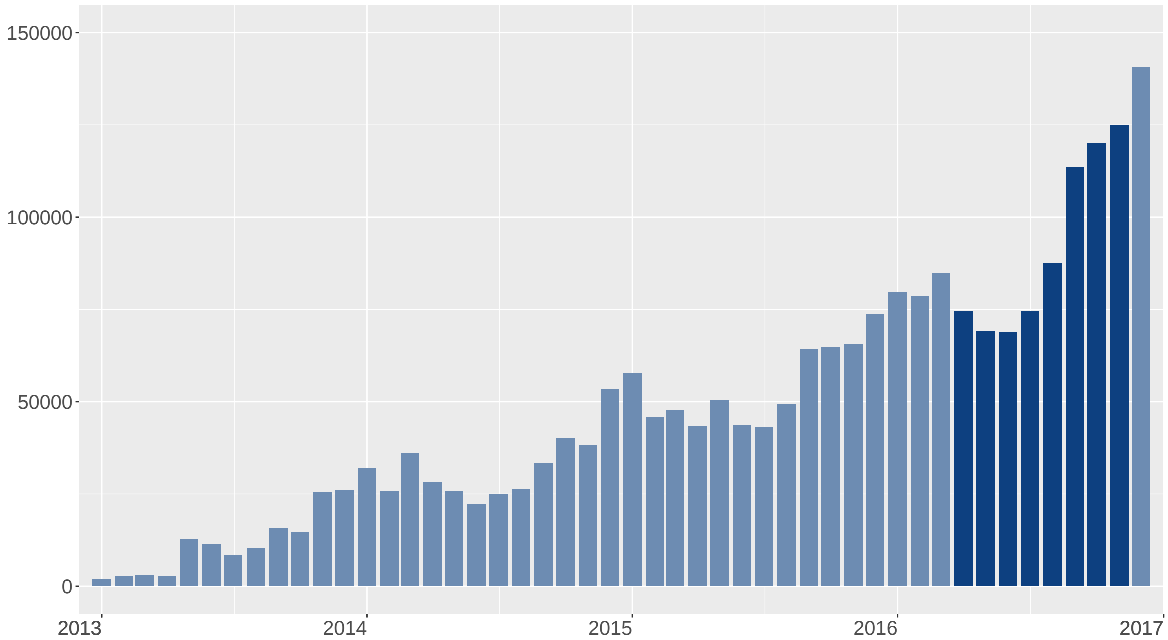
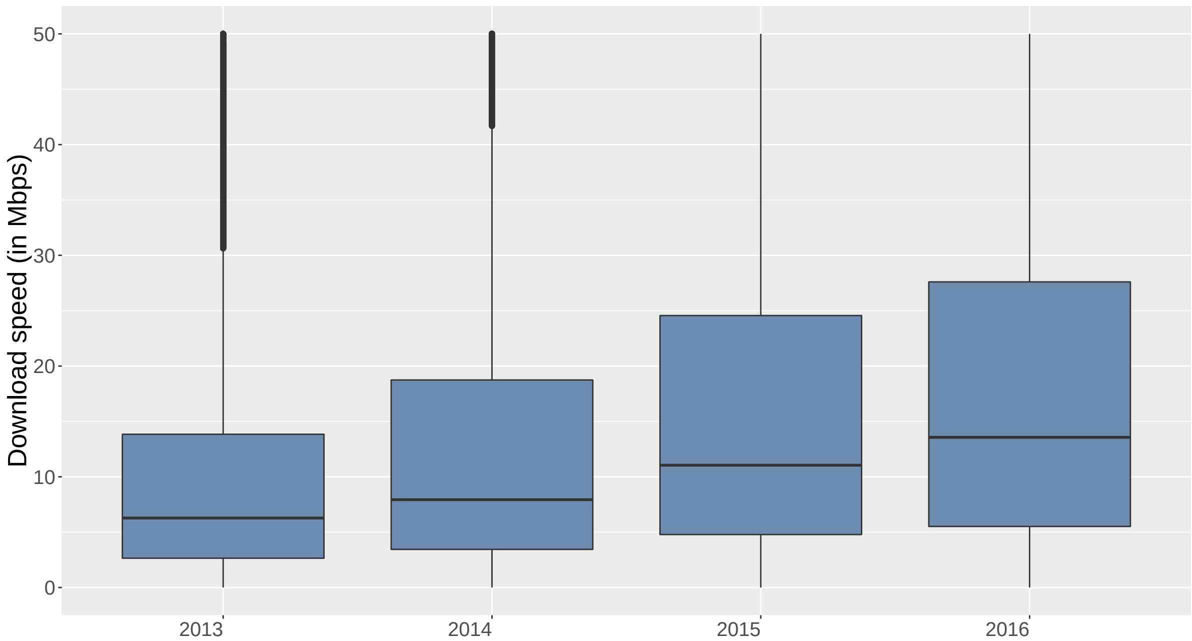
A Appendix

Figure A.1: Number of speed tests from 2013 to 2016 (darker blue analysis period)



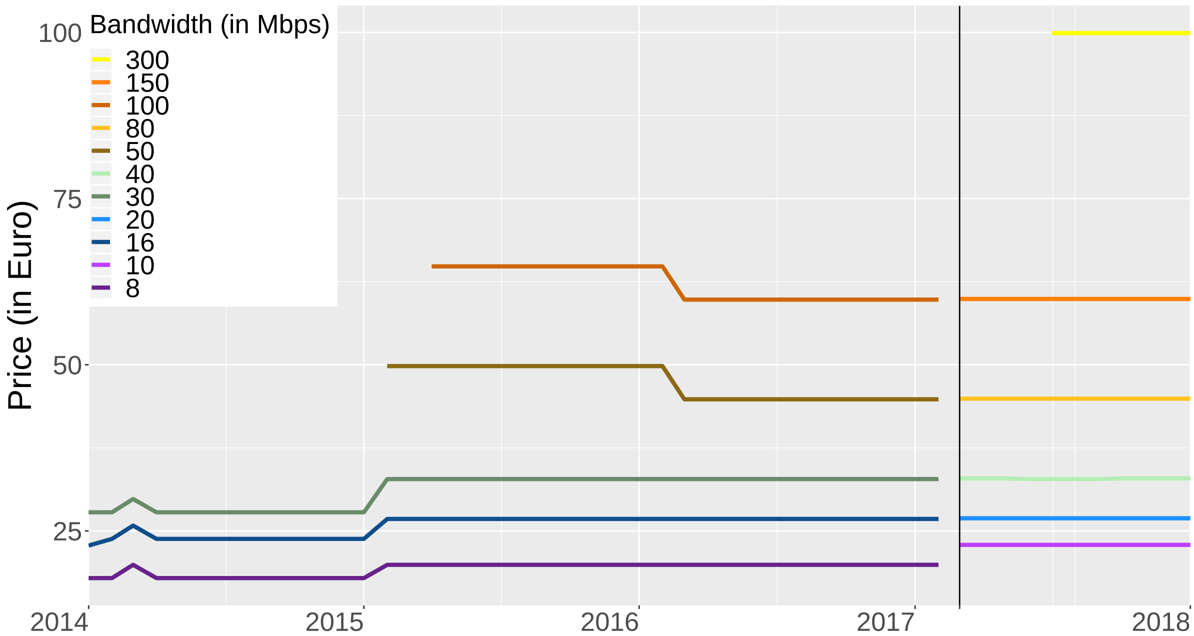
Note: Data from RTR-NetTest from the Austrian Regulatory Authority for Broadcasting and Telecommunications

Figure A.2: Boxplot of speed tests from 2013 to 2016



Note: Data from RTR-NetTest from the Austrian Regulatory Authority for Broadcasting and Telecommunications

Figure A.3: A1 Telekom contracts (download speed and prices from 2014 to 2017)

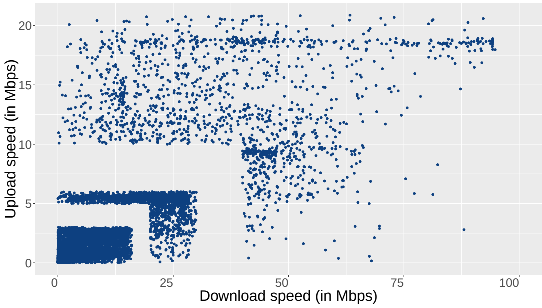


Note: Data from *AK-Tarifwegweiser*

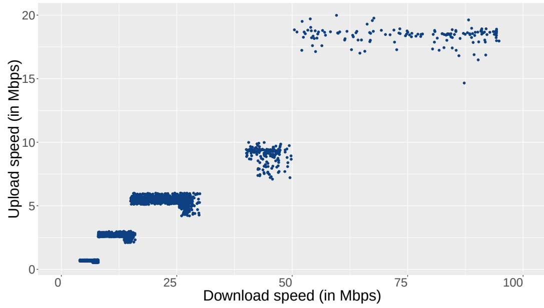
Figure A.4: Measured download speed for tests with fixed-line and mobile providers

A1

(a) Whole sample

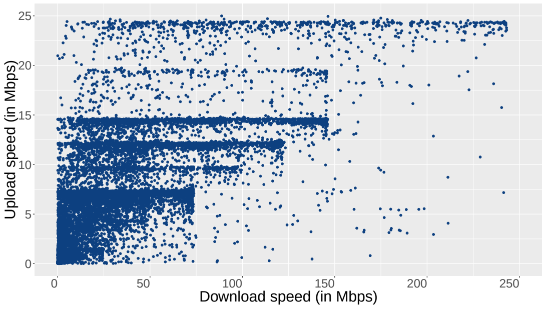


(b) Reduced sample

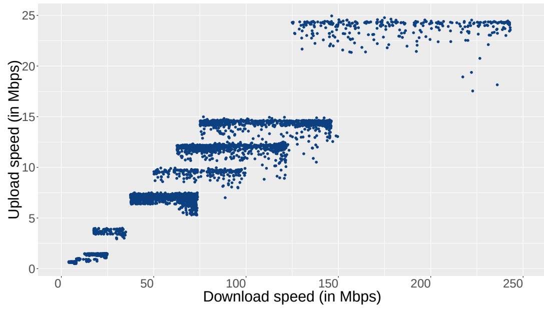


UPC

(c) Whole sample

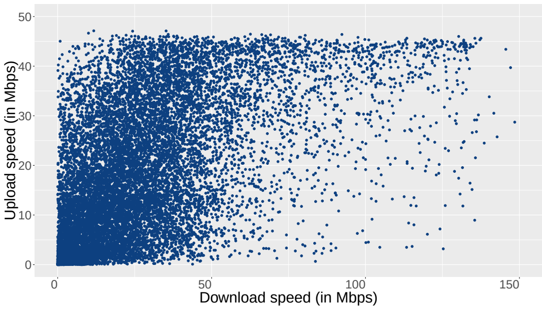


(d) Reduced sample

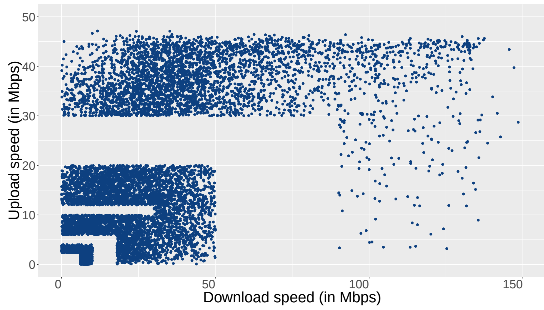


Drei

(e) Whole sample

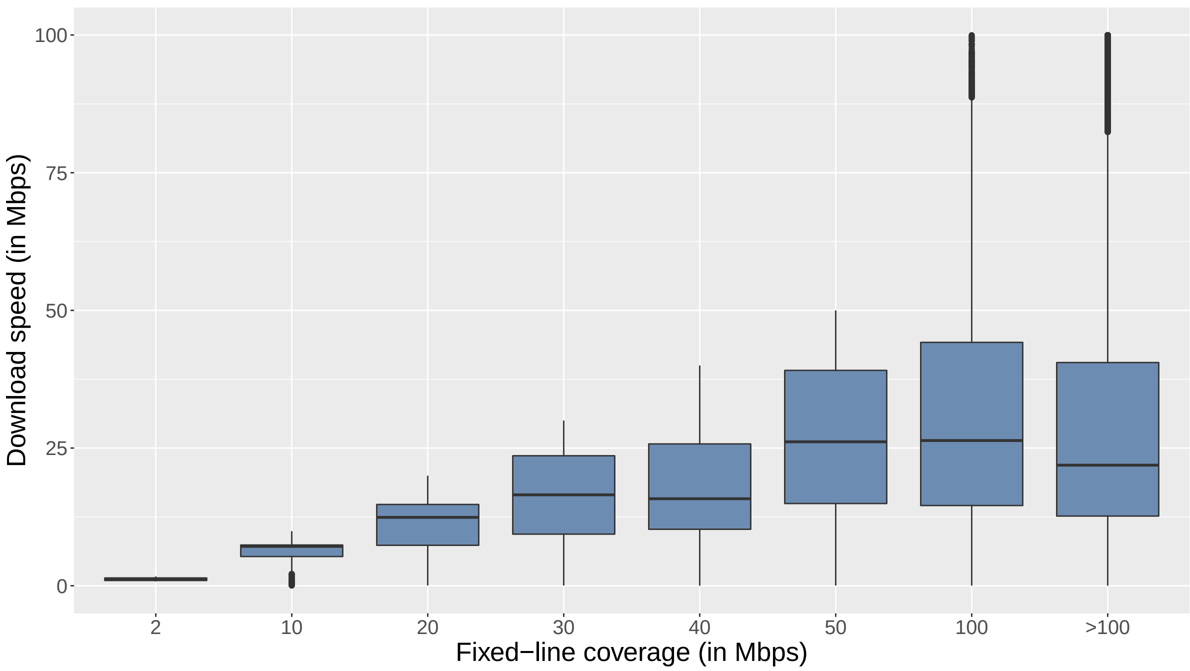


(f) Reduced sample



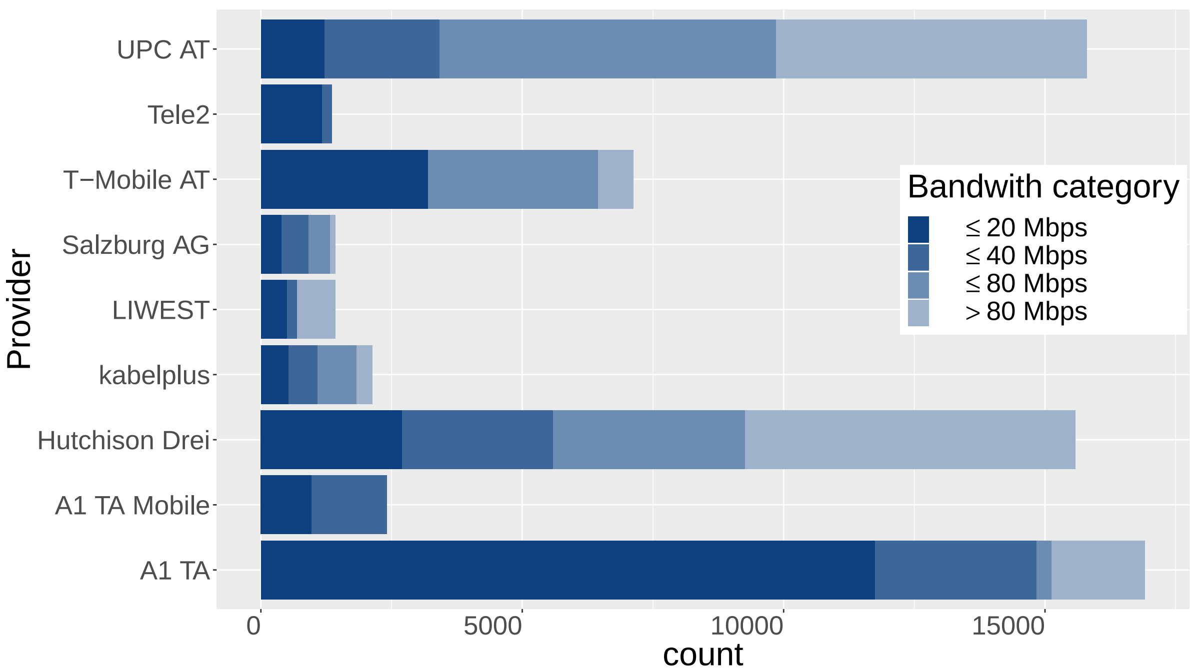
Note: The figures plot the tests for the most important providers for copper, cable, and mobile Internet. In the left column, the whole sample is shown. In the right column, on the tests close to a known contract are shown (reduced sample). This column illustrates the corridors when filtering the noise. Data from RTR-NetTest from the Austrian Regulatory Authority for Broadcasting and Telecommunications.

Figure A.5: Distribution of download speed by fixed-line coverage



Note: Data from RTR-NetTest from the Austrian Regulatory Authority for Broadcasting and Telecommunications and *Broadband Atlas* provided by the Ministry for Transport, Innovation and Technology (bmvit)

Figure A.6: Number of tests for each provider, classified into four bandwidths alternatives



Note: Data from RTR-NetTest from the Austrian Regulatory Authority for Broadcasting and Telecommunications

Table A.1: Broadband coverage in Austria, overall and for rural areas, for 2012 and 2017, compared to EU 28 (different technologies and different bandwidths in the columns)

	NGA	VDSL	FTTP	DOCSIS 3.0	>30 Mbps	>100 Mbps
Austria (2012): total	69.5%	50.5%	6.3%	35.3%	-	-
Austria (2012): rural	14.4%	0.0%	1.2%	13.4%	-	-
Austria (2017): total	90.0%	82.2%	13.5%	52.8%	81.1%	57.2%
Austria (2017): rural	45.0%	22.1%	5.4%	20.5%	-	-
EU 28 (2017): total	80.1%	53.4%	26.8%	44.7%	79.0%	50.8%
EU 28 (2017): rural	46.9%	32.5%	11.3%	10.8%	-	-

Note: Data from the Europe's Digital Progress (Country) Report

Table A.2: Contractual prices (in Euros) by provider and contractual download (in Mbps)

	8	10	15	16	20	25	30	35	40	50	70	75	100	125	150	250
A1 TA	19.90			26.80			32.80			44.80			59.80			
Tele2	17.80				24.90		29.90									
UPC AT	24.90			31.80	24.90	26.15		29.90				29.90	29.90	39.90	39.90	58.03
Hutchison Drei		18.00					25.00			35.00					45.00	
Salzburg AG			19.90				29.00			39.00	49.00				79.00	
kabelplus				19.90			29.90					39.90			69.90	99.90
A1 TA Mobile					26.33				39.90							
LIWEST					19.90			29.90					39.90		59.90	
T-Mobile AT					19.99					29.99					49.99	

Note: Data from *AK-Tarifwegweiser*

Table A.3: Contractual upload (in Mbps) by provider and contractual download (in Mbps)

	8	10	15	16	20	25	30	35	40	50	70	75	100	125	150	250
A1 TA	0.75			3.00			6.00			10.00			20.00			
Tele2	0.75				4.00		4.00									
UPC AT	0.70			1.00	1.00	1.50		4.00				7.50	10.00	12.50	15.00	25.00
Hutchison Drei		4.00					10.00			20.00					50.00	
Salzburg AG			1.50				3.00			5.00	7.00				10.00	
kabelplus				1.00			3.00					7.50			15.00	25.00
A1 TA Mobile					5.00				10.00							
LIWEST					3.00			6.00					10.00		20.00	
T-Mobile AT					5.00					10.00					30.00	

Note: Data from *AK-Tarifwegweiser*, complemented with upload information from the providers' websites

Table A.4: Number of choices (in the whole sample)

	alternative							
	≤ 20 Mbps	≤ 40 Mbps	≤ 80 Mbps	> 80 Mbps	mobile ≤ 20 Mbps	mobile ≤ 80 Mbps	mobile > 80 Mbps	Total
A1 TA	34987	8646	833	4791	3182	4642	0	57081
Hutchison Drei	0	0	0	0	7003	19681	15332	42016
LIWEST	653	210	0	754	0	0	0	1617
Salzburg AG	414	538	419	117	0	0	0	1488
T-Mobile AT	0	0	0	0	8623	8317	1701	18641
Tele2	1991	560	0	0	0	0	0	2551
UPC AT	2474	2725	7486	6547	0	0	0	19232
kabelplus	659	862	975	461	0	0	0	2957
Total	41178	13541	9713	12670	18808	32640	17033	145583

Note: This table shows how the choices distribute between alternatives and choices. The numbers are shown for the whole set.

Table A.5: Number of choices (in the reduced sample)

	alternative							
	≤ 20 Mbps	≤ 40 Mbps	≤ 80 Mbps	> 80 Mbps	mobile ≤ 20 Mbps	mobile ≤ 80 Mbps	mobile > 80 Mbps	Total
A1 TA	11619	5849	641	1699	4897	5214	0	29919
Hutchison Drei	0	0	0	0	3276	14416	8109	25801
LIWEST	123	93	0	88	0	0	0	304
Salzburg AG	167	322	195	64	0	0	0	748
T-Mobile AT	0	0	0	0	5046	7130	799	12975
Tele2	531	518	0	0	0	0	0	1049
UPC AT	450	883	3005	2404	0	0	0	6742
kabelplus	365	355	324	82	0	0	0	1126
Total	13255	8020	4165	4337	13219	26760	8908	78664

Note: This table shows how the choices distribute between alternatives and choices. The numbers are shown for the reduced set.

Table A.6: Number of choices (with full fixed-line coverage in 2015)

	alternative							
	≤ 20 Mbps	≤ 40 Mbps	≤ 80 Mbps	> 80 Mbps	mobile ≤ 20 Mbps	mobile ≤ 80 Mbps	mobile > 80 Mbps	Total
A1 TA	4336	2143	201	692	1596	1630	0	10598
Hutchison Drei	0	0	0	0	1257	4832	3627	9716
LIWEST	119	86	0	85	0	0	0	290
Salzburg AG	161	318	193	54	0	0	0	726
T-Mobile AT	0	0	0	0	1789	2804	343	4936
Tele2	341	159	0	0	0	0	0	500
UPC AT	230	734	2596	2222	0	0	0	5782
kabelplus	317	292	280	65	0	0	0	954
Total	5504	3732	3270	3118	4642	9266	3970	33502

Note: This table shows how the choices distribute between alternatives and choices. The numbers are shown for the reduced set, restricted to full fixed-line coverage in 2015.

Table A.7: Summary of control variables with respect to full fixed-line coverage in 2015

coverage	<100 Mbps	≥ 100 Mbps
population (<5000)	0.56	0.17
population (<10000)	0.15	0.13
population (<100.000)	0.25	0.54
population (>100.000)	0.29	0.71
age (young)	0.20	0.19
age (middle)	0.49	0.51
age (old)	0.31	0.30
male	0.49	0.48
newborns	0.88	0.78
education (low)	0.23	0.23
education (middle)	0.52	0.49
education (high)	0.09	0.12

Note: This table shows how observations with and without full fixed-line coverage in 2015 differ. Number are calculated from the whole sample. Population is divided into the following categories: less than 5000, less than 10.000, less than 100.000, at least 100.000 in 2014. Comparison is also provided for the number of newborns, the share of males, education level (compulsory, secondary and tertiary) and age distribution (young is defined as not older than 20 and old is defined as at least 60 years old).

Table A.8: Own- and cross-price elasticities (whole sample)

	≤ 20 Mbps	≤ 40 Mbps	≤ 80 Mbps	> 80 Mbps	mobile ≤ 20 Mbps	mobile ≤ 80 Mbps	mobile > 80 Mbps
≤ 20 Mbps	-2.559	.755	.876	1.299	.258	.524	.203
≤ 40 Mbps	1.347	-4.425	1.04	1.353	.264	.54	.241
≤ 80 Mbps	1.117	.734	-5.031	1.603	.239	.467	.227
> 80 Mbps	1.092	.636	1.081	-6.205	.225	.469	.245
mobile ≤ 20 Mbps	1.12	.632	.809	1.126	-3.358	.869	.852
mobile ≤ 80 Mbps	.832	.479	.591	.886	.319	-4.259	1.553
mobile > 80 Mbps	.307	.204	.275	.437	.302	1.498	-4.547

Note: The own- and cross-price elasticities are simulated 100 times with the regression coefficients of the whole sample (Table 1, first column).

Table A.9: Own- and cross-price elasticities of the reduced sample with more control variables on municipality level

	≤ 20 Mbps	≤ 40 Mbps	≤ 80 Mbps	> 80 Mbps	mobile ≤ 20 Mbps	mobile ≤ 80 Mbps	mobile > 80 Mbps
≤ 20 Mbps	-3.005	1.2	.946	1.19	.286	.704	.093
≤ 40 Mbps	1.318	-4.533	1.019	1.177	.31	.805	.189
≤ 80 Mbps	1.052	1.012	-5.527	1.652	.262	.659	.176
> 80 Mbps	.97	.866	1.238	-6.987	.249	.697	.204
mobile ≤ 20 Mbps	1.032	1.004	.848	1.079	-3.701	1.208	.748
mobile ≤ 80 Mbps	.664	.692	.574	.823	.317	-4.216	1.57
mobile > 80 Mbps	.109	.202	.191	.29	.25	1.991	-4.459

Note: The own- and cross-price elasticities are simulated 100 times with the regression coefficients of the reduced sample and with some control variables on the zip code level (Table 1, third column).

Table A.10: Own- and cross-price elasticities (control variables on zip code level)

	≤ 20 Mbps	≤ 40 Mbps	≤ 80 Mbps	> 80 Mbps	mobile ≤ 20 Mbps	mobile ≤ 80 Mbps	mobile > 80 Mbps
≤ 20 Mbps	-3.011	1.2	.936	1.195	.288	.711	.093
≤ 40 Mbps	1.321	-4.553	1.03	1.181	.311	.808	.189
≤ 80 Mbps	1.046	1.025	-5.52	1.638	.261	.657	.177
> 80 Mbps	.977	.868	1.221	-6.994	.253	.704	.201
mobile ≤ 20 Mbps	1.041	1.009	.845	1.095	-3.721	1.215	.748
mobile ≤ 80 Mbps	.672	.695	.571	.833	.318	-4.242	1.577
mobile > 80 Mbps	.11	.202	.191	.286	.25	1.996	-4.465

Note: The own- and cross-price elasticities are simulated 100 times with the regression coefficients of the reduced sample and with the complete set of control variables on the zip code level (Table 1, fourth column).

Table A.11: Own- and cross-price elasticities (unweighted mean prices)

	≤ 20 Mbps	≤ 40 Mbps	≤ 80 Mbps	> 80 Mbps	mobile ≤ 20 Mbps	mobile ≤ 80 Mbps	mobile > 80 Mbps
≤ 20 Mbps	-3.182	1.297	.946	1.256	.309	.751	.101
≤ 40 Mbps	1.418	-4.87	1.022	1.326	.34	.866	.216
≤ 80 Mbps	1.097	1.071	-5.804	1.79	.267	.689	.181
> 80 Mbps	1.045	1.001	1.26	-7.575	.272	.762	.243
mobile ≤ 20 Mbps	1.125	1.117	.834	1.167	-3.985	1.275	.847
mobile ≤ 80 Mbps	.727	.767	.588	.898	.339	-4.583	1.711
mobile > 80 Mbps	.118	.23	.185	.334	.279	2.103	-4.785

Note: The own- and cross-price elasticities are simulated 100 times with the regression coefficients of the reduced sample which was estimated with unweighted mean prices.

Table A.12: Own- and cross-price elasticities (no weights)

	≤ 20 Mbps	≤ 40 Mbps	≤ 80 Mbps	> 80 Mbps	mobile ≤ 20 Mbps	mobile ≤ 80 Mbps	mobile > 80 Mbps
≤ 20 Mbps	-2.467	.722	.598	.724	.468	.874	.023
≤ 40 Mbps	.829	-3.68	.641	.759	.495	.974	.047
≤ 80 Mbps	.659	.601	-4.397	1.149	.435	.828	.051
> 80 Mbps	.594	.536	.877	-5.66	.42	.888	.096
mobile ≤ 20 Mbps	.618	.564	.524	.668	-2.556	1.321	.309
mobile ≤ 80 Mbps	.382	.371	.337	.482	.437	-2.907	1.019
mobile > 80 Mbps	.016	.028	.033	.081	.165	1.641	-2.917

Note: The own- and cross-price elasticities are simulated 100 times with the regression coefficients of the reduced sample which was estimated with no weights.

Table A.13: Own- and cross-price elasticities (control for incumbent choice)

	≤ 20 Mbps	≤ 40 Mbps	≤ 80 Mbps	> 80 Mbps	mobile ≤ 20 Mbps	mobile ≤ 80 Mbps	mobile > 80 Mbps
≤ 20 Mbps	-2.594	1.59	.404	1.065	.275	.423	.04
≤ 40 Mbps	2.158	-5.885	.879	1.688	.387	.884	.166
≤ 80 Mbps	.492	.778	-6.525	3.609	.353	1.04	.319
> 80 Mbps	.599	.7	1.708	-8.364	.335	1.293	.396
mobile ≤ 20 Mbps	1.055	1.052	1.057	2.086	-4.611	1.621	1.041
mobile ≤ 80 Mbps	.365	.579	.777	2.086	.386	-5.06	2.036
mobile > 80 Mbps	.044	.134	.287	.755	.318	2.519	-5.694

Note: The own- and cross-price elasticities are simulated 100 times with the regression coefficients of the reduced sample and with a control variable if a tester had a A1 Telekom contract.

Table A.14: Own- and cross-price elasticities (random sample split in halves)

	≤ 20 Mbps	≤ 40 Mbps	≤ 80 Mbps	> 80 Mbps	mobile ≤ 20 Mbps	mobile ≤ 80 Mbps	mobile > 80 Mbps
≤ 20 Mbps	-2.978	1.198	.941	1.194	.283	.678	.09
≤ 40 Mbps	1.338	-4.537	1.017	1.197	.309	.777	.187
≤ 80 Mbps	1.049	.995	-5.584	1.71	.263	.659	.187
> 80 Mbps	1	.888	1.311	-7.154	.251	.696	.219
mobile ≤ 20 Mbps	1.025	.99	.853	1.061	-3.691	1.184	.793
mobile ≤ 80 Mbps	.664	.68	.589	.824	.32	-4.269	1.635
mobile > 80 Mbps	.106	.196	.2	.302	.262	1.981	-4.486

Note: The own- and cross-price elasticities are simulated 100 times with the regression coefficients of the reduced sample which was estimated with a random subset of only half of the observations.

Table A.15: Own- and cross-price elasticities (other half of the random subset)

	≤ 20 Mbps	≤ 40 Mbps	≤ 80 Mbps	> 80 Mbps	mobile ≤ 20 Mbps	mobile ≤ 80 Mbps	mobile > 80 Mbps
≤ 20 Mbps	-3.003	1.209	.921	1.18	.283	.718	.093
≤ 40 Mbps	1.314	-4.564	.974	1.212	.312	.843	.194
≤ 80 Mbps	1.027	.981	-5.536	1.781	.258	.661	.17
> 80 Mbps	.941	.881	1.308	-7.072	.249	.726	.232
mobile ≤ 20 Mbps	1.025	1.028	.831	1.094	-3.702	1.208	.729
mobile ≤ 80 Mbps	.669	.724	.566	.857	.31	-4.239	1.524
mobile > 80 Mbps	.113	.219	.192	.348	.251	2.045	-4.625

Note: The own- and cross-price elasticities are simulated 100 times with the regression coefficients of the reduced sample which was estimated with the other half of the random subset.

Table A.16: Own- and cross-price elasticities (five percent random subset)

	≤ 20 Mbps	≤ 40 Mbps	≤ 80 Mbps	> 80 Mbps	mobile ≤ 20 Mbps	mobile ≤ 80 Mbps	mobile > 80 Mbps
≤ 20 Mbps	-2.792	1.081	.835	1.246	.241	.628	.097
≤ 40 Mbps	1.062	-3.971	.893	1.076	.263	.779	.233
≤ 80 Mbps	.945	1.002	-5.102	1.631	.229	.573	.097
> 80 Mbps	.912	.787	1.074	-6.021	.19	.563	.131
mobile ≤ 20 Mbps	.907	.988	.75	.974	-3.312	1.047	.573
mobile ≤ 80 Mbps	.605	.766	.502	.759	.269	-3.853	1.315
mobile > 80 Mbps	.123	.301	.112	.222	.196	1.77	-4.033

Note: The own- and cross-price elasticities are simulated 100 times with the regression coefficients of the reduced sample which was estimated with a random subset that only contains five percent of the original observations.

Table A.17: Own- and cross-price elasticities (at least 10 tests per municipality)

	≤ 20 Mbps	≤ 40 Mbps	≤ 80 Mbps	> 80 Mbps	mobile ≤ 20 Mbps	mobile ≤ 80 Mbps	mobile > 80 Mbps
≤ 20 Mbps	-3.075	1.224	.966	1.237	.28	.714	.095
≤ 40 Mbps	1.318	-4.588	1.016	1.243	.308	.823	.194
≤ 80 Mbps	1.037	.994	-5.607	1.788	.259	.672	.186
> 80 Mbps	.971	.897	1.338	-7.155	.25	.715	.231
mobile ≤ 20 Mbps	1.012	1.019	.869	1.12	-3.747	1.218	.775
mobile ≤ 80 Mbps	.665	.712	.597	.858	.314	-4.288	1.574
mobile > 80 Mbps	.113	.215	.213	.345	.262	2.053	-4.685

Note: The own- and cross-price elasticities are simulated 100 times with the regression coefficients of the reduced sample which was estimated with a subset containing only municipalities were at least 10 tests were performed.

Table A.18: Own- and cross-price elasticities (at least 20 tests per municipality)

	≤ 20 Mbps	≤ 40 Mbps	≤ 80 Mbps	> 80 Mbps	mobile ≤ 20 Mbps	mobile ≤ 80 Mbps	mobile > 80 Mbps
≤ 20 Mbps	-3.184	1.246	1.023	1.287	.286	.724	.104
≤ 40 Mbps	1.314	-4.69	1.064	1.291	.314	.841	.212
≤ 80 Mbps	1.04	1.009	-5.68	1.83	.263	.681	.197
> 80 Mbps	.969	.913	1.382	-7.214	.253	.714	.239
mobile ≤ 20 Mbps	1.017	1.044	.917	1.165	-3.825	1.224	.782
mobile ≤ 80 Mbps	.67	.739	.635	.892	.319	-4.394	1.584
mobile > 80 Mbps	.124	.238	.238	.372	.268	2.069	-4.841

Note: The own- and cross-price elasticities are simulated 100 times with the regression coefficients of the reduced sample which was estimated with a subset containing only municipalities were at least 20 tests were performed.

Table A.19: Own- and cross-price elasticities (at least 50 tests per municipality)

	≤ 20 Mbps	≤ 40 Mbps	≤ 80 Mbps	> 80 Mbps	mobile ≤ 20 Mbps	mobile ≤ 80 Mbps	mobile > 80 Mbps
≤ 20 Mbps	-3.34	1.252	1.099	1.431	.287	.719	.119
≤ 40 Mbps	1.284	-4.772	1.13	1.414	.315	.82	.23
≤ 80 Mbps	1.014	1	-5.682	1.94	.259	.674	.218
> 80 Mbps	.963	.919	1.44	-7.205	.252	.695	.255
mobile ≤ 20 Mbps	1.003	1.062	.976	1.28	-3.919	1.204	.816
mobile ≤ 80 Mbps	.687	.764	.715	1.001	.33	-4.585	1.546
mobile > 80 Mbps	.146	.273	.296	.458	.292	2.007	-5.068

Note: The own- and cross-price elasticities are simulated 100 times with the regression coefficients of the reduced sample which was estimated with a subset containing only municipalities were at least 50 tests were performed.

Table A.20: Own- and cross-price elasticities (less than 1000 tests per municipality)

	≤ 20 Mbps	≤ 40 Mbps	≤ 80 Mbps	> 80 Mbps	mobile ≤ 20 Mbps	mobile ≤ 80 Mbps	mobile > 80 Mbps
≤ 20 Mbps	-3.073	1.249	1.031	1.152	.282	.733	.069
≤ 40 Mbps	1.359	-4.767	1.137	1.192	.316	.871	.188
≤ 80 Mbps	1.077	1.069	-5.716	1.671	.263	.699	.166
> 80 Mbps	1.051	.99	1.504	-7.571	.244	.677	.12
mobile ≤ 20 Mbps	1.049	1.067	.939	.974	-3.88	1.311	.834
mobile ≤ 80 Mbps	.676	.738	.631	.695	.324	-4.358	1.711
mobile > 80 Mbps	.075	.191	.18	.143	.254	2.089	-4.372

Note: The own- and cross-price elasticities are simulated 100 times with the regression coefficients of the reduced sample which was estimated with a subset containing only municipalities were less than 1000 tests were performed.

Table A.21: Own- and cross-price elasticities (less than 1500 tests per municipality)

	≤ 20 Mbps	≤ 40 Mbps	≤ 80 Mbps	> 80 Mbps	mobile ≤ 20 Mbps	mobile ≤ 80 Mbps	mobile > 80 Mbps
≤ 20 Mbps	-2.853	1.162	.895	1.151	.26	.666	.076
≤ 40 Mbps	1.272	-4.362	.96	1.168	.286	.783	.181
≤ 80 Mbps	.979	.941	-5.335	1.714	.237	.642	.18
> 80 Mbps	.917	.841	1.279	-6.812	.227	.68	.222
mobile ≤ 20 Mbps	.974	.968	.812	1.044	-3.564	1.167	.742
mobile ≤ 80 Mbps	.63	.676	.565	.814	.294	-4.089	1.539
mobile > 80 Mbps	.088	.193	.197	.319	.237	1.932	-4.322

Note: The own- and cross-price elasticities are simulated 100 times with the regression coefficients of the reduced sample which was estimated with a subset containing only municipalities were less than 1500 tests were performed.

Table A.22: Own- and cross-price elasticities of the reduced sample for Vienna

	≤ 20 Mbps	≤ 40 Mbps	≤ 80 Mbps	> 80 Mbps	mobile ≤ 20 Mbps	mobile ≤ 80 Mbps	mobile > 80 Mbps
≤ 20 Mbps	-3.796	1.037	1.786	1.974	.223	.565	.117
≤ 40 Mbps	1.054	-5.291	1.847	2.003	.252	.692	.272
≤ 80 Mbps	.887	.89	-5.468	2.364	.229	.576	.246
> 80 Mbps	.747	.74	1.829	-6.449	.203	.532	.287
mobile ≤ 20 Mbps	.83	.916	1.728	1.979	-4.257	.953	.688
mobile ≤ 80 Mbps	.601	.724	1.273	1.524	.271	-5.048	1.289
mobile > 80 Mbps	.18	.414	.805	1.178	.289	1.89	-6.568

Note: The own- and cross-price elasticities are simulated 100 times with the regression coefficients of the reduced sample which was estimated with a subset containing only tests from Vienna.

Table A.23: Own- and cross-price elasticities of the reduced sample for all locations but Vienna

	≤ 20 Mbps	≤ 40 Mbps	≤ 80 Mbps	> 80 Mbps	mobile ≤ 20 Mbps	mobile ≤ 80 Mbps	mobile > 80 Mbps
≤ 20 Mbps	-2.535	1.16	.634	.876	.276	.677	.07
≤ 40 Mbps	1.312	-3.939	.665	.839	.302	.778	.126
≤ 80 Mbps	1.244	1.136	-5.659	.938	.291	.735	.089
> 80 Mbps	1.226	1.038	.68	-7.662	.308	.876	.1
mobile ≤ 20 Mbps	.983	.934	.52	.749	-3.222	1.19	.699
mobile ≤ 80 Mbps	.615	.623	.344	.565	.304	-3.66	1.531
mobile > 80 Mbps	.077	.124	.051	.078	.224	1.909	-3.717

Note: The own- and cross-price elasticities are simulated 100 times with the regression coefficients of the reduced sample which was estimated with a subset containing only outside Vienna.

Table A.24: Own- and cross-price elasticities of the reduced sample for all of the cities (Graz, Linz, Salzburg, Innsbruck)

	≤ 20 Mbps	≤ 40 Mbps	≤ 80 Mbps	> 80 Mbps	mobile ≤ 20 Mbps	mobile ≤ 80 Mbps	mobile > 80 Mbps
≤ 20 Mbps	-2.758	1.206	.419	1.1	.326	.703	.18
≤ 40 Mbps	1.242	-3.88	.461	1.071	.353	.703	.18
≤ 80 Mbps	.981	1.043	-5.506	1.691	.364	.519	.078
> 80 Mbps	1.015	.96	.66	-6.394	.36	.656	.129
mobile ≤ 20 Mbps	.904	.937	.427	1.064	-3.134	1.052	.711
mobile ≤ 80 Mbps	.7	.682	.228	.736	.381	-3.814	1.258
mobile > 80 Mbps	.272	.263	.052	.212	.401	1.933	-4.89

Note: The own- and cross-price elasticities are simulated 100 times with the regression coefficients of the reduced sample which was estimated with a subset containing only tests from Graz, Linz, Salzburg, and Innsbruck.

Table A.25: Own- and cross-price elasticities of the reduced sample for remaining locations (without Vienna, Graz, Linz, Salzburg, and Innsbruck)

	≤ 20 Mbps	≤ 40 Mbps	≤ 80 Mbps	> 80 Mbps	mobile ≤ 20 Mbps	mobile ≤ 80 Mbps	mobile > 80 Mbps
≤ 20 Mbps	-2.524	1.184	.692	.773	.268	.712	.047
≤ 40 Mbps	1.386	-4.081	.745	.76	.298	.837	.099
≤ 80 Mbps	1.319	1.195	-5.857	.818	.28	.817	.081
> 80 Mbps	1.333	1.12	.753	-8.295	.291	.903	.054
mobile ≤ 20 Mbps	1.036	.971	.565	.629	-3.357	1.33	.684
mobile ≤ 80 Mbps	.627	.628	.38	.452	.301	-3.676	1.597
mobile > 80 Mbps	.048	.087	.043	.031	.185	1.899	-3.447

Note: The own- and cross-price elasticities are simulated 100 times with the regression coefficients of the reduced sample which was estimated with a subset containing only tests outside Vienna, Graz, Linz, Salzburg, and Innsbruck.

Table A.26: Own- and cross-price elasticities of the reduced sample for April and May

	≤ 20 Mbps	≤ 40 Mbps	≤ 80 Mbps	> 80 Mbps	mobile ≤ 20 Mbps	mobile ≤ 80 Mbps	mobile > 80 Mbps
≤ 20 Mbps	-2.912	1.092	.961	1.287	.275	.621	.127
≤ 40 Mbps	1.348	-4.426	.986	1.236	.307	.669	.173
≤ 80 Mbps	1.056	.853	-5.292	1.695	.275	.598	.152
> 80 Mbps	1.077	.83	1.339	-7.502	.257	.719	.253
mobile ≤ 20 Mbps	1.003	.895	.928	1.088	-3.57	1.077	.821
mobile ≤ 80 Mbps	.638	.554	.576	.873	.303	-4.247	1.859
mobile > 80 Mbps	.127	.139	.142	.29	.23	1.844	-4.071

Note: The own- and cross-price elasticities are simulated 100 times with the regression coefficients of the reduced sample which was estimated with a subset containing tests from April and May.

Table A.27: Own- and cross-price elasticities of the reduced sample for June and July

	≤ 20 Mbps	≤ 40 Mbps	≤ 80 Mbps	> 80 Mbps	mobile ≤ 20 Mbps	mobile ≤ 80 Mbps	mobile > 80 Mbps
≤ 20 Mbps	-3.465	1.476	1.13	1.334	.307	.769	.068
≤ 40 Mbps	1.535	-5.354	1.156	1.358	.384	1.013	.219
≤ 80 Mbps	1.214	1.174	-6.499	2.124	.281	.737	.191
> 80 Mbps	1.093	1.053	1.628	-8.549	.279	.896	.332
mobile ≤ 20 Mbps	1.184	1.402	.996	1.265	-4.452	1.371	.869
mobile ≤ 80 Mbps	.75	.953	.684	1.09	.35	-5.058	1.779
mobile > 80 Mbps	.078	.243	.208	.462	.269	2.128	-4.903

Note: The own- and cross-price elasticities are simulated 100 times with the regression coefficients of the reduced sample which was estimated with a subset containing tests from June and July.

Table A.28: Own- and cross-price elasticities of the reduced sample for August and September

	≤ 20 Mbps	≤ 40 Mbps	≤ 80 Mbps	> 80 Mbps	mobile ≤ 20 Mbps	mobile ≤ 80 Mbps	mobile > 80 Mbps
≤ 20 Mbps	-3.088	1.318	.935	1.079	.292	.73	.103
≤ 40 Mbps	1.48	-4.736	1.001	1.061	.312	.857	.211
≤ 80 Mbps	1.179	1.092	-5.879	1.738	.257	.668	.15
> 80 Mbps	1.102	.953	1.454	-7.44	.249	.675	.154
mobile ≤ 20 Mbps	1.197	1.12	.836	.969	-3.947	1.284	.763
mobile ≤ 80 Mbps	.783	.814	.582	.717	.335	-4.416	1.488
mobile > 80 Mbps	.16	.293	.193	.233	.298	2.215	-5.1

Note: The own- and cross-price elasticities are simulated 100 times with the regression coefficients of the reduced sample which was estimated with a subset containing tests from August and September.

Table A.29: Own- and cross-price elasticities of the reduced sample for October and November

	≤ 20 Mbps	≤ 40 Mbps	≤ 80 Mbps	> 80 Mbps	mobile ≤ 20 Mbps	mobile ≤ 80 Mbps	mobile > 80 Mbps
≤ 20 Mbps	-2.683	1.025	.797	1.105	.268	.68	.079
≤ 40 Mbps	1.074	-3.99	.875	1.169	.274	.747	.17
≤ 80 Mbps	.836	.862	-4.944	1.584	.243	.638	.198
> 80 Mbps	.766	.767	1.068	-5.93	.227	.623	.195
mobile ≤ 20 Mbps	.835	.807	.719	1.006	-3.168	1.11	.631
mobile ≤ 80 Mbps	.562	.586	.51	.753	.293	-3.683	1.333
mobile > 80 Mbps	.086	.177	.21	.304	.225	1.795	-4.064

Note: The own- and cross-price elasticities are simulated 100 times with the regression coefficients of the reduced sample which was estimated with a subset containing tests from October and November.

Table A.30: Heterogeneous effects across covariates

	fixed-line			mobile		
alternative	≤ 40 $Mbps$	≤ 80 $Mbps$	>80 Mbpps	≤ 20 $Mbps$	≤ 80 $Mbps$	>80 Mbpps
mobile upload	0.0452***	0.0503***	0.0684***	0.0782***	0.141***	0.294***
	(0.000549)	(0.000597)	(0.000652)	(0.000511)	(0.000539)	(0.000924)
first zip code digit=2	-0.190***	-0.513***	-2.118***	-0.862***	-0.846***	-0.0579
	(0.0137)	(0.0171)	(0.0264)	(0.0201)	(0.0172)	(0.0331)
first zip code digit=3	-0.174***	-1.856***	-3.955***	-0.865***	-1.376***	-0.762***
	(0.0156)	(0.0216)	(0.0293)	(0.0225)	(0.0201)	(0.0421)
first zip code digit=4	-0.298***	-2.730***	-1.765***	-0.571***	-0.708***	-0.193***
	(0.0150)	(0.0255)	(0.0316)	(0.0199)	(0.0174)	(0.0386)
first zip code digit=5	0.562***	-1.348***	-3.814***	0.281***	-0.341***	-0.228***
	(0.0147)	(0.0179)	(0.0258)	(0.0186)	(0.0172)	(0.0395)
first zip code digit=6	0.128***	-1.056***	-0.865***	-0.0476*	-0.0757***	0.169***
	(0.0153)	(0.0208)	(0.0259)	(0.0195)	(0.0173)	(0.0395)
first zip code digit=7	-0.863***	-2.455***	-5.250***	-0.696***	-1.304***	-1.594***
	(0.0218)	(0.0313)	(0.0547)	(0.0288)	(0.0253)	(0.0564)
first zip code digit=8	-0.380***	-2.253***	-2.292***	-0.191***	-0.755***	-0.453***
	(0.0164)	(0.0200)	(0.0289)	(0.0208)	(0.0191)	(0.0414)
first zip code digit=9	0.602***	-0.207***	-0.0323	-0.0314	0.483***	1.772***
	(0.0219)	(0.0244)	(0.0359)	(0.0316)	(0.0250)	(0.0572)
wireless LAN	0.0325***	0.0547***	-0.0516***	-0.695***	-0.632***	-0.0803***
	(0.00706)	(0.00752)	(0.0107)	(0.00867)	(0.00759)	(0.0191)
population=low	-0.0901***	0.137***	-0.848***	-0.120***	-0.0620***	-0.299***
	(0.0110)	(0.0152)	(0.0232)	(0.0147)	(0.0122)	(0.0255)
population=medium	0.381***	-0.0471***	-0.951***	0.0215	0.280***	0.510***
	(0.0106)	(0.0110)	(0.0154)	(0.0137)	(0.0127)	(0.0248)
population=high	-0.420***	-0.211***	0.268***	-0.110***	-0.426***	-1.562***
	(0.0155)	(0.0181)	(0.0240)	(0.0205)	(0.0184)	(0.0378)
newborns	-3.284***	-3.318***	0.767***	0.184	-1.782***	-5.587***
	(0.104)	(0.145)	(0.205)	(0.145)	(0.122)	(0.266)
male	22.67***	31.46***	65.00***	17.63***	21.73***	15.36***
	(0.495)	(0.614)	(0.901)	(0.678)	(0.576)	(1.271)
education=low	2.079**	25.40***	-26.60***	-0.128	5.300***	25.70***
	(0.671)	(0.804)	(1.221)	(0.868)	(0.767)	(1.651)
education=medium	2.340***	23.74***	-11.89***	1.310	6.373***	28.73***
	(0.654)	(0.773)	(1.170)	(0.851)	(0.768)	(1.600)
education=high	6.122***	26.31***	-2.352*	2.203**	6.297***	21.30***
	(0.570)	(0.689)	(1.033)	(0.744)	(0.665)	(1.379)
age=young	1.694***	2.298***	25.41***	2.172***	13.49***	23.26***
	(0.329)	(0.422)	(0.599)	(0.456)	(0.397)	(0.818)
age=old	1.723***	8.540***	-40.45***	-0.0169	4.050***	15.08***
	(0.352)	(0.448)	(0.696)	(0.507)	(0.410)	(0.914)
	(0.700)	(0.838)	(1.288)	(0.924)	(0.787)	(1.711)
Constant	-9.274***	-5.960***	-38.62***	-9.303***	-13.81***	-15.26***
	(0.383)	(0.505)	(0.731)	(0.539)	(0.439)	(0.960)

Standard errors in parentheses
* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Note: The regression shows the results for the reduced sample with four fixed-line and three mobile alternatives. The sample was reduced to test which have had full fixed-line coverage (at least 100 Mbps) in 2015 to make sure that all choices are eligible and that the results are comparable. It was control for whether the device, from which the test was performed, was connected via WLAN or LAN. Furthermore, the first digit of the postal code and the mobile upload coverage from the *Broadband Atlas* were applied as geographic covariates. Moreover, characteristics on zip code level were included. It was controlled for population (less than 10.000, less than 100.000, at least 100.000 in 2014, compared to less than 5.000), number of newborn, share of males, education level (compulsory, secondary and tertiary) and age distribution (young is defined as not older than 20 and old is defined as at least 60 years old).