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The Value of Connectivity: High-Speed Broadband Internet and Real Estate Prices

Abstract

Governments worldwide subsidize rural broadband expansion to address the urban-rural connectivity divide, but the economic benefits and costs remain unclear. This paper examines the causal effect of high-speed Internet on real estate prices and evaluates the fiscal effectiveness of rural broadband subsidies. Using a spatial regression discontinuity design and comprehensive micro-data, our identification strategy exploits variation at state borders from German states' broadband expansion policies. We find that high-speed Internet availability (16 Mbit/s) increases rents by 3.8 percent (\bigcirc 7/month) and sale prices by 8 percent (\bigcirc 4,700) compared to slower access at the discontinuity, with diminishing returns at higher speeds. The capitalization effects are demand-driven, as evidenced by increased broadband uptake, migration, and remote work adoption, while property supply remains unaffected. A cost-benefit analysis within the marginal-value-of-public-funds framework shows the economic surplus exceeds deployment costs for 90 percent of households, while property owners benefit from subsidies through higher property prices.

JEL-Codes: D600, H400, H700, L860, R200.

Keywords: high-speed broadband internet, real estate prices, capitalization effect, policy evaluation, local public finance, spatial RDD, MVPF.

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1 Introduction

The digital transformation of the economy and society reshapes various aspects of our daily lives with a large and expanding impact. The increasing adoption of remote work, virtual education, e-commerce, and growing consumption of online information and entertainment during the Covid-19 pandemic further accelerated digitization. Given the growing importance of the Internet, fast broadband access at home has become essential for households to capture the benefits of the digital transformation. However, around the world, broadband access remains uneven, with a connectivity divide between rural areas lagging behind and urban regions with advanced broadband infrastructure. To address this divide, governments in advanced and emerging economies have introduced ambitious broadband policies, committing substantial public funds to expand high-speed Internet access in underserved rural areas.¹ Despite these policy efforts and an expanding body of literature on the subject, a comprehensive understanding of the economic benefits and costs of high-speed broadband in rural regions remains elusive. While fast Internet access may be particularly valuable to households in underserved rural areas, the high cost of expanding infrastructure raises questions about the optimal design of subsidies aimed at reducing spatial inequalities.²

This paper examines the causal effect of high-speed Internet access on real estate prices and evaluates the fiscal effectiveness of broadband expansion policies in rural areas. To quantify households' economic benefits from fast Internet, we leverage local variation in broadband availability and property prices. Adopting a capitalization approach, we model each house as a composite good, where its value reflects property features, local amenities, and public infrastructure such as wireline broadband access, making this method particularly suited for capturing broadband's economic value.³ Our analysis exploits a quasi-experiment arising from variation in broadband expansion policies across German states between 2010 and 2019. These policies, differing in scope, funding, and governance, targeted rural areas where private broadband deployment is often unprofitable, creating spatial discontinuities in availability along state boundaries. We use a spatial regression discontinuity design (RDD) and a dataset of broadband availability and over 1.1 million real estate listings from more than 4,000 rural municipalities near state borders to estimate the property price effect of fast Internet access. Integrating administrative and micro-census data on Internet usage at home and migration, we uncover the mechanisms

¹For example, the United States has passed the "National Broadband Plan" (Federal Communications Commission, 2010), the European Union has prioritized fast broadband expansion in its "Digital Agenda 2020" (European Commission, 2021), and China has enacted a national "Broadband Strategy" (Liu, 2017).

 $^{^{2}}$ For the literature on optimal spatial policies and geographic redistribution, see Fajgelbaum and Gaubert (2020) and Gaubert (2021).

³Building on the foundational models of Oates (1969), Rosen (1974), Roback (1982), and Sheppard (1999), Ahlfeldt et al. (2017) pioneered the hedonic property price approach to examine the capitalization effects of first-generation broadband expansion in England, finding positive impacts on property values. Unlike their study, we focus on the economic benefits and costs of faster broadband Internet in underserved rural areas.

behind the property price effects. Importantly, we are the first to evaluate the fiscal effectiveness of rural broadband subsidies using detailed information on total investment costs and subsidies from a major German broadband expansion program in 2016 and 2017. We conduct a cost-benefit analysis within the Marginal Value of Public Funds (MVPF) framework of the local public finance literature (Hendren and Sprung-Keyser, 2020; Finkelstein and Hendren, 2020; Hendren et al., 2022).

We identify the causal effect of high-speed Internet access on real estate prices in a spatial RDD by comparing similar properties in rural municipalities located on either side of the broadband discontinuity at state borders – those in policy-induced "high" broadband states (treatment) and those in "low" broadband states (control). The spatial RDD leverages variation from German states' expansion policies and uses a hedonic property price model to isolate the intent-to-treat effect of broadband access on property prices.⁴ The identifying assumption is that municipalities on either side of state boundaries are valid comparison groups conditional on RD polynomials (distance to boundary as well as longitude and latitude) and boundary-segment-by-year fixed effects to account for spatial and temporal variation. We further control for differential municipality- and state-level characteristics within boundary segments (e.g., tax rates, income, and school quality) and individual property attributes (e.g., property type, size and condition) to isolate the impact of broadband access. Our empirical strategy addresses two key endogeneity concerns: the non-random spatial distribution of broadband access, which may correlate with housing prices, and the challenge of isolating broadband's effect from other property or locational attributes. By controlling for these factors, we ensure that the estimated property price effects are plausibly attributed to differences in local broadband availability. We validate our approach by demonstrating a strong discontinuity in municipal broadband availability at "high" and "low" broadband state borders, while the covariates, such as local, state, and property characteristics, are balanced with minimal discontinuities.

Our main finding is that fast Internet access increases rural real estate prices by about 3.8 percent for rents and 8 percent for sale prices. These estimates translate to a monthly rent increase of approximately \notin 17 and a property sale price increase of \notin 14,700. This capitalization effect of 16 Mbit/s broadband represents the most relevant Internet speed upgrade, compared to the previously available 1 to 6 Mbit/s in rural areas. The surplus from high-speed broadband access at home may be a combination of consumption value from activities such as streaming, information value derived from Internet access as a complement to local amenities, and labor market value through activities like working from home. Notably, the effects differ between property sales and rentals. We interpret the smaller rental price effect (3.8 percent) as the immediate utility of high-speed Internet access, while the larger sale price increase (8 percent) captures both immediate benefits and buyers' expectations of future rental income premiums until full coverage is achieved in

⁴For seminal studies using spatial RDDs, see Black (1999), Dell (2010), Gibbons et al. (2013), Keele and Titiunik (2015), Becker et al. (2016), Calonico et al. (2019), Cantoni (2020), and Gonzalez (2021).

low-broadband states. This difference reflects buyers' stronger internalization of long-term benefits due to their greater commitment to properties, whereas more flexible renters focus on short-term utility. Overall, the capitalization effects reflect households' high willingness to pay and underscore the economic value of fast Internet access in rural areas. Our estimates are consistent and slightly higher than in the previous literature, which investigates the universal delivery of slower first-generation broadband Internet (Ahlfeldt et al., 2017). The magnitude of our estimated effect of fast Internet access is higher than the impact of introducing air pollution regulations (Chay and Greenstone, 2005) and the removal of nearby toxic waste sites (Greenstone and Gallagher, 2008), but lower than the opening of a new metro line (Diao et al., 2017; Gupta et al., 2022).

In the subsequent analysis, we examine the heterogeneity and robustness of our results. First, we find positive but diminishing capitalization effects at higher broadband speeds (30 and 50 Mbit/s) compared to 16 Mbit/s, indicating a decreasing marginal willingness to pay for higher bandwidths. Second, an analysis of temporal heterogeneity shows that capitalization effects for the same broadband speed increase over time. Since we find this effect particularly for higher speeds, we interpret this as a growing demand for bandwidth-intensive applications in more recent years. Third, our results reveal stronger capitalization effects in rural areas with higher population densities, suggesting a positive relationship between broadband's economic value and population density. Fourth, we find that broadband availability has a greater impact on sale prices and rents for houses than for apartments. Fifth, our results are robust to varying bandwidths. Finally, a placebo check finds no discontinuities in property prices along state boundaries in 2019, after the differences in rural broadband availability had disappeared.

Moreover, we uncover the mechanisms behind the capitalization effects of highspeed Internet on property prices, identifying demand rather than supply as the primary driver. Using micro-census data, we find an increased uptake of high-speed broadband subscriptions in "high" broadband states, suggesting that expansion addressed pre-existing demand. This interpretation is consistent with the estimated effects on property rents, while the stronger effects for sale prices likely also incorporate anticipated future demand. The findings of higher net domestic migration to border regions in "high" compared to "low" broadband states and a higher share of remote work adoption (for which fast Internet access at home is plausibly a precondition) in these areas corroborate this interpretation. Conversely, we find no evidence of discontinuities in the number of property listings at state borders, suggesting that the effects are not driven by supply.⁵

Our evaluation of a major public broadband expansion program in rural German regions reveals that the economic benefits of high-speed Internet access exceed total deployment costs and public subsidies for the majority of rural households. In a costbenefit analysis of subsidized broadband deployment projects from 2016 and 2017, we find

⁵Our interpretation is further supported by evidence of low housing elasticity in the short-run (Baum-Snow and Han, 2024).

that the broadband premium exceeds connection costs for nearly 90 percent of households. Using the MVPF approach, we incorporate potential increases in tax revenues from property transactions, which does not substantially change the results. Our findings imply that a lower subsidy level could have achieved the German government's objective of universal broadband access. However, public subsidies may have resolved a potential coordination problem among property owners and renters who, despite their willingness to pay, could not collectively finance broadband deployment. Notably, while both residents and property owners benefit from fast Internet access, property owners capture additional gains through higher property values and rents. This suggests that the subsidies, which aimed at improving households' access to fast Internet, redistributed much of the benefits to property owners.

Our paper contributes to three strands of the literature. Firstly, it adds to research on the economic value of high-speed broadband by assessing the causal impact of rural broadband expansion and evaluating a major public subsidy program. While prior studies focus on slower, first-generation broadband, our results highlight the substantial economic value of more recent, faster broadband access in rural regions. Our work closely follows Ahlfeldt et al. (2017), who studied early broadband adoption in the UK between 1995 and 2010, finding that basic broadband speeds of 8 Mbit/s increase property values by 2.8 percent, with an additional 1 percent increase for speed upgrades to 24 Mbit/s. Similar results have been documented in the US (Molnar et al., 2019; Deller and Whitacre, 2019). Bourreau et al. (2023) study the fiscal effects of state-aid for broadband expansion in France, showing that subsidies induced more broadband expansion while a sizable fraction of them were inefficient. Regarding state aid for broadband infrastructure expansion in two German states between 2011 and 2013, Duso et al. (2021) find that subsidies increase both coverage and competition, leading to lower prices. Other studies find positive price effects from fiber broadband deployment (Wolf and Irwin, 2024; Koutroumpis et al., 2023; Klein, 2022). Unlike these studies, which focus on one broadband technology, we adopt a broader approach, incorporating all wireline broadband technologies.

Secondly, we expand on the literature examining the capitalization effects of local public goods and externalities. Studies show positive effects on property values from high-quality public goods such as schools (Figlio and Lucas, 2004; Gibbons et al., 2013; Collins and Kaplan, 2017). Similarly, other papers find positive housing price premiums of urban infrastructure, such as railway access (Gibbons and Machin, 2005), new metro lines (Diao et al., 2017; Gupta et al., 2022), and urban green spaces (Conway et al., 2010). Further studies analyze the impact of negative externalities on property prices, including air pollution (Chay and Greenstone, 2005), hazardous waste (Greenstone and Gallagher, 2008), power plants (Davis, 2011), shale gas extraction (Muehlenbachs et al., 2015), cancer clusters (Davis, 2004), and neighborhood crime (Linden and Rockoff, 2008). Another set of papers examines the capitalization effects of property taxes (Oates, 1969; Palmon and Smith, 1998; Dolls et al., 2025). Finally, other studies investigate the premium of certain

property amenities, such as energy efficiency (Kahn and Kok, 2014; Aydin et al., 2020).

Finally, our paper contributes to the growing literature on the effects of broadband Internet on economic, political, and social outcomes. For first-generation broadband, Czernich et al. (2011) find that a 10 percentage-point increase in broadband usage is liked to higher GDP per capita growth by 0.9 to 1.5 percentage points. At the firm level, broadband improves performance, particularly in specific sectors and locations (DeStefano et al., 2018; Canzian et al., 2019; DeStefano et al., 2023). In labor markets, broadband has small but positive effects on employment, benefiting skilled workers while disadvantaging unskilled workers (Akerman et al., 2015; Falck et al., 2021; Zuo, 2021). For households, estimates place the average consumer surplus from broadband adoption in the US between USD 98 and USD 165 per month (Greenstein and McDevitt, 2011; Nevo et al., 2016).⁶ The political impacts of broadband Internet have been studied in contexts like social capital (Geraci et al., 2022), protests (Enikolopov et al., 2020), ideological polarization (Gentzkow and Shapiro, 2011), and fake news (Allcott and Gentzkow, 2017). Variation in broadband infrastructure has also been linked to election outcomes in Germany (Falck et al., 2014), Italy (Campante et al., 2018), and the UK (Gavazza et al., 2019).

The remainder of this paper is structured as follows. Section 2 provides an overview of the institutional context, describing the quasi-experiment and detailing the novel microdataset. The third section outlines the spatial RDD and presents summary statistics. Section 4 presents our principal empirical findings, discusses the results, investigates heterogeneities, and conducts robustness checks. The fifth section details the mechanisms underlying our main results. Section 6 conducts cost-benefit and MVPF analyses to evaluate broadband subsidies. The final section concludes.

2 Institutional Background and Data

2.1 High-Speed Broadband Internet

This paper focuses on the provision of fast broadband Internet to households through wireline connections, such as extended bandwidth asymmetric digital subscriber line 2 (ADSL2+), very-high-speed digital subscriber lines (VDSL), cable TV networks (CATV), or fiber-to-the-building/fiber-to-the-home (FTTB/FTTH). This differs from first-generation Internet delivered through dial-up or early DSL (which are not high-speed) or mobile data plans (which are not wireline).⁷ "High-speed" Internet is classified as broadband connections with at least 16 Mbit/s downstream capacity since this is the minimum bandwidth to enable applications such as video streaming/conferencing, fast synchronization of large

⁶Allcott et al. (2020) caution that valuations of Internet services, such as Facebook, may be overstated due to potential addiction or harm. Our valuation approach, based on overall Internet utility, is less susceptible to these concerns.

⁷We additionally include information on mobile Internet availability (3G, 4G/LTE, and 5G), since households with poor broadband coverage may use it as an imperfect substitute for broadband Internet. Mobile Internet is typically slower than wireline connections and not used at home.

files, and thus working from home. We define Internet availability as the location-specific share of households who have access to high-speed broadband.

The provision of high-speed Internet access required the technological upgrading of the pre-existing broadband infrastructure through the deployment of next-generation access (NGA) networks. Specifically, at least the main distribution frames had to be upgraded.⁸ Broadband networks are typically deployed by private telecommunication carriers. These carriers prioritize urban areas because of lower deployment costs per connection, creating an urban-rural connectivity divide. Policy-makers seek to close this divide by subsidizing rural broadband expansion.

2.2 Quasi-Experiment of German States' Broadband Policies

Our study leverages a quasi-experiment of German states' broadband expansion programs in rural areas that induced spatial discontinuities in Internet access at state boundaries. The different German states held distinct political and economic preferences regarding rural broadband expansion. This led them to enact expansion programs for rural municipalities between 2010 and 2019 with significant differences in scope, funding, regulations, and governance. In Appendix A we provide a detailed overview of all German states' broadband expansion policies. Previously, rural broadband speeds in many municipalities were limited to between 1 and 6 Mbit/s, making the subsequent expansion to 16 Mbit/s a significant technological upgrade. Appendix Figure A1 shows that the number and the speed of broadband subscriptions in Germany increased substantially from 2010 until 2019, making this decade the relevant time period to investigate broadband expansion. The states' broadband policies took effect in the absence of federal funding, and we show that they were only weakly related to other state-level policies, such as education, domestic security, and local taxes.⁹ The different broadband policies led to spatial discontinuities in broadband availability at state boundaries, which were plausibly external to residents on both sides of the borders. These spatial discontinuities enable us to categorize German states into two groups – those with policy-induced "high" and those with "low" broadband availability – based on whether they achieve the national goal of covering at least 75 percent of households with fast Internet.¹⁰ In the empirical analysis, we validate this approach by demonstrating a strong discontinuity in local broadband availability in municipalities at state borders between "high" and "low" broadband states. Furthermore,

⁸Previous dial-up and DSL Internet was based on the pre-existing telephone network, which relied on copper wires to connect houses with nearby main distribution frames. Beginning with initial speeds of 384 kbit/s downstream and 128 kbit/s upstream, several technological standards (ADSL, ADSL2) were implemented over the 2000s. First-generation broadband reached its technological limit at 6 Mbit/s Internet speed and had to be upgraded, since it was unable to meet the demand for higher speeds.

⁹A federal broadband expansion scheme was formally enacted in 2015 and revised in 2018, but took effect only several years later.

¹⁰This policy objective was defined in the German broadband expansion agenda (Bundesministerium für Verkehr und digitale Infrastruktur, 2015; Bundesministerium für Verkehr und digitale Infrastruktur, 2018).

we conduct robustness checks to ensure that the results are robust to variations in the coverage threshold level, underscoring the significance of the discontinuity itself.

2.3 Data

Administrative Data on Broadband Internet

The first component of our dataset consists of administrative data on broadband availability across Germany's 16 states and approximately 11,000 municipalities from 2010 to 2019. This information is sourced from the "broadband atlas," published by the German Ministry of Transport and Digital Infrastructure (Bundesministerium für Verkehr und digitale Infrastruktur, 2010).¹¹ The dataset reports the share of households covered by broadband infrastructure at both state and municipality levels.

The data differentiate broadband availability by technology and speed. We focus on all fixed-line broadband technologies (ADSL2+, VDSL, CATV, and FTTB), while mobile Internet is included as a control variable. The dataset covers total fixed-line connections with Internet speeds of 16, 30 and 50 Mbit/s. Appendix Figure A1 shows that these speeds constitute the relevant broadband expansions from 2010 to 2019. State-level data are available for the entire period (2010–2019) across all speeds, while municipality-level data are available for 16 Mbit/s from 2011 to 2016, for 30 Mbit/s from 2013 to 2018, and for 50 Mbit/s from 2011 to 2018.

This dataset provides regional variation in broadband availability across rural municipalities at the borders of "high" and "low" broadband states, enabling us to exploit these discontinuities to estimate the causal effect of broadband access on property prices.

For the cost-benefit and MVPF analyses, we use deployment costs from subsidized projects under the federal program (ifo et al., 2021), since individual project deployment costs under the subsidized state programs are unavailable. These applications were filed in 2016 and 2017, but implemented in subsequent years.

Large Micro-Dataset on the German Real Estate Market

We use a comprehensive micro-dataset on the German real estate market, compiled by the real estate consulting firm F+B IGES. It includes property advertisements from approximately 140 sources, spanning online platforms, newspapers, and property agencies. Covering the period from 2010 to 2019, the dataset comprises over 12 million properties for sale and 13 million for rent with individual property-level information. The observations are evenly distributed over time (approximately 1 million observations per year each for sale and for rent) and geographically across the German states and municipalities.

For each property, the dataset includes detailed attributes (e.g., location, type, amenities) and the final offering price for sales and rentals. Although we do not observe

¹¹The "broadband atlas" was compiled by $T\ddot{U}V$ Rheinland Consulting GmbH from 2010 to 2018 and by atene KOM GmbH since 2018.

transaction prices of sales and rents, the offering prices closely approximate them.¹² We use logarithmized square meter (sqm) prices to ensure comparability across properties. Property-level control variables comprise property characteristics (e.g., type, size, construction year), amenities (e.g., garden, balcony, parking), and neighborhood attributes (e.g., quiet location, public housing). Location data include municipality, postal code, and state. Data cleaning ensures each property is listed only once, although some were offered concurrently on multiple channels. Finally, we winsorize the bottom and top one percent of observations to remove outliers due to false data entries.

Local Socioeconomic and Micro-Census Data

The third component of our dataset includes supplementary socioeconomic data at the municipality level, drawn from the Federal Institute for Research on Building, Urban Affairs and Spatial Development (Bundesinstitut für Bau-, Stadt- und Raumforschung, 2021), the Regional Statistical Agencies (Statistische Ämter des Bundes und der Länder, 2021), and GIS data from the Federal Agency for Cartography and Geodesy (Bundesamt für Kartographie und Geodäsie, 2019). These data comprise municipality characteristics, including population size (in deciles), growth or shrinkage trends, and housing market regions. Geographic data include the longitude and latitude of each municipality's centroid and its proximity to state borders. We also include municipal business tax and property tax rates. Furthermore, we control for state-level differences in real estate transfer taxes, which affect property prices (Dolls et al., 2025). Additionally, we incorporate micro-census data from 2018 at the municipality level (FDZ der Statistischen Ämter des Bundes und der Länder, 2018). The administrative information on broadband uptake (subscriptions), migration, and remote work adoption allows us to examine the mechanisms through which broadband availability impacts property prices.

3 Empirical Framework

3.1 Spatial RDD at State Borders

We estimate the causal effect of high-speed Internet access on real estate prices using a spatial regression discontinuity design (RDD). This section outlines the empirical framework and identification strategy, followed by the sample construction and descriptives.

The spatial RDD exploits geographic discontinuities in rural broadband availability at the borders of "high" and "low" broadband states, induced by the quasi-experiment in broadband expansion policies across German states. This approach compares similar properties in rural municipalities located on either side of state borders, where broadband availability differs due to state expansion policies. Properties in "high" broadband states

 $^{^{12}}$ For the evolution of property prices in Germany over time and the construction of local property price indices, see Ahlfeldt et al. (2023).

are the treatment group, while those in "low" broadband states serve as the control group. The spatial RDD integrates a hedonic property price model to disentangle the effect of rural broadband access from other factors impacting property prices. By leveraging the discontinuity in broadband availability over time and across state boundaries as well as by controlling for municipal, state, and property characteristics, we isolate the intent-to-treat effect of high-speed broadband access on property prices. In particular, our identification benefits from variation in boundary regions that contain municipalities from more than two neighboring states. Our empirical strategy builds on seminal studies that have employed spatial RDDs and hedonic pricing models to infer the value of local public goods (Black, 1999; Dell, 2010; Gibbons et al., 2013; Keele and Titiunik, 2015; Becker et al., 2016; Ahlfeldt et al., 2017; Calonico et al., 2019; Cantoni, 2020; Gonzalez, 2021).

The identifying assumption of the spatial RDD is that municipalities on either side of state borders are valid comparison groups after accounting for observable differences, with broadband availability being the only discontinuous variable. To control for spatial characteristics, we use several RD specifications with polynomials either in distance to the boundary or in longitude and latitude. Boundary-segment-by-year fixed effects capture temporal and local variation at the borders, capturing differential shocks over time at a small spatial level. Within the boundary segments, we control for municipality- and state-level variation, including local tax rates, income, and school quality. We further add individual property-level controls, such as property type, size, and condition, to capture differences in property attributes. These controls ensure that the observed variation in property prices at the boundary is plausibly attributable to differences in broadband availability, which we argue is exogenous to residents in small boundary segments.

We employ the hedonic property pricing model to disentangle the effect of broadband availability from other determinants of property values. This approach assumes that property prices reflect the implicit value of their attributes, including internal characteristics and locational features such as access to local public goods like broadband – although unlike classic public goods, broadband requires households to pay an additional subscription fee to the telecommunications provider. In a spatial equilibrium with free mobility, the hedonic model captures the capitalization effect, i.e., how locational advantages and disadvantages are reflected in property prices. By estimating the relationship between property values and these attributes, we quantify the market premium households are willing to pay for high-speed Internet access. Building on a long tradition of research (Oates, 1969; Rosen, 1974; Roback, 1982), the framework has been widely applied to value local public goods while controlling for confounding factors.

Our empirical strategy addresses two endogeneity concerns. First, broadband access is often correlated with locational characteristics, such as population density or economic activity, which may independently influence housing prices. To mitigate this bias, we leverage variation in broadband availability at state borders and control for municipalityand state-level differences. Second, housing prices represent a bundle of property and locational attributes, making it challenging to isolate the broadband effect. By incorporating RD polynomials, boundary-segment-by-year fixed effects as well as comprehensive controls for property characteristics and local conditions, we ensure that the remaining variation in housing prices is plausibly attributable to differences in broadband access.

Many RDDs assume no selective sorting around the threshold – in this case migration across state borders in response to differences in broadband availability. While this assumption could be violated if households systematically relocate, we treat migration patterns as a potential channel of the treatment effect rather than a source of bias. Using micro-census data, we examine net migration flows to assess their role as a demand-side driver of the observed capitalization effects.

We estimate the spatial RDD for three main outcomes: municipal broadband availability, real estate sale prices, and rents. Our primary analysis focuses on broadband speeds of 16 Mbit/s, capturing the main effects of interest, while the broadband speeds 30 and 50 Mbit/s are used for heterogeneity analyses. First, we validate our empirical strategy by demonstrating a clear discontinuity in municipal broadband availability at borders between "high" and "low" broadband states, while the covariates (local, state, and property characteristics) are balanced with minimal discontinuities. We then estimate the local causal effect of "high" broadband states on sale prices and rents, i.e., the capitalization effect of broadband access on property values.

We estimate the spatial RDD using two sets of specifications. The first employs one-dimensional (linear, quadratic, linear interacted) polynomials in distance to the state border, which is most intuitive. The second specification uses multi-dimensional polynomials in longitude and latitude (linear up to quartic), which leverage more detailed geographic information for greater accuracy but are subject to econometric issues (Gelman and Imbens, 2019). This model identifies the causal effect of broadband access by separating its treatment effects from other continuous effects of geographic location. We primarily use a bandwidth of 25 km around state borders, which has favorable characteristics with regard to the bias-variance tradeoff in RDDs (Calonico et al., 2019). For robustness checks, we use smaller and larger bandwidths (15–50 km) and employ a "donut hole" approach that excludes observations directly at the boundaries.

Formally, we estimate multiple specifications of the spatial RDD (Equation 1):

$$y_{imt} = \beta highbroadbandstate_{mt} + f(geographic \ location)_{b(m)} + X'_{imt}\gamma + \delta_{b(m)} \times \delta_t + \epsilon_{imt}$$
(1)

For municipal broadband availability, the outcome variable y_{mt} represents broadband coverage in municipality m in year t. At the property level, regressions estimate the effects on log sale prices and rents (y_{imt}) . The key variable of interest, $highbroadbandstate_{mt}$, is an indicator equal to 1 if municipality m belongs to a "high" broadband state in year t. The function $f(geographiclocation)_{b(m)}$ captures the RD polynomial (either in distance to the boundary or in longitude and latitude) for the discontinuity at state borders. The vector X_{mt} controls for socioeconomic characteristics, while border-region-by-year fixed effects $\delta_{b(m)} \times \delta_t$ account for spatial and temporal variation. In the property-level estimations, we include property- and local-level controls X_{imt} capturing observable attributes. Standard errors are clustered at the boundary-region-by-year level.

3.2 Sample and Summary Statistics

The sample comprises administrative broadband availability data, real estate offerings, as well as local socioeconomic and micro-census data described in subsection 2.3. In detail, we construct multiple samples along the following three dimensions: (1) sale versus rental properties, (2) broadband speeds (16 Mbit/s for main analysis, with heterogeneity analysis for 30 and 50 Mbit/s), and (3) bandwidth size around state borders (25 km for the baseline analysis, with robustness checks for 15 km and 50 km). These samples allow us to examine the differential effects of broadband access across markets, speeds, and space. We report descriptive statistics for all samples in Appendix B.

For the main analyses, we construct two datasets covering 16 Mbit/s broadband availability in rural municipalities within 25 kilometers of the borders between policyinduced "high" and "low" broadband states from 2010 to 2019: one for properties offered for sale and another for rent. Rural municipalities are defined as those with fewer than 20,000 inhabitants, which excludes larger urban agglomerations and boundary regions of the three German city states. The sample comprises almost 1 million observations from 4,035 municipalities grouped into 57 distinct boundary regions. Figure 1 illustrates the sample, highlighting rural municipalities (dark blue) along state borders (white lines). Appendix Figure A2 provides a detailed view of the individual boundary regions.

Table 1 reports descriptive statistics for the main samples covering 16 Mbit/s broadband, including outcome variables, explanatory variables, and controls. The discontinuities in broadband availability and property prices between "high" and "low" broadband states are consistent with the spatial RDD design, while covariates appear largely balanced across state borders. Columns 1-4 report the full sample, columns 5–6 the "low" broadband states, and columns 7–8 the "high" broadband states. Broadband availability averages 53 percent across the sample, with higher coverage in "high" broadband states (59 percent) compared to "low" states (47 percent). Property sale prices average €1,360 per square meter, with a mean of €1,430 for properties in "high" broadband states and of €1,300 in "low" states. Similarly, rents average €5.9 per square meter, with slightly higher rents in "high" broadband states (€6.1) compared to "low" states (€5.6). For the control variables, which comprise individual property, municipal- and state-level characteristics, we find mostly similar characteristics on either side of the border.



Note: This map of Germany illustrates its 16 federal states, delineated by white lines, as well as its approximately 11,000 municipalities. Highlighted in dark blue, the RDD sample is comprised of 4,035 small municipalities that are located within 25 kilometers distance to the next state border of "high" and "low" broadband states. The municipalities not included in the RDD sample are shown in light blue. Those municipalities are either located further away from state boundaries or belong to larger urban agglomerations with many inhabitants.

Figure 1: Sample Illustration in a Map of Germany

		Full S _i	ample		"Low" Bros	adband States	"High" Bro	adband States
	Mean	$^{\mathrm{SD}}$	Min	Max	Mean	SD	Mean	SD
	(1)	(2)	(3)	(4)	(5)	(9)	(7)	(8)
Outcome and Main Explanatory Variables High Broadband States 16 Mbit/s Broadband Availability Municipalities 16 Mbit/s	$0.49 \\ 0.53$	$0.50 \\ 0.32$	0.00	1.00 1.00	$0.00 \\ 0.47$	0.00 0.33	$1.00 \\ 0.59$	0.00 0.30
Property Sale Price Total Property Sale Price per sqm	188,030.60 1.364.31	121,773.21 715.67	8,800.00 244.28	2,950,000.00 7,175.00	181,621.52 1.302.30	113,848.10 660.27	194,832.86 1,430.12	129,308.80 764.64
Property Rent Total (Monthly) Prometry Boot nor com (Monthly)	484.91	240.80	98.00	3,500.00	461.31	218.98	505.03	256.25 1 71
I TOPCI by Include per admit (monthly)	0.0	00.1	0.00	00.04	10.0	71.1	00.0	
Control Variables	-	92 U	00.1	00 6	1 00	н С	- 1	о 0
r roperty type (ormutat inucator) Number of Rooms in the Property	1.77 4.84	2.54	0.00	57.00	4.90	2.51	4.76	000 2.57
Log of Floor Space in sqm	4.87	0.46	3.50	6.15	4.88	0.44	4.85	0.47
Age of Property (ordinal indicator)	8.40	5.98	1.00	18.00	8.54	6.07	8.26	5.88
Newly Constructed Building	0.13	0.34	0.00	1.00	0.12	0.33	0.13	0.34
Renovation Status (ordinal indicator) Equipmed with Kitchen	0.09 0.03	1.00 0.42	00 U	0.00	0.91 0.91	0.1 0.41	0.00 0.26	1.U/ 0.44
Equipped with Garden	0.29	0.45	0.00	1.00	0.28	0.45	0.30	0.44
Equipped with Balcony or Terrace	0.27	0.44	0.00	1.00	0.26	0.44	0.28	0.45
Equipped with Basement	0.41	0.49	0.00	1.00	0.40	0.49	0.42	0.49
Parking Lot or Garage Available	0.62	0.48	0.00	1.00	0.61	0.49	0.64	0.48
Exclusive/Luxury Equipment or Villa	0.04	0.18	0.00	1.00	0.03	0.18	0.04	0.19
Equipped with Fout, Withipoot, or Sauna Bricht Roome	0.00	0.37	00.0	1.00	0.00	0.36	0.07	0.2.0
Heating Type	0.10	0.95	0.00	5.00	0.28	0.94	0.30	0.96
Central Heating	0.88	0.98	0.00	2.00	0.85	0.98	0.90	0.99
Quiet Location	0.12	0.33	0.00	1.00	0.12	0.32	0.12	0.33
Publicly Subsidized Housing	0.04	0.19	0.00	1.00	0.04	0.20	0.04	0.19
School Quality (PISA score)	-0.24	0.94	-1.39	1.74	-0.14	0.89	-0.34	0.97
Crime Rate per 10,000 Inhabitants	0.07	0.01	0.05	0.09	0.07	0.01	0.07	0.01
Mobile Internet Availability	0.74	0.17	0.47	0.98	0.72	0.15	0.76	0.20
Keal Estate Transfer 1aX Kate Local Dool Ectate Tour Date	0.04 950.74	10.01 5.3 10	150.00	795.00	0.04 996 45	10.0	60.0 21 996	10.01
Local Iteat Estate Tax Trate Local Business Tax Bate	356.69	35.78	200.00	490.00	345 47	42.00 27 11	368.81	39.82
County Pre-Broadband Growth Trend (ordinal indicator)	-0.42	1.09	-2.00	2.00	-0.55	1.04	-0.28	1.12
Log Population Density per Sq. Km.	5.17	0.89	1.56	7.88	5.12	06.0	5.21	0.89
Female Population Share	0.51	0.01	0.12	0.77	0.51	0.01	0.51	0.01
Share of Inhabitants Aged 18 to 64 Years	0.62	0.03	0.46	0.76	0.62	0.03	0.61	0.03
Share of Inhabitants Older Than 65 Years	0.22	0.04	0.03	0.46	0.21	0.04	0.22	0.04
Log Purchasing Power	18.90	0.75	14.11	20.78	18.75	0.73	19.05	0.74
Unemployment Rate	0.05	0.02	0.00	0.19	0.05	0.02	0.05	0.02
Observations	951, 991							
<i>Note:</i> The descriptive statistics of the border sample	s for 16 M	bit/s repor	rt inform	ation on pro	perties for s	ale (N=741,36	9) and for rei	nt (N=210,622)

Table 1: Descriptive Statistics of the Border Samples for 16 Mbit/s Broadband

from 4,035 rural municipalities, which are located within 25 km of the borders of "high" and "low" broadband states. Columns 1 to 4 report the mean, standard deviation, minimum, and maximum for the full samples, whereas columns 5 to 6 state the mean and standard deviation for "low" broadband states only, and columns 7 to 8 report the analogous values for "high" broadband states.

Visual evidence supports these patterns. Appendix Figures A3 and A6 show a balanced distribution of properties near state borders and over time for 16 Mbit/s broadband. Note that the sample composition varies over time, as the RDD sample each year includes only municipalities near the borders of "high" and "low" broadband states with a broadband status discontinuity. Additionally, Appendix Figure A9 highlights that broadband availability in "high" broadband states started from a higher level and exhibits a steeper upward trend compared to "low" broadband states. These summary statistics align with the spatial RDD design, showing discontinuities in broadband availability and property prices as well as largely balanced covariates across state borders. While the summary statistics provide initial support for the identifying assumption of the RDD, we test the smoothness of covariates around the spatial discontinuity in subsection 4.2.

The analogous summary statistics for the higher broadband speeds 30 and 50 Mbit/s are reported in Appendix Tables B.1.1 and B.1.2. Similarly, Appendix Figures A4 and A5 show the spatial distribution of the sample in distance to the boundary, Appendix Figures A7 and A8 present the sample distribution over time, and Appendix Figures A10 and A11 report the distribution of broadband availability in municipalities over time for 30 and 50 Mbit/s.

4 Empirical Results

4.1 Results on Broadband Availability

We provide graphical evidence to validate the spatial RD design by illustrating the relationship between broadband availability in municipalities and distance to the border between "high" and "low" broadband states. Figure 2 presents the spatial discontinuity in broadband availability for 16, 30, and 50 Mbit/s broadband speeds across state boundaries. In each panel, the y-axis represents broadband availability, while the x-axis measures the distance in kilometers to the nearest state border, with negative values indicating "high" broadband states. The RD plots are generated by an evenly spaced number of bins, representing the sample average within each bin, net of boundary-region-by-year fixed effects. The solid lines represent predicted values from a regression of the outcome variable on a first-order polynomial in distance to the boundary, with the corresponding 95 percent confidence intervals displayed by dotted lines. Thanks to the richness of the data, the confidence bands are very narrow.

The discontinuities in broadband availability at the state borders are visually evident for all three speed levels. This suggests that the spatial discontinuities in broadband availability at state borders are induced by differential state-level broadband expansion policies and not by endogenous local factors. The RD plots thus supports the validity of our quasi-experimental framework, demonstrating that neighboring municipalities on either side of the border exhibit significantly different broadband availability. This spatial discontinuity is plausibly exogenous to the individual municipalities and residents, enabling us to exploit this variation later on to estimate the causal effect of broadband access on property prices.

We estimate the spatial RD formally in Table 2, using various RD specifications with boundary-region-by-year fixed effects and standard errors clustered at the boundary-regionby-year level. Columns 1 to 3 use the log availability of 16, 30, and 50 Mbit/s connections respectively as dependent variables. Furthermore, this and the following two tables are divided into an upper and a lower panel to reflect the two different specifications of the spatial RDD. The upper Panel A presents the estimates for linear, quadratic, and linear interacted RDD polynomials in distance to border. In contrast, the lower Panel B reports results for estimations based on linear, quadratic, cubic, and quartic RDD polynomials in longitude and latitude. Since the latter specification uses two-dimensional geographic information, it more accurately controls for regional differences and thus constitutes our preferred specification (with a linear polynomial to avoid problems of higher-order polynomials). Within the tables, each cell shows the point estimates and standard errors of the "high" broadband state variable from a separate regression. Throughout the specifications in Table 2, boundary-region-by-year level.

The estimates for the broadband speed of 16 Mbit/s in column 1 of Table 2 show throughout the RDD specifications a significantly positive effect of "high" broadband states on availability in municipalities in the range of 24 to 28 percentage points. This suggests that the boundary discontinuity of "high" and "low" broadband states indeed has sizable effects on households' local broadband access, even when controlling for regional characteristics through boundary-region-by-year fixed effects, and clustering the standard errors at the boundary-region-by-year level. The effect is identified from variation across boundary regions covering 4,035 municipalities over 6 years. The positive and significant result provides evidence that the "high" broadband state status is indeed relevant for municipality-level broadband availability.

For broadband speeds of 30 Mbit/s and 50 Mbit/s, the relationship is even stronger. The estimates range from 52 to 56 percentage points for 30 Mbit/s and 78 to 94 percentage points for 50 Mbit/s. The positive and significant results for these higher broadband speeds further underscore the impact of the "high" broadband state status on availability at the local level.¹³

 $^{^{13}}$ Note that across columns, the years included in the sample differ due to data availability. The high/low state definition is also specific to the speed level. As a result, the number of municipalities in the sample differs as well.



(b) 30 Mbit/s Broadband Availability in Municipalities



(c) 50 Mbit/s Broadband Availability in Municipalities



Note: Shown are spatial RD plots for broadband availability in municipalities for the Internet speeds 16 Mbit/s (Panel A), 30 Mbit/s (Panel B), and 50 Mbit/s (Panel C). The outcomes are plotted on the y-axis. "Distance to border in km" on the x-axis refers to the distance in kilometers between the observation and the closest state boundary, with negative values of distance indicating "high" broadband states. The RD plots are generated by an evenly spaced number of bins, representing the sample average within each bin, net of boundary-region-by-year fixed effects. The solid lines represent the predicted values from a regression of the outcome variable on a first-order polynomial in distance to the boundary. The corresponding 95 percent confidence intervals are displayed as dotted lines.

Figure 2: Spatial RD Plots for Broadband Internet Availability in Municipalities

Spatial RDD Estimates	Broadband Availability in Municipalities	Broadband Availability in Municipalities	Broadband Availability in Municipalities				
	$16 \mathrm{~Mbit/s}$	$30 \mathrm{~Mbit/s}$	$50 { m ~Mbit/s}$				
	(1)	(2)	(3)				
Panel A: RDD Polynomials in D	istance to Bound	lary					
Linear	0.2804***	0.5239***	0.7751***				
	(0.0974)	(0.0792)	(0.1144)				
Quadratic	0.2774^{***}	0.5613^{***}	0.9298^{***}				
	(0.0572)	(0.0724)	(0.1402)				
Linear Interacted	0.2780^{***}	0.5444^{***} 0.8818^{**}					
	(0.0704)	(0.0745)	(0.1342)				
Panel B: RDD Polynomials in Longitude and Latitude							
Linear	0.2674^{***}	0.5637***	0.9380***				
	(0.0611)	(0.0786)	(0.1619)				
Quadratic	0.2589^{***}	0.5288^{***}	0.9117^{***}				
	(0.0562)	(0.0757)	(0.1585)				
Cubic	0.2382^{***}	0.5354^{***}	0.8580^{***}				
	(0.0547)	(0.0676)	(0.1515)				
Quartic	0.2382^{***}	0.5354^{***}	0.8580^{***}				
	(0.0547)	(0.0676)	(0.1515)				
Boundary Region by Year FE	\checkmark	\checkmark	\checkmark				
Municipalities	4,035	$3,\!341$	3,389				
Data Availability Period	2011-2016	2014-2018	2011-2018				

Note: Shown are the coefficients and standard errors for "high broadband state" under different specifications of the RDD polynomials, with each cell in the table reporting the result of a separate regression. Panel A displays estimates for linear, quadratic, and linear interacted RDD polynomials in distance to the state boundary, whereas Panel B presents the results for linear, quadratic, cubic, and quartic RDD specifications in longitude and latitude. Broadband availability in municipalities are log values to facilitate better comparability of the estimates. Standard errors are clustered at the boundary-region-by-year level. *p<0.1; **p<0.05; ***p<0.01.

Table 2: Spatial RDD Results for Broadband Internet Availability in Municipalities

4.2 Balanced Covariates

Given the evidence of a sharp spatial discontinuity in local broadband availability at the borders between "high" and "low" broadband states, the validity of the spatial RDD rests on the smoothness of other covariates (muncipality-, state-level, and property characteristics) across the boundary. Major discontinuities in these covariates would indicate potential confounding factors, violating the identifying assumption. Since differences in property prices should be attributable to broadband availability and not differences in other local characteristics, we test in this subsection for balanced covariates near the boundary to confirm smoothness.

Figure 3 shows the smoothness of covariates with only minor discontinuities across state borders, presenting evidence in three panels. Panel A shows various individual property characteristics, such as floor space, age, and type (apartment or house). For all of these 12 attributes, the RD plots exhibit minimal variation across the border, with averages on both sides being nearly identical and the trends appearing smooth.

Panel B examines state-level institutional and policy characteristics. While school quality and crime rates show negligible differences between "high" and "low" broadband states, real estate transfer taxes are higher in "high" broadband states. This may have an ambiguous effect, since higher property transaction taxes suggest both greater fiscal capacity, which may be conducive to infrastructure expansion, but also negative capitalization effects of higher tax burdens into property prices. The share of households with mobile Internet, a variable related to broadband access, is balanced across the border. Although mobile Internet could substitute for broadband access in its absence, it is generally less relevant *at home* when broadband is available, since broadband typically provides faster and cheaper connectivity.

Panel C investigates municipality-level policy and economic characteristics. These include the real estate tax rate, business tax rate, log population density, pre-existing growth trend, and demographic characteristics (female, working age, and seniors' population shares). Higher tax rates and pre-existing growth trends in "high" broadband states demonstrate the importance of including these controls to ensure robust results. Population density, an important determinant of the costs of broadband expansion, is balanced around the border. Similarly, the population shares of females, working age people, and seniors are smoothly distributed around the boundary. Local economic controls comprise log purchasing power and the unemployment rate. While some differences are visually detectable, with slightly higher levels in "high" broadband states, they are economically small.

Overall, the broad set of municipality-, state-level, and property covariates displays smooth patterns across state borders, reinforcing the validity of the spatial RDD. Furthermore, these variables are included as controls in our regressions to enhance precision and ensure that the residual variation in property prices is plausibly attributable to differences

in broadband availability.



(a) Panel A: Individual Property Characteristics

Note: Shown are the spatial RD plots for individual property characteristics in Panel A, state-level institutional and policy characteristics in Panel B, as well as municipality policy and local economic characteristics in Panel C. The outcomes are plotted on the y-axis. "Distance to border in km" on the x-axis refers to the distance in kilometers between the observation and the closest state boundary, with negative values of distance indicating "high" broadband states. The RD plot was generated by an evenly spaced number of bins, representing the sample average within each bin, net of boundary-region-by-year fixed effects. The solid lines represent the predicted values from a regression of the outcome variable on a first-order polynomial in distance to the boundary. The corresponding 95 percent confidence intervals are displayed as dotted lines.

Figure 3: Graphical Evidence of Balanced Covariates Around State Borders

4.3 Results on Real Estate Prices and Rents

To illustrate the impact of high-speed broadband access on real estate prices and rents, Figure 4 presents spatial RD plots for 16 Mbit/s broadband Internet. The plots demonstrate clear discontinuities in sale prices (Panel A) and rents (Panel B) at state borders, with higher values observed in municipalities located in "high" broadband states on the left side of the boundary. These discontinuities suggest a significant capitalization effect of broadband access on property prices. As before, the solid lines show predicted values from a first-order polynomial regression in distance to the boundary, while the dotted lines represent the corresponding 95 percent confidence intervals. In both panels, the confidence bands are very narrow.

Moving towards more rigorous evidence, we present the main spatial RDD results on the effect of broadband availability on real estate sale prices and rents in Tables 3 and 4. The tables report results under different specifications of the RDD (Equation 1), with Panel A using polynomials in distance to the boundary and Panel B using polynomials in longitude and latitude. The dependent variable are the log of real estate sale prices and rents, respectively. From columns (1) to (5), we start with boundary-region-by-year fixed effects and gradually add individual property controls, state policy controls, municipality policy controls, and local economic controls. Our preferred specification is the most restrictive in column (5), using a linear polynomial in longitude and latitude, fixed effects, and the full set of controls.

The results for sale prices in Table 3 consistently show significantly positive effects across all specifications. Under the most restrictive specification in column (5) using boundary-region-by-year fixed effects and the full set of controls, the estimated impact ranges from 4.9 to 9.7 percent. Our preferred RDD specification with linear polynomials in longitude and latitude yields an estimated increase of 8.1 percent. Using the mean property sale price in "low" broadband states of $\in 181,622$ (see Table 1), this corresponds to an approximate increase of $\in 14,711$ per property. In terms of sale price per square meter, where the mean is $\in 1,302$, the effect translates into an increase of $\in 105.46$ per square meter.

Table 4 provides complementary results for rents under various RDD specifications, again finding consistently positive and significant effects. Under the most restrictive specification in column (5), the estimated effect on property rents ranges from 2.2 to 4.4 percent. Our preferred specification with linear polynomials in longitude and latitude yields an estimated increase of 3.8 percent. Using the mean property rent in "low" broadband states of \notin 461 per month (see Table 1), this corresponds to an approximate increase of \notin 17.52 per month. For rents per square meter, with a mean of \notin 5.62, the effect implies an increase of \notin 0.21 per square meter.¹⁴

 $^{^{14}{\}rm Appendix}$ Table A11 reports the same regressions for sale prices and rents in levels, directly estimating euro values. The results closely align.



Note: These spatial RD plot show property sale prices (Panel A) and rents (Panel B) around the boundaries of "high" and "low" broadband states for 16 Mbit/s broadband Internet. Property prices and rents are measured in Euro per square meter and plotted on the y-axis. "Distance to border in km" on the x-axis refers to the distance in kilometers between the observation and the closest state boundary, with negative values of distance indicating "high" broadband states. The RD plots are generated by an evenly spaced number of bins, representing the sample average within each bin, net of boundary-region-by-year fixed effects. The solid lines represent the predicted values from a regression of the outcome variable on a first-order polynomial in distance to the boundary. The corresponding 95 percent confidence intervals are displayed as dotted lines.

Figure 4: Spatial RD Plots for Broadband Internet Availability in Municipalities

Overall, the results for both sale prices and rents demonstrate that broadband availability strongly capitalizes into property values, reflecting households' high willingness to pay and underscoring the economic value of high-speed Internet compared to slower access in rural areas. The surplus from high-speed broadband access at home may be a combination of consumption value from activities such as streaming, information value derived from Internet access as a complement to local amenities, and labor market value through activities like working from home, which we further examine in section 5 on mechanisms. Regarding the heterogeneous effects between property sales and rentals, the smaller effect on rents (3.8 percent) likely reflects the immediate utility that households derive from high-speed Internet access. In contrast, the larger sale price increase (8) percent) may capture both the immediate benefits and the anticipated premium on future rental income as broadband coverage improves in neighboring low-broadband states. This difference aligns with buyers' stronger internalization of long-term benefits due to their greater commitment to properties, whereas more flexible renters prioritize short-term utility. Buyers likely anticipated these premiums to persist for several years, given uncertainty about when broadband speeds in low-broadband states would catch up. On average, this catch-up process took four years. As shown in Appendix Figure A12, the broadband effect on property prices is strongest in those municipalities with the highest availability.

In comparison to previous studies on the capitalization effects of broadband in other countries, our findings for the German real estate market are consistent and of slightly higher magnitude. For instance, the estimated effects are higher but broadly in the same range as Ahlfeldt et al. (2017) who estimate 2.8 percent for 8 Mbit/s and 3.8 percent for 24 Mbit/s in the United Kingdom. They also compare well to the results by Molnar et al. (2019) of 3 percent for 25 Mbit/s in the United States. Combined, these findings highlight a rather uniform importance of broadband Internet across advanced economies. More broadly, our results for the capitalization effect of high-speed Internet correspond to improved school quality by approximately half a standard deviation (Gibbons et al., 2013). They are higher than the introduction of air pollution regulations in affected American counties (Chay and Greenstone, 2005) as well as the removal of nearby toxic waste sites (Greenstone and Gallagher, 2008). The magnitude of the estimated effect in our rural setting is lower than the opening of new subway lines in New York City and Singapore (Gupta et al., 2022; Diao et al., 2017).

Spatial RDD Estimates		Real Estate Sale Prices			
	(1)	(2)	(3)	(4)	(5)
Panel A: RDD Polynomials in	Distance t	o Boundar	y		
Linear	0.0475***	0.0407***	0.0866***	0.0573***	0.0493***
	(0.0181)	(0.0139)	(0.0156)	(0.0172)	(0.0175)
Quadratic	0.1087^{***}	0.0948^{***}	0.1355^{***}	0.0959^{***}	0.0786^{***}
	(0.0144)	(0.0118)	(0.0141)	(0.0170)	(0.0170)
Linear Interacted	0.0485^{***}	0.0457^{***}	0.0897^{***}	0.0471^{***}	0.0408^{**}
	(0.0177)	(0.0139)	(0.0156)	(0.0176)	(0.0175)
Panel B: RDD Polynomials in	Longitude-	Latitude			
Linear	0.1120***	0.0973***	0.1392***	0.1000***	0.0810***
	(0.0160)	(0.0129)	(0.0145)	(0.0154)	(0.0154)
\mathbf{Q} uadratic	0.1118^{***}	0.0964^{***}	0.1501^{***}	0.1105^{***}	0.0943^{***}
	(0.0147)	(0.0119)	(0.0135)	(0.0151)	(0.0153)
Cubic	0.1008^{***}	0.0890^{***}	0.1434^{***}	0.1119^{***}	0.0973^{***}
	(0.0143)	(0.0118)	(0.0131)	(0.0153)	(0.0153)
Quartic	0.0711^{***}	0.0634^{***}	0.1117^{***}	0.0923^{***}	0.0812^{***}
	(0.0174)	(0.0142)	(0.0146)	(0.0166)	(0.0163)
Boundary Region by Year FE	\checkmark	\checkmark	\checkmark	\checkmark	\checkmark
Individual Property Controls		\checkmark	\checkmark	\checkmark	\checkmark
State Policy Controls			\checkmark	\checkmark	\checkmark
Municipality Policy Controls				\checkmark	\checkmark
Local Economic Controls					\checkmark
Observations	$741,\!369$	$741,\!369$	$741,\!369$	723,881	$723,\!881$
Municipalities	4,035	4,035	4,035	$3,\!983$	$3,\!983$
Data Availability Period	2010-2017	2010-2017	2010-2017	2010-2017	2010-2017

Note: Shown are the coefficients and standard errors for "high broadband state" under different specifications of the RDD polynomials, with each cell in the table reporting the result of a separate regression. Panel A displays estimates for linear, quadratic, and linear interacted RDD polynomials in distance to the state boundary, whereas Panel B presents the results for linear, quadratic, cubic, and quartic RDD specifications in longitude and latitude. Real estate prices are log values to facilitate better comparability of the estimates. Standard errors are clustered at the boundary-region-by-year level. *p<0.1; **p<0.05; ***p<0.01.

Table 3: Main Results of the Spatial RDD for Real Estate Sale Prices (16 Mbit/s)

Spatial RDD Estimates	Real Estate Rents				
	(1)	(2)	(3)	(4)	(5)
Panel A: RDD Polynomials in	Distance t	o Boundar	y		
Linear	0.0278**	0.0283**	0.0374***	0.0304***	0.0222**
	(0.0132)	(0.0120)	(0.0113)	(0.0104)	(0.0096)
Quadratic	0.0552^{***}	0.0561^{***}	0.0628^{***}	0.0491^{***}	0.0355^{***}
	(0.0085)	(0.0078)	(0.0099)	(0.0103)	(0.0099)
Linear Interacted	0.0290^{***}	0.0319^{***}	0.0390^{***}	0.0248^{***}	0.0172^{**}
	(0.0107)	(0.0099)	(0.0098)	(0.0095)	(0.0086)
Panel B: RDD Polynomials in	Longitude-	Latitude			
Linear	0.0587***	0.0592***	0.0664***	0.0536***	0.0378***
	(0.0097)	(0.0090)	(0.0102)	(0.0087)	(0.0083)
Quadratic	0.0581^{***}	0.0581^{***}	0.0723^{***}	0.0580^{***}	0.0436^{***}
	(0.0079)	(0.0073)	(0.0093)	(0.0090)	(0.0086)
Cubic	0.0506^{***}	0.0510^{***}	0.0677^{***}	0.0554^{***}	0.0414^{***}
	(0.0069)	(0.0065)	(0.0080)	(0.0085)	(0.0083)
Quartic	0.0338^{***}	0.0351^{***}	0.0477^{***}	0.0400^{***}	0.0299^{***}
	(0.0098)	(0.0092)	(0.0093)	(0.0094)	(0.0089)
Boundary Region by Year FE	\checkmark	\checkmark	\checkmark	\checkmark	\checkmark
Individual Property Controls		\checkmark	\checkmark	\checkmark	\checkmark
State Policy Controls			\checkmark	\checkmark	\checkmark
Municipality Policy Controls				\checkmark	\checkmark
Local Economic Controls					\checkmark
Observations	$378,\!348$	$378,\!348$	$378,\!348$	369,335	$369,\!335$
Municipalities	$3,\!628$	$3,\!628$	$3,\!628$	$3,\!579$	$3,\!579$
Data Availability Period	2010-2017	2010-2017	2010-2017	2010-2017	2010-2017

Note: Shown are the coefficients and standard errors for "high broadband state" under different specifications of the RDD polynomials, with each cell in the table reporting the result of a separate regression. Panel A displays estimates for linear, quadratic, and linear interacted RDD polynomials in distance to the state boundary, whereas Panel B presents the results for linear, quadratic, cubic, and quartic RDD specifications in longitude and latitude. Real estate prices are log values to facilitate better comparability of the estimates. Standard errors are clustered at the boundary-region-by-year level. *p<0.1; **p<0.05; ***p<0.01.

Table 4: Main Results of the Spatial RDD for Real Estate Rents (16 Mbit/s)

4.4 Heterogeneity Analysis

Figure 5 provides an overview of the heterogeneity analysis, while detailed results are provided in Appendix C.



Note: This coefficient plot provides an overview of the spatial RDD results for the heterogeneity analyses by different Internet speeds, over time, and by property types. The results for property sale prices are presented in Panel A and the results for property rents in Panel B. The plot reports the coefficients and 95 percent confidence intervals for regressions of "high broadband state" on property sale prices and rents using the preferred RDD specification with linear polynomials in longitude and latitude. Real estate prices are log values to facilitate better comparability of the estimates. Standard errors are clustered at the boundary-region-by-year level. The vertical dotted grey line marks zero. The detailed results are reported in Appendix C.

Figure 5: Overview of Heterogeneity Analysis Results of Spatial RDD

Positive But Diminishing Returns to Higher Internet Speeds. Having established the main results for broadband at 16 Mbit/s, we now turn to the effects of higher speeds, specifically 30 and 50 Mbit/s. The results in Figure 5 indicate that while the effects of "high" broadband states remain positive for these higher speeds, they are slightly smaller than those for the main broadband speed 16 Mbit/s.¹⁵ It is important to note that these estimates capture the difference between a "high" and "low" broadband state *at the specific speed level* and do not directly compare higher speeds to a baseline of less than 16 Mbit/s as in our main analysis. These findings suggest that while consumers in the sample period

 $^{^{15}\}mathrm{Appendix}$ Table A5 reports the results for 30 and 50 Mbit/s, while Figures A13 and A14 display RD plots for sale prices and rents at these speeds. The reduced significance for 30 Mbit/s is likely due, at least in part, to the smaller sample size relative to the 16 and 50 Mbit/s estimations.

value faster Internet speeds, the incremental benefits diminish at higher threshold speeds. The Internet speed upgrade to 16 Mbit/s appears to deliver the most substantial economic value.

Increasing Value of High Internet Speeds over Time. Faster Internet speeds enable new applications that become more valuable as they develop and gain users through network effects. To examine this dynamic, we analyze how the capitalization effects of broadband access vary over time by estimating the spatial RDD with an additional interaction term between the indicator for "high" broadband states and a respective cutoff year for each broadband speed. Figure 5 summarizes the results (coefficients and confidence intervals on the interaction effects), with detailed estimates reported in Appendix Table A6. For sale prices and 16 Mbit/s broadband, we find a significantly positive interaction effect between "high" broadband states and the time period since 2016. The coefficient estimate on this interaction term yields an additional effect of 12.8 percentage points in the preferred linear longitude-latitude specification. For rents, the estimates remain insignificant. For 30 and 50 Mbit/s, we also find significantly positive additional effects on sale prices in later years, while the effects on rents are insignificant. We interpret this as evidence of growing demand for bandwidth-intensive applications in more recent years, as households increasingly value faster Internet to support evolving digital activities. At the same time, the lack of high-speed broadband may be increasingly penalized, particularly in property sales where future expectations of broadband expansion play a larger role.

Stronger Effects in More Densely Populated Municipalities. Figure 5 provides another heterogeneity analysis, splitting the sample based on population density in municipalities (between bottom half and top half; see detailed results in Appendix Table A7). The results show that capitalization effects are more pronounced in slightly more populated municipalities compared to their very rural counterparts for both sale prices and rents, suggesting a positive relationship between broadband's economic value and population density.

Stronger Effects for Houses than Apartments. While the main analysis reports estimates for a pooled sample of houses and apartments, this heterogeneity analysis aims to identify differential effects by separately estimating the effects for houses and apartments. Figure 5 summarizes these results, with detailed estimates in Table A8. We find significantly positive results for both houses and apartments, but the effects on sale prices and rents are higher for houses than for apartments. This difference may reflect lower average moving costs for apartments, which shorten the time horizon over which a fast Internet connection is valued (and uncertainty regarding the next buyer's valuation).

4.5 Specification, Robustness, and Placebo Checks

Figure 6 provides an overview of specification, robustness, and placebo checks, while detailed results are provided in Appendix D.



Note: This coefficient plot provides an overview of the spatial RDD results for the specification checks, robustness checks, and placebo checks. The results for property sale prices are presented in Panel A and the results for property rents in Panel B. The plot reports the coefficients and 95 percent confidence intervals for regressions of "high broadband state" on property sale prices and rents using the preferred RDD specification with linear polynomials in longitude and latitude. Real estate prices are log values to facilitate better comparability of the estimates. Standard errors are clustered at the boundary-region-by-year level. The vertical dotted grey line marks zero. The detailed results are reported in Appendix D Specification Checks, Appendix E Robustness Checks, and Appendix F Placebo Checks.

Figure 6: Overview of Specification, Robustness, and Placebo Checks of Spatial RDD

Specification Checks: Donut Hole Approach. To check the sensitivity of the estimates to the specific sample we select for our main analysis, we employ a "donut hole" approach. This addresses the concern that properties at the border may not be representative of rural municipalities overall. Furthermore, it excludes potential spillover effects near the border. While the bandwidth is again 25 kilometers, as in our main specification, properties which are very close to the border are excluded. Figure 6 shows that omitting a 2, 5, or 10 kilometer radius from the border does not substantially change the effect of "high" broadband states on sale prices and rents (see detailed results in Appendix Table A10).

Specification Checks: Bandwidths. The second set of specification checks uses different bandwidths, both larger and smaller than the main bandwidth of 25 kilometers

around state borders. In Appendix Figures A15 and A16, we present graphical evidence in RD plots for bandwidths of 15 and 50 kilometers, respectively. Table A9 complements the graphs with the corresponding estimates for the smaller and larger bandwidths, as well as the 25 kilometer bandwidth for comparison. Overall, the findings demonstrate that the estimated effects remain consistent in magnitude and statistically significant independent of the specific bandwidth choice. The main 25 km bandwidth strikes a balance between reducing bias and maintaining precision. A narrower bandwidth ensures greater comparability by focusing on locations with similar regional characteristics, but it also restricts the sample, potentially excluding important regions, such as East-West German state borders, where properties may be sparse near the boundary. In contrast, a larger bandwidth increases the sample size and statistical power but risks introducing bias by including more distant and less comparable properties.

Robustness Checks on Sample. We conduct a series of robustness checks of the sample in Appendix Tables A12 and A13 to confirm that our results are not driven by specific regions, states, or boundary regions.

First, we test whether the effects hold in West Germany only by excluding East German states to account for persistent structural differences. The estimates remain significantly positive, which suggests that East Germany does not drive the observed effects but rather that its inclusion may slightly attenuate the results.

Second, we analyze the effects of "high" and "low" broadband states in East Germany only. The estimates yield broadly similar results, although with higher standard errors, suggesting that the effects are not unique to either region.

Third, we remove Rhineland-Palatinate from the sample due to its unique regional structure with extremely small municipalities and status as a "low" broadband state for 16 Mbit/s until 2013. The results without Rhineland-Palatinate are consistent with the main findings, ruling out that its specific characteristics drive the effects.

Fourth, we expand the sample to include larger municipalities around state borders, relaxing the restriction of fewer than 20,000 inhabitants. Large municipalities are slightly more prevalent in "high" broadband states and exhibit higher property prices. Although the estimated effects are marginally larger than in the main sample, this exercise demonstrates that the results are robust to including more urbanized areas.

Fifth, we include additional control variables for commuting times to key infrastructure, such as airports, major cities, motorways, and hospitals. As shown in Appendix Figure A19, they reflect minor regional differences in standard of living and accessibility of infrastructure. Adding these controls does not substantially alter the results.

Finally, we conduct a leave-one-out analysis in Appendix Figures A17 and A18 by systematically excluding individual boundary regions from the sample. The results remain robust, confirming that no boundary region disproportionately influences the results.

"High" Broadband State Threshold. Further results in Figure 6 show the robustness of our results to changing the cutoff for the classification of "high" broadband states (note that changing the cutoff also entails a change of the sample). Using a higher cutoff of 85 percent and a lower one of 65 percent, we find qualitatively similar results as with our main 75 percent cutoff (see Appendix Table A14). Appendix Figure A12 explores to which extent the effect size depends on the level of broadband availability further and shows a smooth curve around the 75 percent threshold used in our main analysis.

Placebo Check: No Effect After Expansion. While the validity of an RDD can never be fully proven, a placebo check provides suggestive evidence for a causal effect (Cattaneo et al., 2019). If differences in property prices between "high" and "low" broadband states are driven by broadband availability, these effects should disappear once "low" broadband states catch up. We test this by examining 2019, the final year of the sample period, when differences in 16 Mbit/s availability between neighboring municipalities had largely disappeared. Persistent differences in property prices or rents would suggest the influence of other factors, undermining broadband availability as the primary driver. The results in Figure 6 and Appendix Table A15 find no significant effects in 2019. This finding has two implications: First, it supports the validity of our RDD framework, suggesting that neighboring border municipalities are sufficiently comparable and that our estimates capture the effects of fast broadband as long as the spatial discontinuity at state borders exists. Second, it highlights the temporary nature of the capitalization effects. As the connectivity gaps close and 16 Mbit/s broadband access becomes universal, the property price premium diminishes. This is not because its benefits disappear, but because it is no longer a differentiating factor. Without a spatial discontinuity, our design can no longer identify capitalization effects, although households still benefit from high-speed Internet.

Coarsened Exact Matching. We conduct a further robustness check using Coarsened Exact Matching (CEM) to address concerns about the similarity of neighboring municipalities in Appendix G.1. By matching on unemployment rate, school quality, and crime rate terciles, we ensure that treatment and control municipalities are comparable while maintaining sufficient observations for estimation. The regression estimates using the CEM sample and weights yield estimates for sale prices and rents that are consistent with our main results, supporting the comparability of the two groups.

Alternative Identification: Event Study Estimates. Finally, a rather different approach is presented with the event study design in Appendix Figure A20. Note that the "event" in our setting happens when a municipality surpasses the threshold of providing 75 percent of households with at least 16 Mbit/s Internet. Since this share increases gradually over time, the observed pre-trend is expected. Nonetheless, the design intuitively illustrates that prices significantly increase as broadband coverage is expanded.

5 Mechanisms

This section examines the mechanisms driving the observed increases in property prices and rents from faster Internet access. Equilibrium price changes can result from shifts in demand and/or supply. However, the absence of significant differences in the number of property listings on the "high" broadband side of state borders (see Appendix Figures A3 and A5) and the low short-term elasticity of housing supply (Baum-Snow and Han, 2024) suggest the effects are demand-driven. We thus focus on two key demand-side mechanisms: migration and Internet usage.

5.1 Migration

Based on administrative data, we study net domestic migration to municipalities in border regions of "high" and "low" broadband states as a potential indicator of increasing demand. As the spatial discontinuity in Figure 7 shows, municipalities in "high" broadband states for 16 Mbit/s exhibit higher net inflows than those in "low" states. The fact that real estate prices and rents increase with faster Internet availability suggests that there is higher demand increasing prices, rather than lower prices attracting new residents. In the next subsection, we explore further why faster Internet speeds may be attractive, i.e. to which extent they are being used and for what purposes.

5.2 Internet Usage

Any conceivable causal channel from broadband access to real estate prices and rents runs through Internet usage. Uptake is necessary for any capitalization effect of broadband's labor market, consumption, and information value. Since both current demand and expectations about future needs may influence capitalization, we examine the relationship between broadband availability and the speed levels households actually purchase.

We use data from the 2018 German micro-census, which provides information on actual broadband usage, to correlate household usage with broadband availability.¹⁶ Since all states were classified as "high" broadband states for 16 Mbit/s by 2018, we classify states based on whether they were "early adopters" of 16, 30, and 50 Mbit/s, defined as being among the earlier half of states to reach the "high" broadband threshold. This approach accounts for time lags in adoption due to contract expirations and delayed upgrades. For consistency, we apply the same classification to 30 and 50 Mbit/s. Thus, variation comes from the duration that these speeds have been available rather than their availability at the time of the micro-census.¹⁷

 $^{^{16}{\}rm Since}$ micro-census responses are available at the county level, municipalities in our sample are assigned the survey responses from the county they belong to.

¹⁷Another reason for this approach is that uptake likely follows availability with some delay, e.g. households might switch provider and upgrade once their existing contracts expire. "Early adopter" states



Note: This spatial RD plot shows average yearly net migration to counties around the boundaries of "high" and "low" broadband states for 16 Mbit/s broadband Internet. "Distance to border in km" on the x-axis refers to the distance in kilometers between the observation and the closest state boundary, with negative values of distance indicating "high" broadband states. The RD plot was generated by an evenly spaced number of bins, representing the sample average within each bin, net of boundary-region-by-year fixed effects. The solid lines represent the predicted values from a regression of the outcome variable on a first-order polynomial in distance to the boundary. The corresponding 95 percent confidence intervals are displayed as dotted lines.

Figure 7: Spatial RD Plot for Average Yearly Net Migration

Uptake of Broadband Subscriptions. Figure 8 Panel A shows that the uptake of high-speed broadband subscriptions above 16 Mbit/s is approximately 10 percentage points higher in "high" municipalities at the boundary. Appendix Table A18 complements the figure with further descriptive statistics on contractual speed levels in municipalities. The speed categories differ slightly from those for broadband availability in the main analysis due to the answer options provided in the survey. Taken together, the higher uptake in "high" municipalities suggests that broadband expansion addresses pre-existing demand for faster Internet speeds. We interpret this as a key mechanism driving the observed capitalization effects on property prices and rents.

The observed increase in the uptake of fast broadband subscriptions may reflect several channels. First, broadband expansion seems to address previously unmet demand for higher speeds in underserved areas. Second, local network effects, such as neighbors adopting faster connections, may additionally boost demand for higher speeds. Third, behavioral factors, such as the compromise effect, might incentivize users to select intermediate speeds, including those that were once the highest available. Finally, increased advertising and the salience of broadband access may elevate demand across all speeds.

are classified as "high" broadband states for 16 Mbit/s for more than six years in the sample, i.e. they have become a "high" broadband state in 2013 or earlier.


Note: Shown are spatial RD plots for the share of households with broadband subscriptions faster than 16 Mbit/s (Panel A), the share of the week worked from home (Panel B), both based on the 2018 German micro-census, and the number of average yearly outbound commuters from counties (Panel C). The outcomes are plotted on the y-axis. "Distance to border in km" on the x-axis refers to the distance in kilometers between the observation and the closest state boundary, with negative values of distance indicating "high" broadband states. The RD plots are generated by an evenly spaced number of bins, representing the sample average within each bin, net of boundary-region-by-year fixed effects. The solid lines represent the predicted values from a regression of the outcome variable on a first-order polynomial in distance to the boundary. The corresponding 95 percent confidence intervals are displayed as dotted lines.

Figure 8: Spatial RD Plots for Broadband Subscriptions, Working From Home, and Outbound Commuters

Working from Home. The pandemic has led to a sudden increase in remote work, making fast Internet connections capable of supporting videoconferencing and other collaboration tools essential for many households. Evidence from the 2018 German microcensus indicates that the link between fast Internet and remote work was already evident even before the pandemic. Figure 8 Panel B shows the corresponding RD plot with the average share of the work week worked from home. A clear discontinuity is visible at the state border, with "high" broadband states exhibiting a 0.6 percentage point higher share of remote work, which is equivalent to a 12 percent increase. As Appendix Table A18 reports, the difference is slightly larger when considering households working remotely at least part-time, at around one percentage point.

Outbound Commuters. Remote work can reduce commuting frequencies, allowing workers to accept jobs at more distant workplaces. To explore this potential mechanism, we study outbound commuters in our sample in the RD plot in Figure 8 Panel C. A discontinuity at the state border is visible here as well, with many more outbound commuters in "high" broadband states. This is consistent with survey evidence showing that work from home has already been more common among long-distance commuters (Alipour et al., 2020). Thus, daily time savings when working from home for these commuters are likely even higher than the average for Germany of 65 minutes found by Aksoy et al. (2022).

Discussion. Overall, the evidence suggests that capitalization effects are primarily driven by current demand rather than by expectations about future needs. One reason contemporary demand plays a larger role is the discounting of future utility from broadband access compared to its immediate value. Additionally, households likely anticipate that broadband availability will eventually improve universally, reducing the perceived scarcity of fast Internet.

6 Policy Evaluation

In this section, we apply our results to evaluate broadband expansion policies. The extent of required government subsidies depends on whether the consumer surplus from fast broadband access exceeds deployment costs. In Germany, where the policy objective is universal access to fast Internet connections, the critical question is not whether rural broadband expansion is justified on welfare grounds but rather *how much subsidies are necessary* to achieve this goal efficiently.

Importantly, a smaller consumer surplus than deployment costs does not necessarily imply that subsidies are unwarranted. Broader economic benefits, such as spillovers or network externalities, may justify public investment. Subsidies can also address coordination failures among households or enable investments that would otherwise be constrained by credit limitations, even when the benefits exceed the costs. Conversely, if households' willingness to pay exceeds deployment costs, this indicates that subsidies are unnecessary and serve primarily as redistribution to property owners, provided no coordination problem exists.

Cost-Benefit Analysis. While we do not have fine-grained data on the costs of a connection in our main sample period, we use data about costs from the later federal NGA program for a cost-benefit analysis. We rank the costs per connected households to estimate the share of households in municipalities (among those that applied for funding through the federal program, i.e., which were not yet sufficiently connected) that could arguably have been connected through private funds, as households' willingness to pay exceeded deployment costs. Note that this cost-benefit calculation compares data from the later federal program, which focused on 50 Mbit/s connections, with estimates from an earlier period based on 16 Mbit/s. Since our estimates are from an earlier period, the relevant and more comparable speed with respect to willingness to pay seemed to be 16 Mbit/s rather than 50 Mbit/s, since costs for a given speed level decrease over time. The calculation is carried out to provide a rough estimate of the share of households that may have been willing to fully finance broadband expansion privately had it not been subsidized.

For the valuation, we show our main estimate with the 95% confidence interval in the graph. To get a euro value, we multiply the percentage increase in sales prices with the median house price in "low" broadband state municipalities.

The results in Figure 9 show that at the main estimate of a valuation of 9154 euros, approximately 90 percent of projects could have been funded. The confidence interval of the share of households that could be connected ranges from approximately 72 to 97 percent.¹⁸ While these calculations are not precise estimates and should be interpreted with caution, they still suggest that a sizable fraction of subsidized projects could potentially have been funded privately, as there may have existed sufficient demand from consumers.¹⁹

MVPF Analysis. The public policy decision can also be studied in the context of the Marginal Value of Public Funds (MVPF) framework, which has been proposed in the public finance literature in recent years (Hendren and Sprung-Keyser, 2020; Finkelstein and Hendren, 2020; Hendren et al., 2022). While a high MVPF typically indicates the efficiency of a public policy, in our context it suggests that broadband access could potentially have

¹⁸Note that, while the constant valuation shown in the figure is a simplification, with the available data we cannot assign specific valuations to different cost levels. It is not clear whether more costly projects tend to belong to households that value faster Internet access more or less. While average valuation may in fact decrease with costs, the valuation curve cannot necessarily be assumed to be downward sloping (as a regular demand curve would be), which would decrease the share of projects that could be privately funded.

¹⁹Note that if redistribution were part of the goal of the policy, there are arguably more targeted approaches than a subsidy, which is appropriated mainly by real estate owners.



Note: Costs per connected 50 Mbit/s household in NGA program for applications filed 2016/17. Blue dashed lines indicate the highest and lowest estimated valuation of 16 Mbit/s connections in our main estimation in levels. The solid blue line indicates the estimate of our preferred specification. The corresponding grey lines indicate the share of households/connections covered at those values.

Figure 9: Cost and Average Valuation per Connected Household (50 Mbit/s)

been provided privately without subsidies, given households' high willingness to pay.

$$MVPF = \frac{\text{Benefit to recipients}}{\text{Net costs for government}} \approx \frac{\text{WTP}}{\text{Costs of access}}$$

For simplicity, we can assume that the entire project is funded by the government, such that the total costs of a project are in the denominator of the equation.²⁰ This allows for a cost-benefit calculation to study the implications of a positive effect of broadband expansion on tax revenues through increased property transaction tax revenue in future sales.

In this exercise, we show the impact on MVPFs of a variety of realistic property transaction tax rates τ and interest rates r to discount future revenue. The real estate transaction tax rate in German states varies from 3.5 to 6.5 percent. We use both, as well as an intermediate rate of 5 percent.

We approximate the time to the next property sale T based on the average mobility

 $^{^{20}}$ Subtracting x euros in the denominator from the costs to the government and subtracting the same amount in the numerator from the recipient's benefit would not change whether the MVPF is larger than one, for example, as long as further revenue implications of this change are negligible and can be disregarded.

of the populations. Every year about one in ten Germans moves (EnBW, 2021). Thus the average time to the next move is five years. Again, this is a simplification, as not every move entails a property sale and for owners mobility may be lower. Moreover, mobility varies across regions. We assume that the added value of this particular broadband expansion for sales after the next one (which would be expected to happen in 15 years) is negligible due to technical progress and the possibility of leapfrogging to even better technologies.

We can then solve the following equation for the maximum costs for an MVPF larger than one:

$$\mathrm{MVPF} = \frac{\mathrm{WTP}}{\mathrm{Cost} - (1+r)^{-T}\tau\mathrm{WTP}} > 1$$

A shorter time to the next property sale implies a larger effect except in the case of a zero interest rate. The discount rate does not play a major role over a short time horizon of 5 years, but the table shows some cases around the interest rates set by the European Central Bank in our time period. Including positive effects on additional later sales would increase the effect.

The results are shown in Table A19 in the Appendix. With realistic numbers, the relative increase of the maximum cost level $((1 + r)^{-T}\tau)$ is slightly smaller than the tax rate (for low interest rates and a short number of years to the next sale). Hence there is some effect, but it is not large, with a maximum cost of access that is about 4 percent higher than in the absence of revenue effects. Thus, a few percent of projects "should" be financed in those cases that would not happen under private funding (which is the benchmark case in the first row of Appendix Table A19).

Discussion. The cost-benefit and MVPF analyses of broadband expansion subsidies in Germany reveal that the willingness to pay exceeds deployment costs for most households, suggesting that subsidies were unnecessary for many connections. This finding indicates that universal broadband access could likely have been achieved at a lower fiscal cost. However, subsidies may have addressed coordination failures among households willing to pay but unable to collectively finance broadband deployment.

The MVPF analysis further suggests that subsidies may be warranted for a small subset of households with a willingness to pay below deployment costs, provided the MVPF exceeds one. Evidence from Hendren and Sprung-Keyser (2020) highlights that educational policies benefiting children often generate higher returns.²¹ In our setting, faster broadband may benefit entire households, including educational gains for children, which are not fully captured in households' willingness to pay. Our estimates do not factor in significant externalities such as network effects, reduced commuting, or broader economic

 $^{^{21}}$ See https://www.policyinsights.org for an overview of MVPFs across policies. Hendren and Sprung-Keyser (2020) find MVPFs lower than one for housing voucher programs.

benefits, which could justify broadband subsidies. Nonetheless, these externalities do not alter the finding that most households' willingness to pay exceeds costs.

Importantly, the broadband subsidies have uneven distributional consequences, at least as long as the discontinuity in availability persists. While residents benefit from faster Internet access, property owners disproportionately capture the gains through increased property values and rents, effectively redistributing some of the subsidies' benefits to them. This highlights distributive inequities in a policy aimed primarily at improving households' access to fast Internet. Overall, the findings suggest that Germany's objective of universal broadband access could have been achieved more efficiently with lower subsidies, reducing inefficiencies in the allocation of public funds.

7 Conclusion

This study demonstrates the significant impact of high-speed broadband Internet on real estate prices in Germany. Using a spatial RDD and rich micro-data, we exploit variation at state borders induced by broadband expansion policies to identify the causal effect. We find that property sale prices increase in "high" broadband states by up to 8 percent (\notin 14,700 on average) and rents by 3.8 percent (\notin 17 per month), underscoring the economic value households place on fast Internet access. Heterogeneity analyses reveal diminishing returns to higher speeds but growing effects over time. We show that the effects are primarily driven by current demand, including migration to high-broadband municipalities, more fast broadband subscriptions and higher remote work adoption.

Our policy evaluation indicates that broadband subsidies were unnecessary for most households, since their willingness to pay exceeded deployment costs. However, subsidies may have addressed coordination failures or generated broader economic benefits, such as educational gains or network externalities. Importantly, the uneven distributional effects show that while residents benefit from faster Internet access, property owners capture much of the value through higher property prices and rents. Overall, our results suggest that Germany's goal of universal broadband access could have been achieved at lower fiscal cost with more targeted subsidies.

Our findings have several implications for public policy and future research. Policymakers should target subsidies more effectively to maximize social benefits and minimize inefficiencies, particularly by prioritizing regions with low willingness or ability to pay. The interplay between broadband expansion and spatial inequality is a potential avenue for future research. Future studies could also investigate how the value of broadband evolves with technological advancements, further speed upgrades and changing user demands, particularly in light of increasing reliance on digital infrastructure for work, education, and healthcare.

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A Institutional Background: Broadband Expansion Policies in Germany's Federal States

Broadband Expansion Policies in Germany's Federal States: Part I

Federal State	Time Period	State's Broadband Expansion Program	Expansion Program Type	Expansion Program Details
Baden- Württemberg	2008-2009	Rural Broadband Initiative [1]-[4]	Financial funding as an investment cost subsidy	Financial funding for municipalities in rural areas with no or insufficient broadband coverage of EUR 20 million.
	2015-2022	Baden-Württemberg Broadband initiative II / Baden-Württemberg NGA funding regulation [5]-[8]	Financial funding in the operator model	Financial funding for municipalities, associations of munic- ipalities and rural districts in rural-and commercial areas on the outskirts of towns that are in 'NGA white and grey areas', after an internal revision by a specialist office or by the Landesanstalt für Kommunikation Baden-Württemberg and an approval from the European Commission in the case
			Support of a simplified legal frame- work	of 'NGA grey areas', amounting to EUR 253.6 million. Financial funding of coordination and management oper- ations in inter-municipal cooperations in the construction of NGA networks, leading to economies of scale of public authorities and thus speeding up the application process.
Bavaria	2008-2010	Broadband development in rural areas of Bavaria [9]	Financial funding in the profitabil- ity gap model	Financial funding for small and medium-sized enterprises in rural areas of Bavaria with little or no existing broadband use, after a verification by public authorities regarding the project's profitebility gan amounting to EUR 20 million
	2012-2019	Directive on the funding of the es- tablishment of high-speed networks in the Free State of Bavaria [10]-[11]	Financial funding in the profitabil- ity gap model	Financial funding for municipalities, associations of municipalities and municipal associations in the Free State of Bavaria where an improvement in existing broadband cover- age can be achieved, amounting to EUR 1.5 billion.
			Support of a simplified legal frame- work	Financial funding in the form of an increase in the maximum funding amount in the case of inter-municipal cooperation.
Berlin	2014-2020	Law on the Joint Task 'Improve- ment of the Regional Economic Structure' (GRW Law) [12]	Financial funding in the profitabil- ity gap model and operator model	Financial funding for the measure sponsors, Berlin districts, natural persons or legal entities that are not profit-oriented in "NGA white" commercial areas/commercial collections, after a market investigation procedure and an application to the Senate Department for Economic Affairs, Energy and Oversitions
			Support of a simplified legal frame- work	Direct funding of network operators, eliminating thus admin- istrative burdens on districts.
Brandenburg	from 2013 onwards	Brandenburg Fiber Optics 2020 [13]-[15]	Financial funding as an investment cost subsidy	Financial funding for TC companies in areas with no connec- tion to backhaul fiber-optic networks and in which broadband coverage cannot be attributed to competing broadband in- frastructures, amounting to EUR 94 million.
Bremen	2014-2021	GA/GRW funding program [16]	Financial funding in the profitabil- ity gap model	Financial funding in areas that lack NGA infrastructure and in 'NGA white areas'. The determination of 'NGA white areas' must be verified within the scope of a market investigation procedure. The classification of Bremen into a C or D funding area, according to which the funding rate can vary, should be noted. Bremen remains a GRW eligible area beyond 2021.
Hamburg	from 2015 onwards	Federal funding program for broad- band expansion [17]-[18]	Financial funding in the profitabil- ity gap model, operator model and in consulting services	Financial funding for local authorities in which the project area is located, especially municipalities, city states, admin- istrative districts, municipal special-purpose associations or another local authority or an association under the respective local authority law of the federal states.
Hesse	2016-2020	Directive on the funding of broad- band supply in the state, Hesse- Part 6: Federal state funding for broadband infrastructure expan- sion [19]-[20]	Financial funding in the profitabil- ity gap model and operator model Support of a simplified legal frame- work	Financial funding for municipalities, associations of munic- ipalities, local authorities and 100 publicly owned private companies in areas with no broadband coverage, amounting to EUR 46 million from the digital dividend II and from federal state funds. Financial funding of coordination and management opera- tions in inter-municipal cooperations in the construction of NGA networks, leading thus to economics of scale of public
Mecklenburg- Western Pomerania	from 2015 onwards	Federal funding program for broad- band expansion [21]-[22]	Financial funding in the profitabil- ity gap model, operator model and in consulting services	Financial funding for local authorities of state of photo authorities and speeding up the application process. Financial funding for local authorities in which the project area is located, especially municipalities, city states, admin- istrative districts, municipal special-purpose associations or another local authority or an association under the respective local authority law of the federal states, amounting to EUR 520 million as co-financing for the government funds and for the municipal share.

Note: All federal states offer financial funding as project share financing in the form of a non-repayable grant. Baden-Württemberg also offers the possibility of a fixed grant as funding. In the states Berlin, Bremen, Hamburg and Mecklenburg-Western Pomerania the programs are not state funding programs, but federal funding programs for broadband expansion or other, such as the GRW funding program.

Table A1: Broadband Expansion Programs Part I

Broadband Expansion Policies in Germany's Federal States: Part II

Federal State	Time Period	State's Broadband Expansion	Expansion Program Type	Expansion Program Details
		Program		
Lower Saxony	2016-2021	Directive Broadband Expansion	Financial funding in the operator	Financial funding for local authorities, joint municipalities
		Lower Saxony [23]-[27]	model	and municipal associations, after an application to the Nbank,
				amounting to EUR 58 million from the digital dividend II.
	from 2019 onwards	Directive Giganet Expansion Lower	Financial funding in the profitabil-	Financial funding in counties, independent cities, the Hanover
		Saxony [28]	ity gap model and operator model	region and local authorities (first-time recipients) that are
				"NGA white areas".
North Rhine-	2016-2021	Directive on the granting of subsi-	Financial funding in the profitabil-	Financial funding for municipalities, associations of munic-
Westphalia		dies to promote NGA in rural areas	ity gap model and operator model	ipalities and districts in residential areas, mixed areas and
		[29]		rural areas in North Rhine-Westphalia with a funding volume
				taken from the digital dividend II and the Eler.
Rhineland-	2015-2020	Directive on the funding of the roll-	Financial funding in the profitabil-	Financial funding for administrative districts, associations
Palatinate		out of high-speed broadband net-	ity gap model and operator model	of associations, municipalities not belonging to associations,
		works [30]-[31]		special-purpose associations and legally responsible institu-
				tions under public law in "NGA white areas", after a review
				by the Ministry of the Interior, Sports and Infrastructure and
				often a feasibility study, amounting to EUR 124.7 million.
Saarland	2019-2022	Directive on the funding of individ-	Financial funding	Financial funding for businesses, cultural institutions, and
		ual fiber-optic connections for high-		non-profit organizations in the Saarland that need a fiber-
		demand customers in the Saarland		optic connection ("high-need users").
		("Gigabit Premium") [32]		
Saxony	2018-2023	Directive Digital Offensive Saxony	Financial funding in the profitabil-	Financial funding, based on the federal funding program,
		[33]-[34]	ity gap model, operator model and	for consulting services of broadband projects and for hot
			in consulting services	spots/WLAN in public areas relevant to tourism, amounting
				to EUR 200 million from state funds, EUR 80 million from
				EU funds and EUR 32 million from the digital dividend II.
Saxony-Anhalt	from 2015 onwards	Directive on the granting of subsi-	Financial funding in the profitabil-	Financial funding for municipalities, including administra-
		dies to fund next generation access	ity gap model, operator model and	tive districts, and special-purpose municipal associations,
		- broadband expansion in Saxony-	in consulting services	amounting to EUR 550 minion (70 minion from EAFRD, 24
		Annan [55]-[50]		funde)
		+	Support of a simplified logal frame	Funding for cortified broadband consultants who support
			Support of a simplified legal frame-	and advise grantees on breadband investments. Funding
			work	for planning services only if these are provided by certified
				broadband consultants
Schleswig-	2017-2021	Directive on the promotion of	Financial funding in the profitabil-	Financial funding for municipalities and associations of mu-
Holstein		broadband supply in rural areas of	ity gap model, operator model and	nicipalities in rural areas, with proof of a lack of or inadequate
		Schleswig-Holstein (Broadband Di-	in consulting services	broadband supply, amounting to EUR 71 million (EUR 36
		rective) [37]-[38]		million from GAK, EAFRD, GRW, EUR 14 million from the
		, , , , , , , , , , , , , , , , , , , ,		state of Schleswig-Holstein, EUR 21 million from the digital
				dividend II).
Thuringia	2017-2020	Directive of the Free State of	Financial funding in the profitabil-	Financial funding for local authorities, associations of local
		Thuringia to promote the expan-	ity gap model, operator model and	authorities or mergers of local authorities in the Free State of
		sion of high-performance broad-	in consulting services	Thuringia, public-law companies, companies organized under
		band infrastructures (Broadband		private law and owned by public-law bodies, and private TC
		Expansion Directive) [39]-[40]		companies, amounting to EUR 520 million (175 million of
		l		which from federal state funds).
			Support of a simplified legal frame-	Financial funding of inter-municipal cooperation.
			work	

Note: All federal states offer financial funding as project share financing in the form of a non-repayable grant. Baden-Württemberg also offers the possibility of a fixed grant as funding. In the states Berlin, Bremen, Hamburg and Mecklenburg-Western Pomerania the programs are not state funding programs, but federal funding programs for broadband expansion or other, such as the GRW funding program.

Table A2: Broadband Expansion Programs Part II

Information Sources Regarding The Broadband Expansion Programs From Tables I and II²²:

- [1] https://mlr.baden-wuerttemberg.de/de/unser-service/presse-und-oeffentlichkeitsarbeit/pressemitteilung/pressemitteilung/pid/erstmalig-landesfoerderung-zum-ausbau-der-breitbandinfrastruktur-im-laendlichen-raum-1/
- https://mlr.baden-wuerttemberg.de/de/unser-service/presse-und-oeffentlichkeitsarbeit/pressemitteilung/pressemitteilung/pid/initiative-baden-wuerttembergs-bei-der-agrarministerkonferenz-erfolgreich-1/
- [3] https://mlr.baden-wuerttemberg.de/de/unser-service/presse-und-oeffentlichkeitsarbeit/pressemitteilung/pid/ministerrat-gibt-gruenes-licht-fuer-deutschlands-umfassendste-breitband-initiative-laendlicher-raum-1/
- [4] https://www.baden-wuerttemberg.de/fileadmin/redaktion/m-im/intern/dateien/publikationen/20200911_Breitbandbericht_ Baden-WÄijrttemberg.pdf
- [5] https://mlr.baden-wuerttemberg.de/de/unser-service/presse-und-oeffentlichkeitsarbeit/pressemitteilungen/pressemitteilung/ pid/leben-und-arbeiten-40-breitbandausbau-kommt-nach-baden-wuerttembergischem-modell-mit-hochgeschwind/
- [6] https://mlr.baden-wuerttemberg.de/de/unser-service/presse-und-oeffentlichkeitsarbeit/pressemitteilung/pressemitteilung/pid/breitbandausbau-laeuft-gruen-rot-hat-jetzt-schon-mehr-projekte-bewilligt-als-alle-vorgaengerregieru/
- [7] https://www.baden-wuerttemberg.de/fileadmin/redaktion/m-im/intern/dateien/publikationen/20200911_Breitbandbericht_ Baden-WÄijrttemberg.pdf
- [8] https://ec.europa.eu/competition/state_aid/cases/257876/257876_1719703_130_2.pdf
- $[9] \ https://ec.europa.eu/competition/state_aid/cases/225952/225952_885446_30_2.pdf$
- [10] https://www.schnelles-internet-in-bayern.de/file/pdf/432/Breitbandrichtlinie%20vom%2010.%20Juli%202014.pdf/www.schnelles-internet-in-bayern.de/file/pdf/432/Breitbandrichtlinie%20vom%2010.%20Juli%202014.pdf/www.schnelles-internet-in-bayern.de/file/pdf/432/Breitbandrichtlinie%20vom%2010.%20Juli%202014.pdf/www.schnelles-internet-in-bayern.de/file/pdf/432/Breitbandrichtlinie%20vom%2010.%20Juli%202014.pdf/www.schnelles-internet-in-bayern.de/file/pdf/432/Breitbandrichtlinie%20vom%2010.%20Juli%202014.pdf/www.schnelles-internet-in-bayern.de/file/pdf/432/Breitbandrichtlinie%20vom%2010.%20Juli%202014.pdf/www.schnelles-internet-in-bayern.de/file/pdf/432/Breitbandrichtlinie%20vom%2010.%20Juli%202014.pdf/www.schnelles-internet-i
- [11] https://www.schnelles-internet-in-bayern.de/file/pdf/453/Digitale_Infrastruktur_Bayern_2021.pdf
- $[12] https://www.breitband.berlin.de/data/BKT_Basisinfo_2020.pdf$
- [13] https://ec.europa.eu/competition/state_aid/cases/246253/246253_1399339_77_1.pdf
- $[14] \ https://ec.europa.eu/competition/state_aid/cases/248698/248698_1471121_80_2.pdf$
- $[15] https://www.breitbandausschreibungen.de/downloadFile/Doc/21_Brandenburg_Glasfaser_2020_III.pdf$
- [16] https://www.bmwi.de/Redaktion/DE/Downloads/J-L/koordinierungsrahmengemeinschaftsaufgabe-verbesserung-regionalewirtschaftsstruktur.pdf?___blob=publicationFile&v=15
- [17] https://custom-maps.data4.solutions/fhh-content/
- [18] https://atenekom.eu/wp-content/uploads/2018/08/foerderrichtlinie-breitbandausbau.pdf
- [19] https://www.breitbandbuero-hessen.de/mm/Breitbandrichtlinie_Hessen.pdf
- $[20] https://www.digitalstrategie-hessen.de/mm/Fortschrittsbericht_Digitalstrategie_Hessen.pdf$
- [21] https://www.regierung-mv.de/Landesregierung/em/Digitalisierung/Breitband/Breitbandausbau/
- [22] https://atenekom.eu/wp-content/uploads/2018/08/foerderrichtlinie-breitbandausbau.pdf
- [23] https://www.nbank.de/medien/nbmedia/Downloads/Programminformation/Richtlinien/Richtlinie-Breitbandausbau-Niedersachsen. pdf
- $[24] \ https://www.bznb.de/fileadmin/dokumente/A__nderung_RL_Breitbandausbau_NI_Endfassung.pdf$
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- [26] https://www.bundestag.de/resource/blob/436906/329bc7b4229cb1191cde4890942a9c77/wd-5-056-16-pdf-data.pdf
- [27] https://www.mw.niedersachsen.de/download/109532/Breitbandausbau_in_Niedersachsen_-_Strategie_und_Foerderkulisse_des_Landes.pdf
- [28] https://www.nbank.de/medien/nb-media/Downloads/Programminformation/Produktinformationen/Produktinformation Ausbau-von-Gigabitnetzen-in-Niedersachsen.pdf
- [29] https://www.bezreg-muenster.de/zentralablage/dokumente/foerderung/foerderbereich_gigabit/breitband/Rechtsgrundlage_ RiLi-NGA-Laendlicher-Raum.pdf
- [30] https://breitband.rlp.de/fileadmin/breitbandinitiative/Foerderrichtlinie_Land_2015.pdf

²²All links were last accessed on 4 March 2022.

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Note: The descriptive statistics of the border samples for 30 Mbit/s report information on properties for sale (N=287,967) and for "Low" Broadband States "High" Broadband States $\begin{array}{c} 0.00\\ 0.29\\ 129,021.28\\ 847.96\\ 250.12\\ 1.77\end{array}$ $\begin{array}{c} 0.47\\ 5.591\\ 1.15\\ 5.601\\ 1.15\\ 0.36\\ 0.48\\ 0.048\\ 0.049\\ 0.027\\ 0.022\\ 0.022\\ 0.033\\ 0.010\\ 0.033\\ 0.010\\ 0.003\\ 0.010\\ 0.001\\ 0.003\\ 0.010\\ 0.003\\ 0.001\\ 0.003\\$ 0.56 2.70 \mathbf{SD} 8 $190,516.23 \\ 1,395.34$ 479.426.11 1.784.848.488.488.480.160.260.360.360.420.420.420.420.050.050.010.010.010.010.0360.037Mean $\begin{array}{c} 0.24 \\ 18.80 \\ 0.05 \end{array}$ $1.00 \\ 0.64$ $4.81 \\ 0.50 \\ 0.61$ 6 120,150.29 $219.48 \\ 1.51$ 763.88 $0.00 \\ 0.33$ $\begin{array}{c} 0.54\\ 0.044\\ 0.044\\ 0.047\\ 0.047\\ 0.047\\ 0.024\\ 0.024\\ 0.023\\ 0.022\\ 0.023\\ 0.00\\ 0.03\\ 0.00\\ 0.03\\ 0.00\\ 0.02\\ 0.02\\ 0.00\\ 0$ \mathbf{SD} 9 176,387.12 Mean 1,297.79439.09 $\begin{array}{c} 1.79\\ 4.71\\ 4.71\\ 4.71\\ 0.25\\ 0.25\\ 0.33\\ 0.41\\ 0.61\\ 0.33\\ 0.33\\ 0.33\\ 0.33\\ 0.33\\ 0.33\\ 0.33\\ 0.05\\ 0.02\\ 0.02\\ 0.02\\ 0.05\\$ $0.00 \\ 0.49$ 5.75 357.04 -1.204.700.500.610.2318.830.05**(2**) 2,500,000.003,450.0020.007,180.00 $\begin{array}{c} 3.00\\ 6.15\\ 6.15\\ 1100\\ 118.00\\ 11.00$ $\begin{array}{c} 0.45 \\ 20.78 \\ 0.17 \end{array}$ Max $1.00 \\ 1.00$ (4)8,800.00 Min 244.2890.00 $\begin{array}{c} 0.00\\ 0.00\\ -1.39\\ 0.05\\ 0.88\\ 0.04\\ 150.00\end{array}$ $\begin{array}{c} 200.00 \\ -2.00 \\ 1.56 \\ 0.18 \end{array}$ $0.00 \\ 0.00$ 3.530.00 0.00 $0.00 \\ 0.00$ $0.00 \\ 0.00$ 0.460.033 1.001.00 0.00 Full Sample $1.00 \\ 0.00$ 3.50 0.00 0.00 0.00 0.00 0.00 125, 378.25236.64813.36 $\begin{array}{c} 36.00 \\ 1.10 \\ 0.92 \\ 0.01 \\ 0.03 \end{array}$ $0.50 \\ 0.32$ 1.666.050.36 $\begin{array}{c} 1.15\\ 0.45\\ 0.48\\ 0.48\\ 0.49\\ 0.49\\ 0.22\\ 0.26\\ 0.28\\ 0.26\\ 0.23\\ 0.26\\ 0.33\\ 0.26\\ 0.33\\ 0.10\\ 0.01\\$ 60.46 $0.55 \\ 2.65$ $\begin{array}{c} 0.04 \\ 0.78 \\ 0.02 \end{array}$ 0.46 \mathbf{SD} 6 84,277.81 $\frac{459.90}{5.94}$ Mean 1,352.27 $\begin{array}{c} 1.79\\ 4.78\\ 8.56\\ 8.56\\ 0.15\\ 3.50\\ 0.25\\ 0.35\\ 0.35\\ 0.35\\ 0.35\\ 0.35\\ 0.35\\ 0.35\\ 0.05\\ 0.07\\ 0.07\\ 0.01\\ 0.07\\ 0.02\\ 0.09\\ 0.02\\ 0.09\\ 0.01\\ 0.07\\ 0.03\\ 378.50\\ 0.09\\ 0.03\\ 361.77\\ -0.93\end{array}$ 164.092 $0.56 \\ 0.57$ $4.76 \\ 0.50$ $0.24 \\ 18.81$ (1)0.610.05Broadband Availability Municipalities 30 Mbit/s Outcome and Main Explanatory Variables Share of Inhabitants Older Than 65 Years Equipped with Pool, Whirlpool, or Sauna Share of Inhabitants Aged 18 to 64 Years County Pre-Broadband Growth Trend Exclusive/Luxury Equipment or Villa Log Population Density per Sq. Km. Crime Rate per 10,000 Inhabitants Equipped with Balcony or Terrace ²roperty Rents per sqm (Monthly) Number of Rooms in the Property High Broadband States 30 Mbit/s Parking Lot or Garage Available Property Rents Total (Monthly) **Unemployment Rate in Percent** Mobile Internet Availability Real Estate Transfer Tax Rate Newly Constructed Building Property Sale Price per sqm Publicly Subsidized Housing Local Real Estate Tax Rate Log of Floor Space in sqm Property Sale Price Total Equipped with Basement Female Population Share Local Business Tax Rate Equipped with Kitchen Equipped with Garden Log Purchasing Power School Quality (PISA) Control Variables **Renovation Status** Age of Property Central Heating Property Type Quiet Location Bright Rooms Heating Type Observations

B Descriptives

B.1 Descriptive Statistics

B.1.1 Descriptive Statistics of the RDD Samples for 30 Mbit/s

rent (N=176,125) from 3,341 rural municipalities, which are located within 25 km of the borders of "high" and "low" broadband states. Columns 1 to 4 report the mean, standard deviation, minimum, and maximum for the full samples, whereas columns 5 to 6 state the mean and standard deviation for "low" broadband states only, and columns 7 to 8 report the analogous values for "high" broadband states.

Table A3: Descriptive Statistics of the Border Samples for 30 Mbit/s Broadband

		Full S ₆	umple		"Low" Bro	adband States	" "High" Bro	adband States
	Mean	$^{\mathrm{SD}}$	Min	Max	Mean	$^{\mathrm{SD}}$	Mean	SD
	(1)	(2)	(3)	(4)	(5)	(9)	(1)	(8)
Outcome and Main Explanatory Variables High Broadband States 50 Mbit/s Broadband Availability Municipalities 50 Mbit/s	$0.49 \\ 0.44$	$0.50 \\ 0.35$	0.00	1.00 1.00	0.00 0.30	$0.00 \\ 0.33$	$1.00 \\ 0.57$	0.00 0.32
Property Sale Price Total Property Sale Price per som	211,663.53 1,560.54	131,273.37 788.44	9,000.00 244.28	2,950,000.00 7,180.00	206,176.08 1,515.03	126,956.38 736.19	217, 320.16 1, 607.45	135,347.25 836.31
Property Rents Total (Monthly) Property Rents per som (Monthly)	512.98 6.21	$\begin{array}{c} 250.50\\ 1.68\end{array}$	90.00 3.53	2,800.00 20.00	$\frac{495.96}{5.99}$	$236.88 \\ 1.56$	528.83 6.43	$\begin{array}{c} 261.55\\ 1.76\end{array}$
Control Vaniahlee								
Control Variances Dronorty Tyme	1 7.1	0 57	1 00	3 00	1 7.4	0 56	1 73	0 58
Number of Rooms in the Property	4.75	2.50	0.00	57.00	4.75	2.47	4.76	2.53
Log of Floor Space in sqm	4.85	0.46	3.50	6.15	4.86	0.45	4.85	0.47
Age of Property	7.97	6.05	1.00	18.00	8.05	6.16	7.89	5.94
Newly Constructed Building	0.17	0.38	0.00	1.00	0.17	0.38	0.17	0.38
Renovation Status	3.49	1.16	1.00	5.00	3.48	1.16	3.50 0.95	1.16
Equipped with Mitchen Equipmed with Carden	0.23	0.42 0.46	0.00	1.00	0.30	0.41 0.46	0.20	0.43
Equipped with Balconv or Terrace	0.30	0.46	0.00	1.00	0.29	0.45	0.32	0.47
Equipped with Basement	0.43	0.50	0.00	1.00	0.42	0.49	0.45	0.50
Parking Lot or Garage Available	0.61	0.49	0.00	1.00	0.60	0.49	0.62	0.49
Exclusive/Luxury Equipment or Villa	0.04	0.20	0.00	1.00	0.04	0.19	0.04	0.20
Equipped with Pool, Whirlpool, or Sauna	0.06	0.24	0.00	1.00	0.06	0.23	0.07	0.25
Bright Rooms	0.19	0.39	0.00	1.00	0.18	0.38	0.20	0.40
Leaung 1ype Centrel Heating	0.30 0.03	0.94 0.90	0.00	9.00 9.00	0.29	0.93	0.01	0.90
Current Incourts Oniet Location	0.13	0.33	0.00	1.00	0.13	0.34	0.13	0.33
Publicly Subsidized Housing	0.02	0.14	0.00	1.00	0.02	0.14	0.02	0.15
School Quality (PISA)	0.08	0.99	-1.39	1.74	0.25	1.01	-0.09	0.93
Crime Rate per 10,000 Inhabitants	0.06	0.01	0.05	0.09	0.06	0.01	0.06	0.01
Mobile Internet Availability	0.79	0.20	0.47	0.99	0.78	0.18	0.80	0.22
Real Estate Transfer Tax Rate	0.05	0.01	170.00	0.06	0.04	0.01	0.05	0.01
Local Real Estate Tax Rate Local Rusiness Tay Rate	354.80	00.47 34 11	200.00	515.00	346.95 346.95	40.U <i>l</i> 28.40	010.00 363 78	7 01 37 01
County Pre-Broadband Growth Trend	-0.26	1.13	-2.00	2.00	-0.28	1.12	-0.23	1.15
Log Population Density per Sq. Km.	5.17	0.91	1.43	7.88	5.13	0.92	5.20	0.91
Female Population Share	0.50	0.01	0.20	0.77	0.50	0.01	0.50	0.01
Share of Inhabitants Aged 18 to 64 Years	0.62	0.03	0.43	0.76	0.62	0.03	0.61	0.03
Share of Inhabitants Older Than 65 Years	0.22	0.04	0.09	0.49	0.21	0.04	0.22	0.04
Log Purchasing Power	18.84	0.77	14.11	20.73	18.72	0.76	18.96	0.77
Unemployment Rate in Percent	0.04	0.02	0.00	0.14	0.04	0.02	0.04	0.02
Observations	695, 234							
Note: The descriptive statistics of the boundary $(N-297, 809)$ from 3.380 must municip	rder samp	les for 50 ich are loc	Mbit/s ated wit	report infor	mation on of the bords	properties for rs of "high" a	r sale (N=46	07,432) and for
TELL ($N = 221, 002$) ITOLI 0,003 FUTER INTUINT	Manues, wr	ICH STATE TOC	area wi		The point		nia woi nia	Dadualla states.

B.1.2 Descriptive Statistics of the RDD Samples for 50 Mbit/s

Table A4: Descriptive Statistics of the Border Samples for 50 Mbit/s Broadband

B.2 Descriptive Figures







(b) Speed Distribution of Broadband Subscriptions in Germany 2010-2019

Note: Panel (a) shows the number of registered broadband subscriptions in Germany from 2010 to 2019, indicating a gradual increase over time. Panel (b) displays the annual distribution of broadband subscriptions by Internet speeds during the same period, illustrating a shift towards faster broadband. Data source: Bundesnetzagentur, 2010-2020.

Figure A1: Trends in Broadband Subscriptions in Germany 2010-2019

B.2.2 Illustration of Boundary Regions in RDD Sample



Note: This map of Germany illustrates its 16 federal states, delineated by white lines, as well as its approximately 11,000 municipalities. The RDD sample is comprised of small municipalities located around state orders of "high" and "low" broadband states. These sample municipalities are grouped in 59 boundary regions, which are highlighted in different shades of blue and red.

Figure A2: Illustration of Boundary Regions in a Map of Germany



B.2.3 Sample Distribution in Distance to Boundary

Note: This graph shows the spatial distribution of the RDD sample around the boundaries of "high" and "low" broadband states for 16 Mbit/s broadband Internet. The number of properties, i.e. the number of observations in the RDD sample, are plotted on the y-axis. "Distance to border in km" on the x-axis refers to the distance in kilometers between the observation and the closest state boundary, with negative values of distance indicating "high" broadband states. The plot was generated by an evenly spaced number of bins, representing the sum of observations within each bin.

Figure A3: Sample Distribution in Distance to Boundary for 16 Mbit/s Broadband Internet



Note: This graph shows the spatial distribution of the RDD sample around the boundaries of "high" and "low" broadband states for 30 Mbit/s broadband Internet. The number of properties, i.e. the number of observations in the RDD sample, are plotted on the y-axis. "Distance to border in km" on the x-axis refers to the distance in kilometers between the observation and the closest state boundary, with negative values of distance indicating "high" broadband states. The plot was generated by an evenly spaced number of bins, representing the sum of observations within each bin.

Figure A4: Sample Distribution in Distance to Boundary for 30 Mbit/s Broadband Internet



Note: This graph shows the spatial distribution of the RDD sample around the boundaries of "high" and "low" broadband states for 50 Mbit/s broadband Internet. The number of properties, i.e. the number of observations in the RDD sample, are plotted on the y-axis. "Distance to border in km" on the x-axis refers to the distance in kilometers between the observation and the closest state boundary, with negative values of distance indicating "high" broadband states. The plot was generated by an evenly spaced number of bins, representing the sum of observations within each bin.

Figure A5: Sample Distribution in Distance to Boundary for 50 Mbit/s Broadband Internet





(a) Sample Distribution Over Time for 16 Mbit/s

(b) Number of "High" and "Low" Broadband States Over Time for 16 Mbit/s

Note: Panel (a) shows the annual distribution of the RDD sample over time for 16 Mbit/s broadband Internet from 2010 to 2017. The y-axis displays the number of properties offered for sale and rent, and the x-axis shows the years included in the RDD sample. Panel (b) shows the number of "high" and "low" broadband states for 16 Mbit/s broadband Internet from 2010 to 2017. The RDD sample each year consists only of municipalities near the borders of states with a discontinuity in broadband status, leading to variation in sample composition over time.

Figure A6: Distribution of RDD Sample and Broadband Status Over Time for 16 Mbit/s





(b) Number of "High" and "Low" Broadband States Over Time for 30 Mbit/s

Note: Panel (a) shows the annual distribution of the RDD sample over time for 30 Mbit/s broadband Internet from 2010 to 2017. The y-axis displays the number of properties offered for sale and rent, and the x-axis shows the years included in the RDD sample. Panel (b) shows the number of "high" and "low" broadband states for 30 Mbit/s broadband Internet from 2010 to 2017. The RDD sample each year consists only of municipalities near the borders of states with a discontinuity in broadband status, leading to variation in sample composition over time.

Figure A7: Distribution of RDD Sample and Broadband Status Over Time for 30 Mbit/s



(b) Number of "High" and "Low" Broadband States Over Time for 50 Mbit/s

Note: Panel (a) shows the annual distribution of the RDD sample over time for 50 Mbit/s broadband Internet from 2010 to 2017. The y-axis displays the number of properties offered for sale and rent, and the x-axis shows the years included in the RDD sample. Panel (b) shows the number of "high" and "low" broadband states for 50 Mbit/s broadband Internet from 2010 to 2017. The RDD sample each year consists only of municipalities near the borders of states with a discontinuity in broadband status, leading to variation in sample composition over time.

Figure A8: Distribution of RDD Sample and Broadband Status Over Time for 50 Mbit/s



B.2.5 Broadband Availability in Sample Municipalities

Note: This figure shows annual histograms of the availability of 16 Mbit/s broadband Internet in municipalities (measured as share of households per municipality with access to this Internet speed). Panel A portrays fast Internet availability in municipalities located in "high" broadband states while Panel B displays broadband access in "low" broadband states. The black dots represent yearly population-weighted means across all municipalities. The figure indicates differences in both level and time trend of Internet availability between "high" and "low" broadband states.

Figure A9: High-Speed Internet Availability 16 Mbit/s in "High" and "Low" Broadband States

(a) "High" Broadband States



Note: This figure shows annual histograms of the availability of 30 Mbit/s broadband Internet in municipalities (measured as share of households per municipality with access to this Internet speed). Panel A portrays fast Internet availability in municipalities located in "high" broadband states while Panel B displays broadband access in "low" broadband states. The black dots represent yearly population-weighted means across all municipalities. The figure indicates differences in both level and time trend of Internet availability between "high" and "low" broadband states.

Figure A10: High-Speed Internet Availability 30 Mbit/s in "High" and "Low" Broadband States



(a) "High" Broadband States

Note: This figure shows annual histograms of the availability of 50 Mbit/s broadband Internet in municipalities (measured as share of households per municipality with access to this Internet speed). Panel A portrays fast Internet availability in municipalities located in "high" broadband states while Panel B displays broadband access in "low" broadband states. The black dots represent yearly population-weighted means across all municipalities. The figure indicates differences in both level and time trend of Internet availability between "high" and "low" broadband states.

Figure A11: High-Speed Internet Availability 50 Mbit/s in "High" and "Low" Broadband States

C Heterogeneity Analysis

C.1 Effect Size Heterogeneity



Note: This figure illustrates the effect size heterogeneity by correlating state-level broadband availability and property sale prices / rents. The state-level broadband availability of 16 Mbit/s on the x-axis is the determinant of "high" broadband states with the threshold of providing at least 75 percent of households with fast Internet. Log sale prices / log rents per square meter are on the y-axis. The shown conditional correlation is the result of a regression with control variables for individual property, state-level, municipality-level, and local economic characteristics as well as boundary-region-by-year fixed effects. The solid line represents the quadratic fit.

Figure A12: Effect Size Heterogeneity of Property Sale Prices and Rents

C.2 Heterogeneity by Internet Speeds



Note: Shown are spatial RD plots for property sale prices (measured in Euro per square meter) for the Internet speeds 16 Mbit/s (Panel A), 30 Mbit/s (Panel B), and 50 Mbit/s (Panel C). The outcomes are plotted on the y-axis. "Distance to border in km" on the x-axis refers to the distance in kilometers between the observation and the closest state boundary, with negative values of distance indicating "high" broadband states. The RD plots are generated by an evenly spaced number of bins, representing the sample average within each bin, net of boundary-region-by-year fixed effects. The solid lines represent the predicted values from a regression of the outcome variable on a first-order polynomial in distance to the boundary. The corresponding 95 percent confidence intervals are displayed as dotted lines.

Figure A13: Spatial RD Plots of Property Sale Prices for Different Internet Speeds



Note: Shown are spatial RD plots for property rents (measured in Euro per square meter) for the Internet speeds 16 Mbit/s (Panel A), 30 Mbit/s (Panel B), and 50 Mbit/s (Panel C). The outcomes are plotted on the y-axis. "Distance to border in km" on the x-axis refers to the distance in kilometers between the observation and the closest state boundary, with negative values of distance indicating "high" broadband states. The RD plots are generated by an evenly spaced number of bins, representing the sample average within each bin, net of boundary-region-by-year fixed effects. The solid lines represent the predicted values from a regression of the outcome variable on a first-order polynomial in distance to the boundary. The corresponding 95 percent confidence intervals are displayed as dotted lines.

Figure A14: Spatial RD Plots of Property Rents for Different Internet Speeds

Spatial RDD Estimates		Sale Prices		Rents		
	16 Mbit/s	$30 \mathrm{~Mbit/s}$	$50 \mathrm{~Mbit/s}$	16 Mbit/s	$30 \mathrm{~Mbit/s}$	$50 { m ~Mbit/s}$
	(1)	(2)	(3)	(4)	(5)	(6)
Panel A: RDD Polynomials in D	istance to Ba	oundary				
Linear	0.0493***	0.0282	0.0552**	0.0222**	0.0035	0.0324***
	(0.0175)	(0.0209)	(0.0214)	(0.0096)	(0.0116)	(0.0108)
Quadratic	0.0786***	0.0416**	0.0569***	0.0355***	0.0080	0.0319***
	(0.0170)	(0.0205)	(0.0204)	(0.0099)	(0.0116)	(0.0102)
Linear Interacted	0.0408^{**}	0.0319	0.0517^{**}	0.0172^{**}	0.0050	0.0287^{***}
	(0.0175)	(0.0205)	(0.0209)	(0.0086)	(0.0116)	(0.0103)
Panel B: RDD Polynomials in L	ongitude and	Latitude				
Linear	0.0810***	0.0443**	0.0584***	0.0378***	0.0097	0.0351***
	(0.0154)	(0.0197)	(0.0214)	(0.0083)	(0.0114)	(0.0111)
Quadratic	0.0943^{***}	0.0404^{**}	0.0600^{***}	0.0436^{***}	0.0126	0.0379^{***}
	(0.0153)	(0.0191)	(0.0197)	(0.0086)	(0.0115)	(0.0113)
Cubic	0.0973^{***}	0.0455^{**}	0.0640^{***}	0.0414^{***}	0.0076	0.0382^{***}
	(0.0153)	(0.0196)	(0.0217)	(0.0083)	(0.0121)	(0.0118)
Quartic	0.0812^{***}	0.0365^{*}	0.0469^{**}	0.0299^{***}	0.0075	0.0269^{***}
	(0.0163)	(0.0200)	(0.0195)	(0.0089)	(0.0136)	(0.0099)
Boundary Region by Year FE	\checkmark	√	\checkmark	\checkmark	\checkmark	\checkmark
Individual Property Controls	\checkmark	\checkmark	\checkmark	\checkmark	\checkmark	\checkmark
State Policy Controls	\checkmark	\checkmark	\checkmark	\checkmark	\checkmark	\checkmark
Municipality Policy Controls	\checkmark	\checkmark	\checkmark	\checkmark	\checkmark	\checkmark
Local Economic Controls	\checkmark	\checkmark	\checkmark	\checkmark	\checkmark	\checkmark
Observations	$723,\!881$	$277,\!859$	460,871	369,335	170,719	$225,\!055$
Municipalities	4,035	3,341	3,389	$3,\!628$	2,953	2,973
Data Availability Period	2010-2017	2014 - 2018	2010-2018	2010-2017	2014 - 2018	2010-2018

Note: Shown are the coefficients and standard errors for "high broadband state" under different specifications of the RDD polynomials, with each cell in the table reporting the result of a separate regression. Panel A displays estimates for linear, quadratic, and linear interacted RDD polynomials in distance to the state boundary, whereas Panel B presents the results for linear, quadratic, cubic, and quartic RDD specifications in longitude and latitude. Columns (1) to (3) report the results for property sale prices, while columns (4) to (6) show the results for rents. Real estate prices are log values to facilitate better comparability of the estimates. Standard errors are clustered at the boundary-region-by-year level. *p<0.1; **p<0.05; ***p<0.01.

Table A5: Heterogeneity of Spatial RDD Results by Internet Speeds (16, 30, & 50 Mbit/s)

C.3 Heterogeneity Over Time

Spatial RDD Estimates	patial RDD Estimates Sale Prices Rents			Rents		
	$16 \mathrm{~Mbit/s}$	$30 \mathrm{~Mbit/s}$	$50 \mathrm{~Mbit/s}$	$16 \mathrm{~Mbit/s}$	$30 \mathrm{~Mbit/s}$	$50 \mathrm{~Mbit/s}$
	>= 2016	>= 2017	>= 2018	>= 2016	>= 2017	>= 2018
	(1)	(2)	(3)	(4)	(5)	(6)
Panel A: RDD Polynomials in L	Distance to B	oundary				
Linear	0.1220***	0.0839**	0.1502***	0.0084	0.0300*	0.0507**
	(0.0363)	(0.0344)	(0.0415)	(0.0333)	(0.0175)	(0.0243)
Quadratic	0.1209^{***}	0.0730^{**}	0.1416^{***}	0.0080	0.0241	0.0487^{**}
	(0.0356)	(0.0341)	(0.0408)	(0.0336)	(0.0175)	(0.0227)
Linear Interacted	0.1198^{***}	0.0802^{**}	0.1516^{***}	0.0081	0.0277	0.0548^{**}
	(0.0365)	(0.0340)	(0.0413)	(0.0334)	(0.0174)	(0.0232)
Panel B: RDD Polynomials in L	ongitude and	Latitude				
Linear	0.1280***	0.0714**	0.1393***	0.0168	0.0225	0.0457*
	(0.0329)	(0.0350)	(0.0415)	(0.0301)	(0.0185)	(0.0246)
Quadratic	0.1380***	0.0605^{*}	0.1564***	0.0480*	0.0227	0.0680**
-	(0.0298)	(0.0344)	(0.0426)	(0.0274)	(0.0210)	(0.0271)
Cubic	0.1736***	0.0601*	0.1740***	0.0690**	0.0232	0.0786***
	(0.0322)	(0.0334)	(0.0437)	(0.0286)	(0.0212)	(0.0280)
Quartic	0.1482***	0.0392	0.1307***	0.0631**	0.0214	0.0593**
	(0.0314)	(0.0319)	(0.0401)	(0.0285)	(0.0209)	(0.0283)
Boundary Region by Year FE	\checkmark	\checkmark	\checkmark	\checkmark	\checkmark	\checkmark
Individual Property Controls	\checkmark	\checkmark	\checkmark	\checkmark	\checkmark	\checkmark
State Policy Controls	\checkmark	\checkmark	\checkmark	\checkmark	\checkmark	\checkmark
Municipality Policy Controls	\checkmark	\checkmark	\checkmark	\checkmark	\checkmark	\checkmark
Local Economic Controls	\checkmark	\checkmark	\checkmark	\checkmark	\checkmark	\checkmark
Observations	723,881	277,859	460,871	369,335	170,719	225,055
Municipalities	4,035	3,341	3,389	3,628	2,953	2,973
Data Availability Period	2010-2017	2014-2018	2010-2018	2010-2017	2014-2018	2010-2018

Note: Shown are the coefficients and standard errors for "high broadband state" under different specifications of the RDD polynomials, with each cell in the table reporting the result of a separate regression. Panel A displays estimates for linear, quadratic, and linear interacted RDD polynomials in distance to the state boundary, whereas Panel B presents the results for linear, quadratic, cubic, and quartic RDD specifications in longitude and latitude. Columns (1) to (3) report the results for property sale prices, while columns (4) to (6) show the results for rents. Real estate prices are log values to facilitate better comparability of the estimates. Standard errors are clustered at the boundary-region-by-year level. *p<0.1; **p<0.05; ***p<0.01.

Table A6: Heterogeneity of Spatial RDD Results Over Time (16, 30, & 50 Mbit/s)

C.4 Heterogeneity by Population Density

Spatial RDD Estimates	Sale l	Prices	Rents	
	Lower Density Half	Upper Density Half	Lower Density Half	Upper Density Half
	(1)	(2)	(3)	(4)
Panel A: RDD Polynomials in D	istance to B	Soundary		
Linear	0.0357*	0.0508**	0.0296	0.0119
	(0.0199)	(0.0216)	(0.0297)	(0.0256)
Quadratic	0.0701^{***}	0.0780^{***}	0.0074	0.0504^{***}
	(0.0153)	(0.0197)	(0.0127)	(0.0160)
Linear Interacted	0.0269	0.0468^{**}	-0.0174	0.0436^{**}
	(0.0188)	(0.0212)	(0.0242)	(0.0180)
Panel B: RDD Polynomials in L	ongitude and	l Latitude		
Linear	0.0612***	0.0831***	0.0041	0.0506***
	(0.0156)	(0.0177)	(0.0134)	(0.0124)
Quadratic	0.0689^{***}	0.0966^{***}	0.0130	0.0568^{***}
	(0.0155)	(0.0169)	(0.0137)	(0.0124)
Cubic	0.0732^{***}	0.0976^{***}	0.0027	0.0602^{***}
	(0.0164)	(0.0165)	(0.0184)	(0.0118)
Quartic	0.0482^{***}	0.0824^{***}	0.0198	0.0526^{***}
	(0.0184)	(0.0189)	(0.0164)	(0.0156)
Boundary Region by Year FE	\checkmark	\checkmark	\checkmark	\checkmark
Individual Property Controls	\checkmark	\checkmark	\checkmark	\checkmark
State Policy Controls	\checkmark	\checkmark	\checkmark	\checkmark
Municipality Policy Controls	\checkmark	\checkmark	\checkmark	\checkmark
Local Economic Controls	\checkmark	\checkmark	\checkmark	\checkmark
Observations	$153,\!833$	$570,\!048$	37,508	$167,\!862$
Municipalities	2,017	2,018	1,048	1,048
Data Availability Period	2010-2017	2010-2017	2010-2017	2010-2017

Note: Shown are the coefficients and standard errors for "high broadband state" under different specifications of the RDD polynomials, with each cell in the table reporting the result of a separate regression. Panel A displays estimates for linear, quadratic, and linear interacted RDD polynomials in distance to the state boundary, whereas Panel B presents the results for linear, quadratic, cubic, and quartic RDD specifications in longitude and latitude. Columns (1) to (3) report the results for property sale prices, while columns (4) to (6) show the results for rents. Real estate prices are log values to facilitate better comparability of the estimates. Standard errors are clustered at the boundary-region-by-year level. *p<0.1; **p<0.05; ***p<0.01.

Table A7: Heterogeneity of Spatial RDD Results by Population Density

C.5 Heterogeneity by Property Types

Spatial RDD Estimates	Sale Prices		F	lents			
	Houses	Apartments	Houses	Apartments			
	(1)	(2)	(3)	(4)			
Panel A: RDD Polynomials in	Distance t	o Boundary					
Linear	0.0543***	0.0461**	0.0487***	0.0204**			
	(0.0179)	(0.0192)	(0.0150)	(0.0092)			
Quadratic	0.0969***	0.0494**	0.0609***	0.0336***			
	(0.0163)	(0.0205)	(0.0125)	(0.0097)			
Linear Interacted	0.0494***	0.0301	0.0466***	0.0151*			
	(0.0175)	(0.0195)	(0.0113)	(0.0085)			
Panel B: RDD Polynomials in	Longitude	and Latitude					
Linear	0.0946***	0.0557***	0.0600***	0.0363***			
	(0.0147)	(0.0192)	(0.0096)	(0.0083)			
Quadratic	0.1028***	0.0770***	0.0674^{***}	0.0421^{***}			
	(0.0151)	(0.0184)	(0.0093)	(0.0088)			
Cubic	0.1051^{***}	0.0887^{***}	0.0678^{***}	0.0391^{***}			
	(0.0152)	(0.0174)	(0.0089)	(0.0084)			
Quartic	0.0877^{***}	0.0788^{***}	0.0482^{***}	0.0292^{***}			
	(0.0165)	(0.0194)	(0.0099)	(0.0089)			
Boundary Region by Year FE	\checkmark	\checkmark	\checkmark	\checkmark			
Individual Property Controls	\checkmark	\checkmark	\checkmark	\checkmark			
State Policy Controls	\checkmark	\checkmark	\checkmark	\checkmark			
Municipality Policy Controls	\checkmark	\checkmark	\checkmark	\checkmark			
Local Economic Controls	\checkmark	\checkmark	\checkmark	\checkmark			
Observations	$507,\!349$	$216{,}531$	$42,\!477$	$326,\!856$			
Municipalities	4,017	$3,\!485$	2,764	3,509			
Data Availability Period	2010-2017	2010-2017	2010-2017	2010-2017			

Note: Shown are the coefficients and standard errors for "high broadband state" under different specifications of the RDD polynomials, with each cell in the table reporting the result of a separate regression. Panel A displays estimates for linear, quadratic, and linear interacted RDD polynomials in distance to the state boundary, whereas Panel B presents the results for linear, quadratic, cubic, and quartic RDD specifications in longitude and latitude. Real estate prices are log values to facilitate better comparability of the estimates. Standard errors are clustered at the boundary-region-by-year level. *p<0.1; **p<0.05; ***p<0.01.

Table A8: Heterogeneity by Property Types: Results of the Spatial RDD for 16Mbit/s Broadband

D Specification Checks

D.1 Graphical Evidence

D.1.1 RD Plots of Main Outcomes for 15km Bandwidth



Note: Shown are spatial RD plots for broadband availability in municipalities (Panel A), property sale prices (Panel B), and property rents (Panel C) for the Internet speed of 16 Mbit/s using an alternative bandwidth of 15 kilometers around the state borders. The outcomes are plotted on the y-axis. "Distance to border in km" on the x-axis refers to the distance in kilometers between the observation and the closest state boundary, with negative values of distance indicating "high" broadband states. The RD plots are generated by an evenly spaced number of bins, representing the sample average within each bin, net of boundary-region-by-year fixed effects. The solid lines represent the predicted values from a regression of the outcome variable on a first-order polynomial in distance to the boundary. The corresponding 95 percent confidence intervals are displayed as dotted lines.

Figure A15: Spatial RD Plots of Main Outcomes for Alternative 15km Bandwidth
D.1.2 RD Plots of Main Outcomes for 50km Bandwidth



Note: Shown are spatial RD plots for broadband availability in municipalities (Panel A), property sale prices (Panel B), and property rents (Panel C) for the Internet speed of 16 Mbit/s using an alternative bandwidth of 50 kilometers around the state borders. The outcomes are plotted on the y-axis. "Distance to border in km" on the x-axis refers to the distance in kilometers between the observation and the closest state boundary, with negative values of distance indicating "high" broadband states. The RD plots are generated by an evenly spaced number of bins, representing the sample average within each bin, net of boundary-region-by-year fixed effects. The solid lines represent the predicted values from a regression of the outcome variable on a first-order polynomial in distance to the boundary. The corresponding 95 percent confidence intervals are displayed as dotted lines.

Figure A16: Spatial RD Plots of Main Outcomes for Alternative 50km Bandwidth

D.2 Tables

D.2.1 Sensitivity of Spatial RDD Results to Different Bandwidths Around State Boundaries

Spatial RDD Estimates		Sale Prices	8		Rents					
Bandwidth Around State Borders	$15~\mathrm{km}$	$25~\mathrm{km}$	$50 \mathrm{km}$	$15~\mathrm{km}$	$25~\mathrm{km}$	$50 \mathrm{km}$				
	(1)	(2)	(3)	(4)	(5)	(6)				
Panel A: RDD Polynomials in Dista	nce to Bor	indary								
Linear	0.0388**	0.0493***	0.0609***	0.0091	0.0222**	0.0155*				
	(0.0192)	(0.0175)	(0.0163)	(0.0115)	(0.0096)	(0.0092)				
Quadratic	0.0822***	0.0786***	0.0495***	0.0317***	0.0355***	-0.0019				
	(0.0140)	(0.0170)	(0.0123)	(0.0079)	(0.0099)	(0.0081)				
Linear Interacted	0.0363**	0.0408**	0.0207	0.0094	0.0172**	-0.0053				
	(0.0181)	(0.0175)	(0.0160)	(0.0089)	(0.0086)	(0.0088)				
Panel B: RDD Polynomials in Longitude and Latitude										
Linear	0.0859***	0.0810***	0.0460***	0.0339***	0.0378***	-0.0012				
	(0.0139)	(0.0154)	(0.0124)	(0.0078)	(0.0083)	(0.0079)				
Quadratic	0.0924***	0.0943***	0.0610***	0.0394***	0.0436***	0.0098				
	(0.0139)	(0.0153)	(0.0119)	(0.0083)	(0.0086)	(0.0071)				
Cubic	0.0874***	0.0973***	0.0768***	0.0376***	0.0414***	0.0138*				
	(0.0143)	(0.0153)	(0.0138)	(0.0080)	(0.0083)	(0.0074)				
Quartic	0.0696***	0.0812***	0.0815***	0.0147**	0.0299***	0.0136				
	(0.0139)	(0.0163)	(0.0161)	(0.0067)	(0.0089)	(0.0086)				
Boundary Region by Year FE	\checkmark	\checkmark	\checkmark	\checkmark	\checkmark	~				
Individual Property Controls	\checkmark	\checkmark	\checkmark	\checkmark	\checkmark	\checkmark				
State Policy Controls	\checkmark	\checkmark	\checkmark	\checkmark	\checkmark	\checkmark				
Municipality Policy Controls	\checkmark	\checkmark	\checkmark	\checkmark	\checkmark	\checkmark				
Local Economic Controls	\checkmark	\checkmark	\checkmark	\checkmark	\checkmark	\checkmark				
Observations	466,560	723,881	1,299,127	$241,\!635$	369,335	662,592				
Municipalities	2,664	4.035	6.141	2,395	3.628	5,575				
Data Availability Period	2010-2017	2010-2017	2010-2017	2010-2017	2010-2017	2010-2017				

Note: Shown are the coefficients and standard errors for "high broadband state" under different specifications of the RDD polynomials, with each cell in the table reporting the result of a separate regression. Panel A displays estimates for linear, quadratic, and linear interacted RDD polynomials in distance to the state boundary, whereas Panel B presents the results for linear, quadratic, cubic, and quartic RDD specifications in longitude and latitude. Real estate prices are log values to facilitate better comparability of the estimates. Standard errors are clustered at the boundary-region-by-year level. *p<0.1; **p<0.05; ***p<0.01.

Table A9: Sensitivity of Spatial RDD Results to Different Bandwidths Around State Borders (Bandwidths 15, 25, and 50km)

D.2.2 Sensitivity of Spatial RDD Results to Observations near the State Borders ("Donut Hole Approach")

Spatial RDD Estimates	:	Sale Prices	6		Rents			
"Donut Hole" Size	2 km	$5~\mathrm{km}$	10 km	2 km	$5~\mathrm{km}$	10 km		
	(1)	(2)	(3)	(4)	(5)	(6)		
Panel A: RDD Polynomials in I	Distance to	Boundary						
Linear Linear	0.0510***	0.0797***	0.0686**	0.0264***	0.0566***	0.0259		
	(0.0181)	(0.0227)	(0.0339)	(0.0093)	(0.0156)	(0.0219)		
Quadratic	0.0826***	0.0879***	0.0898***	0.0414***	0.0484***	0.0485***		
•	(0.0173)	(0.0183)	(0.0198)	(0.0100)	(0.0118)	(0.0143)		
Linear Interacted	0.0408**	0.0537***	0.0710**	0.0225***	0.0396***	0.0360**		
	(0.0174)	(0.0201)	(0.0306)	(0.0079)	(0.0131)	(0.0163)		
Panel B: RDD Polynomials in Longitude and Latitude								
Linear	0.0860***	0.0891***	0.0875***	0.0440***	0.0500***	0.0475***		
	(0.0156)	(0.0163)	(0.0171)	(0.0086)	(0.0099)	(0.0111)		
Quadratic	0.0999***	0.1061***	0.1081***	0.0494***	0.0570***	0.0554***		
	(0.0153)	(0.0163)	(0.0176)	(0.0088)	(0.0103)	(0.0116)		
Cubic	0.1036***	0.1151***	0.1194***	0.0475***	0.0585***	0.0543***		
	(0.0154)	(0.0159)	(0.0172)	(0.0085)	(0.0100)	(0.0107)		
Quartic	0.0871***	0.1053***	0.1066***	0.0344***	0.0514***	0.0460***		
	(0.0163)	(0.0178)	(0.0205)	(0.0087)	(0.0116)	(0.0141)		
Boundary Region by Year FE	\checkmark	\checkmark	\checkmark	\checkmark	\checkmark	\checkmark		
Individual Property Controls	\checkmark	\checkmark	\checkmark	\checkmark	\checkmark	\checkmark		
State Policy Controls	\checkmark	\checkmark	\checkmark	\checkmark	\checkmark	\checkmark		
Municipality Policy Controls	\checkmark	\checkmark	\checkmark	\checkmark	\checkmark	\checkmark		
Local Economic Controls	\checkmark	\checkmark	\checkmark	\checkmark	\checkmark	\checkmark		
Observations	673,445	562,963	397,683	344,925	288,305	205,371		
Municipalities	3,829	3,293	2,334	3,432	2,944	2,096		
Data Availability Period	2010-2017	2010-2017	2010-2017	2010-2017	2010-2017	2010-2017		

Note: Shown are the coefficients and standard errors for "high broadband state" under different specifications of the RDD polynomials, with each cell in the table reporting the result of a separate regression. Panel A displays estimates for linear, quadratic, and linear interacted RDD polynomials in distance to the state boundary, whereas Panel B presents the results for linear, quadratic, cubic, and quartic RDD specifications in longitude and latitude. Real estate prices are log values to facilitate better comparability of the estimates. Standard errors are clustered at the boundary-region-by-year level. *p<0.1; **p<0.05; ***p<0.01.

Table A10: Sensitivity of Spatial RDD Results to Observations Near StateBorders ("Donut Hole Approach")

		 D and a						
Spatial RDD Estimates	Sale P	rices	Kents					
	Total	Per sqm	Total	Per sqm				
	(1)	(2)	(3)	(4)				
Panel A: RDD Polynomials in	Distance to Bo	undary						
Linear	7,096.1190**	62.7443***	10.5060*	0.1742***				
	(3, 154.6028)	(22.1291)	(5.6605)	(0.0619)				
Quadratic	14,801.8921***	103.1682***	19.9307***	0.2516^{***}				
	(3, 493.2355)	(24.0175)	(5.5306)	(0.0665)				
Linear Interacted	7,175.8117**	61.1233***	9.5201**	0.1409^{***}				
	(3,032.6033)	(20.8117)	(3.9528)	(0.0498)				
Panel B: RDD Polynomials in Longitude and Latitude								
Linear	14,935.2847***	106.5146***	21.0093***	0.2662***				
	(3,026.7221)	(20.7082)	(4.4063)	(0.0558)				
Quadratic	$16,\!888.0011^{***}$	127.9448^{***}	24.4822***	0.3063^{***}				
	(2,949.7367)	(20.8545)	(4.6001)	(0.0584)				
Cubic	$16,\!639.3790^{***}$	128.6799^{***}	22.5143***	0.2859^{***}				
	(2,876.2996)	(20.2915)	(4.4776)	(0.0556)				
Quartic	$13,\!244.4593^{***}$	100.1892^{***}	15.5439***	0.2134^{***}				
	(3, 162.1126)	(20.9734)	(4.7907)	(0.0585)				
Boundary Region by Year FE	\checkmark	\checkmark	\checkmark	\checkmark				
Individual Property Controls	\checkmark	\checkmark	\checkmark	\checkmark				
State Policy Controls	\checkmark	\checkmark	\checkmark	\checkmark				
Municipality Policy Controls	\checkmark	\checkmark	\checkmark	\checkmark				
Local Economic Controls	\checkmark	\checkmark	\checkmark	\checkmark				
Observations	723,881	723,881	$369,\!335$	369,335				
Municipalities	$3,\!983$	$3,\!983$	$3,\!579$	$3,\!579$				
Data Availability Period	2010-2017	2010-2017	2010-2017	2010-2017				

D.2.3 Sensitivity of Spatial RDD Results to Estimations in Levels (Total Prices and Prices per Square Meter)

Note: Shown are the coefficients and standard errors for "high broadband state" under different specifications of the RDD polynomials, with each cell in the table reporting the result of a separate regression. Panel A displays estimates for linear, quadratic, and linear interacted RDD polynomials in distance to the state boundary, whereas Panel B presents the results for linear, quadratic, cubic, and quartic RDD specifications in longitude and latitude. Real estate prices are log values to facilitate better comparability of the estimates. Standard errors are clustered at the boundary-region-by-year level. *p<0.1; **p<0.05; ***p<0.01.

 Table A11: Sensitivity of Spatial RDD Results to Estimations in Levels (Total Prices and Prices per Square Meter)

E Robustness Checks

E.1 Robustness Checks on Sample

E.1.1 Sample Robustness Checks of Leaving One Boundary Region Out



Note: This coefficient plot presents the coefficients and standard errors for regressions of "high broadband state" on property sale prices using the preferred RDD specification with linear polynomials in longitude and latitude. Each row reports the result of a separate regression that leaves out one distinct boundary region at a time. The dotted red line shows the baseline coefficient estimate of the entire sample. Real estate prices are log values to facilitate better comparability of the estimates. Standard errors are clustered at the boundary-region-by-year level.

Figure A17: Leaving One Border Region Out: Property Sale Prices



Note: This coefficient plot presents the coefficients and standard errors for regressions of "high broadband state" on property rents using the preferred RDD specification with linear polynomials in longitude and latitude. Each row reports the result of a separate regression that leaves out one distinct boundary region at a time. The dotted red line shows the baseline coefficient estimate of the entire sample. Real estate prices are log values to facilitate better comparability of the estimates. Standard errors are clustered at the boundary-region-by-year level.

Figure A18: Leaving One Border Region Out: Property Rents

E.1.2 Sample Robustness Check With Additional Control Variables



Note: This combined figure of RD plots shows additional regional socioeconomic characteristics around the state boundary discontinuity. These variables are the share of age group 18-64; the share of age group 65+; the share of female population; the population density; the commuting time to the nearest major city; the commuting time to the nearest highway. The outcomes are plotted on the y-axis. "Distance to border in km" on the x-axis refers to the distance in kilometers between the observation and the closest state boundary, with negative values of distance indicating "high" broadband states. The RD plots are generated by an evenly spaced number of bins, representing the sample average within each bin, net of boundary-region-by-year fixed effects. The solid lines represent the predicted values from a regression of the outcome variable on a first-order polynomial in distance to the boundary. The corresponding 95 percent confidence intervals are displayed as dotted lines.

Figure A19: Spatial RD Plots for Additional Controls Around State Boundaries

E.1.3 Sample Robustness Checks of the Spatial RDD

Spatial RDD Estimates	Real Estate Sale Prices						
	West Germany	East Germany	Without RLP	With Larger Municipalities	With Add. Controls		
	(1)	(2)	(3)	(4)	(5)		
Panel A: RDD Polynomials in D	istance to B	oundary					
Linear	0.0341	0.1234**	0.0309**	0.0436***	0.0402**		
	(0.0245)	(0.0527)	(0.0148)	(0.0164)	(0.0163)		
Quadratic	0.0690***	0.1305***	0.0666***	0.0857***	0.0614***		
-	(0.0246)	(0.0471)	(0.0141)	(0.0123)	(0.0165)		
Linear Interacted	0.0324	0.1035**	0.0198	0.0393**	0.0364**		
	(0.0247)	(0.0499)	(0.0156)	(0.0159)	(0.0158)		
Panel B: RDD Polynomials in Longitude-Latitude							
Linear	0.0747***	0.1600***	0.0753***	0.0843***	0.0620***		
	(0.0216)	(0.0572)	(0.0141)	(0.0111)	(0.0149)		
Quadratic	0.0723***	0.1732***	0.0829***	0.0967***	0.0748***		
	(0.0212)	(0.0558)	(0.0144)	(0.0116)	(0.0149)		
Cubic	0.0619***	0.0966*	0.0842***	0.0995***	0.0741***		
	(0.0195)	(0.0544)	(0.0171)	(0.0120)	(0.0150)		
Quartic	0.0453**	0.0805	0.0613***	0.0849***	0.0752***		
	(0.0207)	(0.0534)	(0.0157)	(0.0125)	(0.0149)		
Boundary Region by Year FE	\checkmark	\checkmark	\checkmark	\checkmark	\checkmark		
Individual Property Controls	\checkmark	\checkmark	\checkmark	\checkmark	\checkmark		
State Policy Controls	\checkmark	\checkmark	\checkmark	\checkmark	\checkmark		
Municipality Policy Controls	\checkmark	\checkmark	\checkmark	\checkmark	\checkmark		
Local Economic Controls	\checkmark	\checkmark	\checkmark	\checkmark	\checkmark		
Observations	619,094	104,787	577,907	1,282,186	723,881		
Municipalities	2,731	1,304	2,816	4,340	4,035		
Data Availability Period	2010-2017	2010-2017	2010-2017	2010-2017	2010-2017		

Note: Shown are the coefficients and standard errors for "high broadband state" under different specifications of the RDD polynomials, with each cell in the table reporting the result of a separate regression. Panel A displays estimates for linear, quadratic, and linear interacted RDD polynomials in distance to the state boundary, whereas Panel B presents the results for linear, quadratic, cubic, and quartic RDD specifications in longitude and latitude. Real estate prices are log values to facilitate better comparability of the estimates. Standard errors are clustered at the boundary-region-by-year level. *p<0.1; **p<0.05; ***p<0.01.

Table A12: Sample Robustness Checks for Real Estate Sale Prices

Spatial RDD Estimates	Real Estate Rents						
	West	East	Without	With Larger	With Add.		
	Germany	Germany	RLP	Municipalities	Controls		
Panel A: RDD Polynomials in D	istance to Be	oundary					
Linear	0.0424***	0.0487^{*}	0.0050	0.0366***	0.0144*		
	(0.0131)	(0.0256)	(0.0105)	(0.0088)	(0.0082)		
Quadratic	0.0584^{***}	0.0277	0.0127	0.0529^{***}	0.0221**		
	(0.0158)	(0.0224)	(0.0085)	(0.0074)	(0.0093)		
Linear Interacted	0.0405***	0.0328	-0.0079	0.0393***	0.0110		
	(0.0136)	(0.0294)	(0.0087)	(0.0083)	(0.0068)		
Panel B: RDD Polynomials in Longitude-Latitude							
Linear	0.0591***	0.0531**	0.0197**	0.0497***	0.0238***		
	(0.0123)	(0.0236)	(0.0097)	(0.0060)	(0.0078)		
Quadratic	0.0569^{***}	0.0587^{**}	0.0255^{**}	0.0541^{***}	0.0296^{***}		
	(0.0111)	(0.0239)	(0.0100)	(0.0065)	(0.0083)		
Cubic	0.0453^{***}	0.0284	0.0218^{**}	0.0524^{***}	0.0285^{***}		
	(0.0093)	(0.0194)	(0.0107)	(0.0069)	(0.0076)		
Quartic	0.0392^{***}	0.0368^{**}	0.0159^{*}	0.0345^{***}	0.0277^{***}		
	(0.0095)	(0.0184)	(0.0095)	(0.0074)	(0.0080)		
Boundary Region by Year FE	\checkmark	\checkmark	\checkmark	√	\checkmark		
Individual Property Controls	\checkmark	\checkmark	\checkmark	\checkmark	\checkmark		
State Policy Controls	\checkmark	\checkmark	\checkmark	\checkmark	\checkmark		
Municipality Policy Controls	\checkmark	\checkmark	\checkmark	\checkmark	\checkmark		
Local Economic Controls	\checkmark	\checkmark	\checkmark	\checkmark	\checkmark		
Observations	296,243	73,092	313,384	1,006,586	369,335		
Municipalities	2,563	1,065	2,532	3,932	$3,\!628$		
Data Availability Period	2010-2017	2010-2017	2010-2017	2010-2017	2010-2017		

Note: Shown are the coefficients and standard errors for "high broadband state" under different specifications of the RDD polynomials, with each cell in the table reporting the result of a separate regression. Panel A displays estimates for linear, quadratic, and linear interacted RDD polynomials in distance to the state boundary, whereas Panel B presents the results for linear, quadratic, cubic, and quartic RDD specifications in longitude and latitude. Real estate prices are log values to facilitate better comparability of the estimates. Standard errors are clustered at the boundary-region-by-year level. *p<0.1; **p<0.05; ***p<0.01.

Table A13: Sample Robustness Checks for Real Estate Rents

Spatial RDD Estimates	Sale 1	Prices	Rents				
	65% Threshold	85% Threshold	65% Threshold	85% Threshold			
	(1)	(2)	(3)	(4)			
Panel A: RDD Polynomials in	Distance to	Boundary					
Linear	0.0629**	0.0151	0.0374***	0.0122			
	(0.0265)	(0.0287)	(0.0141)	(0.0175)			
Quadratic	0.0500**	0.0199	0.0331***	0.0132			
	(0.0238)	(0.0285)	(0.0119)	(0.0175)			
Linear Interacted	0.0464^{*}	0.0148	0.0312**	0.0112			
	(0.0258)	(0.0282)	(0.0130)	(0.0174)			
Panel B: RDD Polynomials in Longitude and Latitude							
Linear	0.0466**	0.0336	0.0291***	0.0219			
	(0.0180)	(0.0285)	(0.0074)	(0.0210)			
Quadratic	0.0556^{***}	0.0239	0.0356^{***}	0.0234			
	(0.0205)	(0.0327)	(0.0092)	(0.0204)			
Cubic	0.0704^{***}	0.0652^{*}	0.0419^{***}	0.0387^{**}			
	(0.0203)	(0.0363)	(0.0091)	(0.0193)			
Quartic	0.0411^{*}	0.0656^{**}	0.0295^{**}	0.0473^{***}			
	(0.0242)	(0.0319)	(0.0119)	(0.0167)			
Boundary Region by Year FE	\checkmark	\checkmark	\checkmark	\checkmark			
Individual Property Controls	\checkmark	\checkmark	\checkmark	\checkmark			
State Policy Controls	\checkmark	\checkmark	\checkmark	\checkmark			
Municipality Policy Controls	\checkmark	\checkmark	\checkmark	\checkmark			
Local Economic Controls	\checkmark	\checkmark	\checkmark	\checkmark			
Observations	$512,\!899$	$305,\!497$	$255,\!878$	$165,\!203$			
Municipalities	4,168	$3,\!603$	$3,\!640$	3,038			
Data Availability Period	2010-2015	2015 - 2019	2010-2015	2015 - 2019			

E.2 Robustness Checks of "High Broadband State" Threshold

Note: Shown are the coefficients and standard errors for "high broadband state" under different specifications of the RDD polynomials, with each cell in the table reporting the result of a separate regression. Panel A displays estimates for linear, quadratic, and linear interacted RDD polynomials in distance to the state boundary, whereas Panel B presents the results for linear, quadratic, cubic, and quartic RDD specifications in longitude and latitude. Real estate prices are log values to facilitate better comparability of the estimates. Standard errors are clustered at the boundary-region-by-year level. *p<0.1; **p<0.05; ***p<0.01.

Table A14: Results of the Spatial RDD Using Alternative "High Broadband State" Thresholds

F Placebo Checks

	Sale Prices	Rents
	(1)	(2)
Panel A: RDD Polynomials in I	Distance to Boundary	y
Linear	0.0072	0.0212
	(0.0480)	(0.0235)
Quadratic	0.0067	0.0208
	(0.0477)	(0.0235)
Linear Interacted	0.0072	0.0212
	(0.0480)	(0.0235)
Panel B: RDD Polynomials in I	Longitude and Latitue	de
Linear	0.0096	0.0290
	(0.0510)	(0.0257)
Quadratic	0.0002	0.0330
	(0.0600)	(0.0284)
Cubic	-0.0114	0.0225
	(0.0598)	(0.0274)
Quartic	0.0076	0.0450
	(0.0584)	(0.0273)
Boundary Region by Year FE	\checkmark	\checkmark
Individual Property Controls	\checkmark	\checkmark
State Policy Controls	\checkmark	\checkmark
Municipality Policy Controls	\checkmark	\checkmark
Local Economic Controls	\checkmark	\checkmark
Observations	489,817	$242,\!306$
Municipalities	4,219	$3,\!570$
Data Availability Period	2018-2019	2018-2019

Note: Shown are the coefficients and standard errors for "high broadband state" under different specifications of the RDD polynomials, with each cell in the table reporting the result of a separate regression. Panel A displays estimates for linear, quadratic, and linear interacted RDD polynomials in distance to the state boundary, whereas Panel B presents the results for linear, quadratic, cubic, and quartic RDD specifications in longitude and latitude. Real estate prices are log values to facilitate better comparability of the estimates. Standard errors are clustered at the boundary-region-by-year level. *p<0.1; **p<0.05; ***p<0.01.

Table A15: Placebo Checks for Housing Sale Prices and Rents

G Alternative Identification Strategies

G.1 Coarsened Exact Matching

In this section, we present a robustness check aimed at addressing concerns regarding the similarity of neighboring municipalities in our main specification. To enhance comparability between the two groups - "high" and "low" broadband states - we employ a coarsened exact matching (CEM) approach as proposed by Iacus et al., 2012. The selection of matching variables and the extent to which variables are coarsened is a trade-off between getting treatment and control group to be as similar as possible on the one hand and leaving enough observations for the estimation in the sample on the other hand.

The CEM approach facilitates the matching of "treatment" observations, where in our context, treatment status is based on a municipality being located in a "high" broadband state for 16 Mbit/s in 2015. The matching uses coarsened variables and assigns weights to observations to improve balance between the groups. For this purpose, we utilize the unemployment rate, school quality, and crime rate from 2013 as the matching variables. To ensure "exact" matches, these variables are coarsened into terciles, thereby requiring that treatment and control municipalities fall within the same tercile for matching variables.

The matching results are summarized in Table A16. As the first column shows, more than two thirds of the control ("low" broadband state) group have been matched to treated ("high" broadband state) group municipalities. The second column shows that from the "treated" group, nearly 60 percent of observations have been matched. Note that we do not apply one-to-one matching. Observations are weighted to increase balance. These weights are also used in the following regressions.

Table A17 shows the same regressions as in our main analyses for sale prices and rents using the CEM sample. The estimates are very similar to the main results. For sale prices, the linear estimate in longitude-latitude is 10.0 percent. The respective estimate for rents is 7.9 percent. As in the main specification, this effect is lower than for sale prices. Overall, the fact that results remain qualitatively unchanged supports the comparability of the two groups in our main analysis.

	Control: "Low"	Treatment: "High"
	Broadband	Broadband
	States	States
All Municipalities	$1,\!554$	4,930
Matched	1,042	2,932
Unmatched	512	1,998

Note: The table summarizes the coarsened exact matching on school quality, crime rate, and unemployment rate in 2013, each with tercile bins. Treatment status is assigned based on whether the municipality was a high broadband state (16 Mbit/s) in 2015.

Table A16: Matching Summary

Spatial RDD Estimates	Coarsened Exact Matching		
	Sale Prices	Rents	
Panel A: RDD Polynomials Di	stance to Border		
Linear	0.0412***	0.0725**	
	(0.0171)	(0.0329)	
Quadratic	0.0904^{***}	0.0609***	
	(0.0172)	(0.0197)	
Linear Interacted	0.0385^{**}	0.0518^{**}	
	(0.0167)	(0.0232)	
Panel B: RDD Polynomials in	Longitude-Latitude	2	
Linear	0.1005***	0.0787***	
	(0.0199)	(0.0242)	
Quadratic	0.1061^{***}	0.0777^{***}	
	(0.0189)	(0.0242)	
Cubic	0.1039^{***}	0.0733^{**}	
	(0.0219)	(0.0324)	
Quartic	0.0820***	0.0560^{*}	
	(0.0210)	(0.0305)	
Boundary Region by Year FE	\checkmark	\checkmark	
Individual Property Controls	\checkmark	\checkmark	
State Policy Controls	\checkmark	\checkmark	
Municipality Policy Controls	\checkmark	\checkmark	
Local Economic Controls	\checkmark	\checkmark	
Observations	469,538	135,758	
Municipalities	2,168	1,080	
Data Availability Period	2010-2017	2010-2017	

Note: Shown are the coefficients and standard errors for "high broadband state" under different specifications of the RDD polynomials, with each cell in the table reporting the result of a separate regression, using the matched sample. In addition to the selection of the sample, coarsened exact matching is used to weight observations. Panel A displays estimates for linear, quadratic, and linear interacted RDD polynomials in distance to the state boundary, whereas Panel B presents the results for linear, quadratic, cubic, and quartic RDD specifications in longitude and latitude. Real estate prices are log values to facilitate better comparability of the estimates. Standard errors are clustered at the boundary-region-by-year level. *p<0.1; **p<0.05; ***p<0.01.

Table A17: Alternative Identification Strategy: Coarsened ExactMatching Results

G.2 Event Study



Note: This figure plots event study estimates of property sale prices on the event of states surpassing the "high" broadband threshold. The dependent variable is the log property sale price to facilitate comparability with the main RDD estimates. Confidence intervals are drawn at the 95 percent level and standard errors are clustered at the boundary-region-by-year level. The regression specification is similar to the main RDD analyses and includes all property and socioeconomic controls as well as boundary-region-by-year fixed effects. Contrary to the main analysis, in which the sample is comprised of municipalities around state borders, where one state is considered a "high" and the other one "low", the event study sample consists of all municipalities located at state borders over time. Therefore the event study sample is larger than the main RDD sample sample (3.9 million compared to 0.7 million observations). For the event study, the reference period is normalized to the year -1, i.e. the first year in which a municipality surpassed the threshold of providing 75 percent of households with at least 16 Mbit/s broadband Internet, accounting for the dynamic nature of the "event."

Figure A20: Alternative Identification Strategy II: Event Study Results

	High B	troadband St. 16 Mbit/s	ates	High I	30 Mbit/s	ates	High I	3roadband St 50 Mbit/s	ates
	Early	Late	Diff	Early	Late	Diff	Early	Late	Diff
	(1)	(2)		(3)	(4)		(5)	(9)	
Panel A: Speed of Ho	useholds' Purci	hased Interne	t Subscription	S					
>6 Mbit/s	75.73	71.37	4.36	73.98	71.97	2.01	75.94	71.60	4.34
>16 Mbit/s	52.30	45.54	6.76	53.00	43.20	9.80	52.75	45.61	7.14
>50 Mbit/s	21.96	13.71	8.26	17.15	14.05	3.10	21.80	14.15	7.66
Panel B: Working fro	m Home								
Homeoffice (any)	10.68	9.52	1.16	10.57	8.75	1.82	10.94	9.10	1.85
Homeoffice (share)	6.06	5.42	0.64	6.17	4.95	1.22	6.22	5.18	1.04
Municipalities	270	3,250	4,020	1,272	2,053	3, 325	663	2,711	3,374
<i>Note:</i> This table sho offering a speed abov the average share of analyses with 16 Mb they are among the t the municipalities fr Mbit/s in 2018. The	ws the share c /e 6, 16 and 50 the workweel it/s. Municipe sarlier half of 5 om the 30 MH third pair of	of households 0 Mbit/s, res k worked fro: alities are spl states to be o sit/s sample columns uses	in the micro spectively, as m home. Th mome. Th lit based on v classified as a from the ma s the 50 Mbit	-census reporvell as the s well as the s e first pair o whether their thigh broadb in analyses of s/s sample ar	rting that the share of house f columns us state has be and state for based on who id also splits	ey have a sul- eholds worki es the samp en an early this speed. ether their s according to	bscription wit ing from home le of municip: adopter or a l The second r tate is a high 50 Mbit/s a	h their Interr a at least som alities used fo ate adopter, i air of columr broadband s vailability in	tet provider tetimes and or the main .e. whether is is divides state for 30 2018.

Table A18: Mechanism: Households' Subscriptions, and Working From Home Based on the German Micro-Census

H Mechanism

I Policy Evaluation

Disc. rate	Transaction tax	Cost	% Projects	Cost (lb)	% (lb)	Cost (ub)	% (ub)
		9154	92	5485	73	12822	97
0	3.5	9486	93	5684	73	13287	98
2	3.5	9454	93	5665	73	13242	98
4	3.5	9425	93	5647	73	13202	98
2	5	9588	93	5745	74	13430	98
2	6.5	9727	93	5828	74	13624	98
2	6.5	9790	93	5866	75	13713	98

Note: The table shows costs per connected household up to which the marginal value of public funds (MVPF) is larger than one for various scenarios of different discount rates and property transaction tax rates. The table also shows the lower and upper bound costs from the confidence interval as well as the share of projects that has costs up to the shown level.

Table A19: Marginal Value of Public Funds