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Toward Digital Inclusion

Broadband Access in the Third Federal Reserve District

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Introduction

Few innovations have comprehensively changed the nature of the American economy and daily life like high-speed internet — commonly known as broadband. Access to fixed wireline broadband connects millions of people to digital information networks, which can have a transformative effect on the quality of life an individual leads[1] and the competitiveness of regional economies.[2] However, the digital divide — the uneven distribution of broadband service and adoption — adversely affects residents of rural areas, black and Hispanic groups, and low- and moderate-income (LMI) communities (Strover 2001, Pew Research Center 2019, Gallardo, Whitacre, and Grant 2018).

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[1] For example, Horrigan (2010) found that broadband internet at home helps low-income people better manage time, money, and family schedules.

[2] In a wide-ranging literature review, Salemink, Strijker, and Bosworth (2017) find that rural economies are in need of broadband connections to compensate for their remote geography.

This report provides an overview of the digital divide in the Third Federal Reserve District, with a focus on determining which groups stand to benefit the most from a concerted effort toward digital inclusion. The report describes patterns of broadband availability and adoption for the Third District (eastern Pennsylvania, southern New Jersey, and Delaware) as a whole, followed by a regional comparison of digital access using a typology of broadband. This report makes a distinction between broadband availability and broadband adoption (or "subscription") in order to better understand barriers to access. Broadband is defined as available in census tracts (or "neighborhoods") where at least half of the resident population have at least one provider present. Broadband adoption is defined as the rate at which households subscribe to high-speed internet.[3] Although broadband may be available to residents, the actual adoption of high-speed internet can vary significantly between neighborhoods. With these two metrics, I create a typology that identifies three kinds of neighborhoods: unserved neighborhoods (broadband is not available to residents), low-uptake neighborhoods (broadband is available to residents, but tract-level household subscription rates fall below the Third District average), and high-uptake neighborhoods (broadband is available to residents, and tract-level household subscription rates are equal to or exceed the Third District average). Last, this report applies regression analysis to contextualize the main findings while controlling for additional variables of interest.[4] Neighborhood-level characteristics such as population demographics and whether a neighborhood is located in a metropolitan (urban and suburban) or non-metropolitan (rural) area are focuses in both the descriptive and regression analyses.

THE KEY FINDINGS OF THIS REPORT INCLUDE:

- Broadband is unavailable to 13 percent of nonmetropolitan residents, compared with just 1 percent of MSA residents and 2 percent of Third District residents overall.
- The median maximum advertised download and upload speeds in MSAs (200/10 Mbps) are higher than nonmetropolitan regions (50/5 Mbps).
- There are substantial differences in the household adoption rate of broadband between different types of neighborhoods: nonmetropolitan (62 percent) and metropolitan (71 percent); LMI (58 percent) and upper-income (82 percent) neighborhoods; and predominantly Latino or Hispanic (50 percent), predominantly black (53 percent), and predominantly white (73 percent) neighborhoods.
- About 44 percent of all Third District residents live in low-uptake neighborhoods.

Literature Review

Recent findings from the Federal Communications Commission (FCC) confirm that disparities persist in broadband access between rural and urban communities. The FCC's 2016 Broadband Progress Report found that 39 percent of Americans living in rural communities lack access to broadband, compared with just 4 percent of those living in urban areas (Broadband Progress Report 2016). An explanation for the geographic availability gap lies in the profit incentive. Many internet service providers (ISP) neglect to deploy broadband in rural communities based on the low profitability of providing service to areas with fewer customers, along with the considerable challenge of building and maintaining infrastructure on difficult terrain.[5]

[3] Availability uses population and adoption uses households because of data features that I describe in the Data section.

[4] Results of the regression model can be viewed in Appendix B.

[5] In testimony to the Government Accountability Office, ISPs noted, "The most frequently cited cost factor affecting broadband deployment was the population density of a market…Terrain was also frequently cited as a factor affecting broadband deployment decisions. In particular, we were told that infrastructure built-out can be difficult in mountainous and forested areas because these areas may be difficult to reach or difficult on which to deploy the required equipment." (Hecker 2006)

Demographic patterns of broadband subscription indicate that the digital divide carries adverse effects by race. The Pew Research Center maintains an ongoing survey of broadband usage, which shows adoption rates for black and Hispanic users consistently fall below their white counterparts (Pew Research Center 2019). Another study from the Brookings Institution found that income level was one of the strongest predictors of broadband adoption (Tomer and Kane 2015). Additional research indicates that LMI households, in particular, face challenges in adopting broadband, where economic marginalization and resource scarcity are compounded by low broadband uptake (Dailey, Bryne, Powell, Karaganis, and Chung 2010). Furthermore, an FCC survey of broadband users found that service cost was the main inhibitor to subscription, with 36 percent of nonadopters citing it as a primary barrier to access (Horrigan 2010). Altogether, socioeconomic factors based on place, race, and income have substantially contributed to the digital divide. As home life, work, and business operations become more digitally dependent, access to broadband can be an important mechanism for promoting economic growth and mobility, especially for disadvantaged populations.

Past studies of broadband access have highlighted patterns of broadband availability and subscription rates, particularly at the national level or between larger MSAs. Descriptive regional studies of broadband access are crucial in understanding the differences and similarities between communities, and ultimately considering effective policy solutions to bridge the digital divide. I add to this work with an analysis that includes rural regions, particularly nonmetropolitan counties in the Third Federal Reserve District. I also add a new typology that distinguishes between availability and adoption, which is important for better understanding reasons for the divide and potential policy solutions.

Data

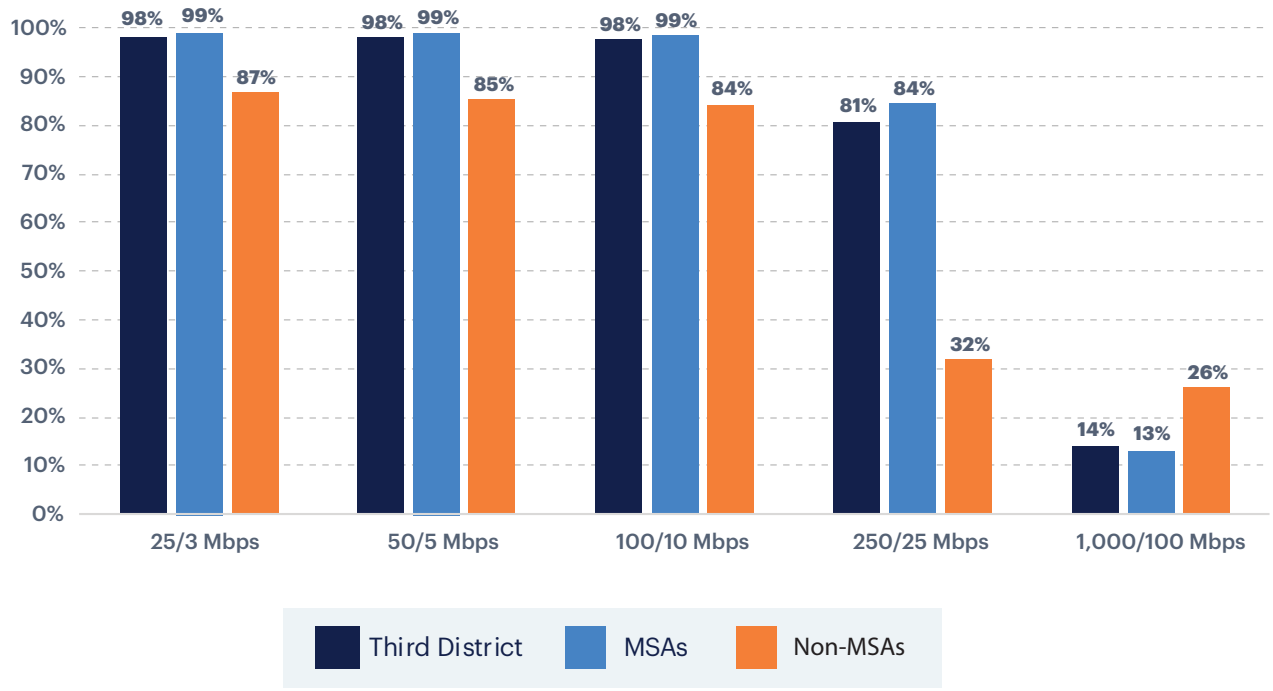
This study analyzes patterns of residential broadband access by place, race, and income in the Third Federal Reserve District along two dimensions: neighborhood service availability, or the deployment of broadband infrastructure, and household subscription rates. To evaluate broadband availability, I use FCC Form 477 Fixed Broadband Deployment data from December 2017. Twice a year, the FCC requires ISPs to report through Form 477 the internet services they can or do offer to at least one household or business in a census block by the type of technology and the advertised download and upload speeds. These data provide information on service availability by all fixed wireline technologies, such as DSL, cable, copper wireline, fiber optic cable to the home or business end user, satellite internet, and terrestrial fixed wireless. This study focuses on a subset of Form 477 filings for digital subscriber line (DSL), cable, and fiber optic cable aggregated up to the tract level, which aligns best with data on household subscription rates and additional demographic indicators from the U.S. Census Bureau.

To estimate broadband availability, I use 2010 Decennial Census population estimates as the unit of analysis, which are the most recent estimates available at the block level. It is important to note that Form 477 states that ISPs can report service if they do or could deploy broadband within a period that is typical for that particular connection to an end-user premises within the block. Based on that response, providers that report serving a block may not necessarily cover the entirety of the area, resulting in the likely overestimation of broadband availability when aggregating the population estimates to the tract level. However, the Form 477 data do indicate whether a census block has any service and can provide insight on how many ISPs deploy broadband at various speed thresholds in that geography.[6]

To estimate household subscription, data are derived from the U.S. Census Bureau's 2013–2017 American Community Survey (ACS) five-year estimates at the census tract level. The survey asks households to report whether they subscribe to an internet service and, if so, the type of connection

[6] The FCC produces a separate data set on mobile broadband availability that is not included in this analysis.

FIGURE 1: BROADBAND AVAILABILITY BY GEOGRAPHY



they have. The analysis in this paper focuses on the survey's high-speed category that includes "broadband such as cable, fiber optic, or DSL."[7] Additional demographic characteristics included in the analysis are taken from the same data set. With these data, I calculate the share of households in a tract that subscribe to broadband. The use of ACS data to report broadband subscription rates is a notable contribution compared with previous studies of broadband access. It facilitates the calculation of a more precise estimate of tract-level household subscription rates and focuses on a specific set of technologies that are more likely to deliver high-speed internet.

Broadband Availability by Speed Threshold

The term broadband refers to the speed at which information is transmitted from the technology providing the service. As the data management needs of consumers have increased and internet service at lower speeds has become more widely available, the FCC's definition of broadband internet has increased to speeds of at least 25 megabits per second download (Mbps) and 3 Mbps upload.[8] While the 25 Mbps download threshold constitutes sufficient broadband service for households, higher speeds are necessary to operate small businesses (50 Mbps+), schools (100 Mbps–1,000 Mbps), and hospitals (1,000 Mbps) (BroadbandUSA 2019). To assess the demand of consumers and developments in the market, the FCC monitors broadband access at higher speed thresholds, such as 50/5 Mbps, 100/10 Mbps, and 250/25 Mbps (Federal Communications Commission 2019).

Regional Variation in Availability

Figure 1 displays broadband availability at various speed thresholds in the Third District overall, as well

[7] See Appendix A and B for more details on the data and methodology for this analysis.

[8] Prior to 2015, the definition of broadband was benchmarked at 4 Mbps download and 1 Mbps upload speeds, which was "dated and inadequate for evaluating whether advanced broadband is being deployed..." (Federal Communications Commission 2015).

as its metropolitan and nonmetropolitan regions. Overall, broadband is widely available (98 percent) to Third District residents at the FCC benchmark of 25 Mbps. Broadband availability rates begin to drop at the higher speed thresholds of 250 Mbps (81 percent) and 1,000 Mbps (14 percent). Gigabit internet, or the 1,000 Mbps threshold, is widely considered the next generation of broadband that supports greater capabilities in data sharing and high-capacity internet use (Kenny and Williamson 2016).

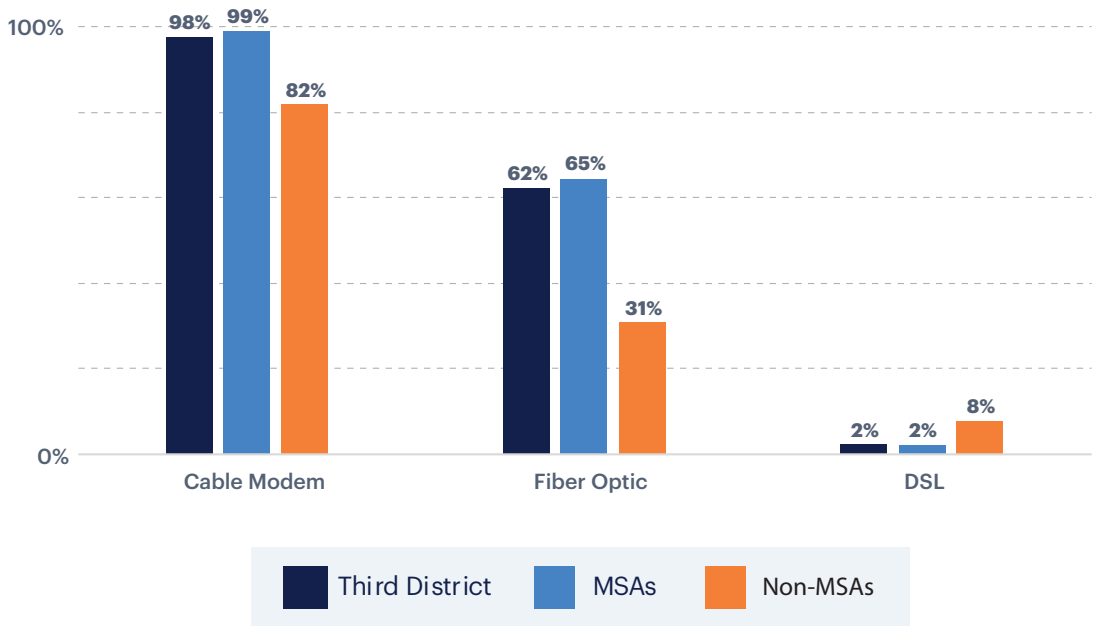
Differences in broadband availability between metropolitan and nonmetropolitan areas are also included in Figure 1. Generally, nonmetropolitan regions have lower rates of broadband availability than their MSA counterparts, and MSAs have higher broadband deployment than the Third District overall. At the FCC benchmark speed, 99 percent of MSA residents have broadband available in their neighborhoods, compared with just 87 percent of the population living in nonmetropolitan regions. Similar to the findings for the Third District overall, broadband availability rates in both nonmetropolitan areas and MSAs also drop at higher speed thresholds. However, at gigabit speeds, nonmetropolitan regions have greater availability than MSAs and the Third District overall (26 percent, 13 percent, and 14 percent, respectively). Greater gigabit availability for nonmetropolitan residents reflects the steady and ongoing deployment of next-generation broadband technologies and network upgrades that support higher bandwidth.

The remainder of this report focuses on availability at 25 Mbps and 3 Mbps upload and download speeds, respectively, to display trends based on the FCC baseline definition of broadband.

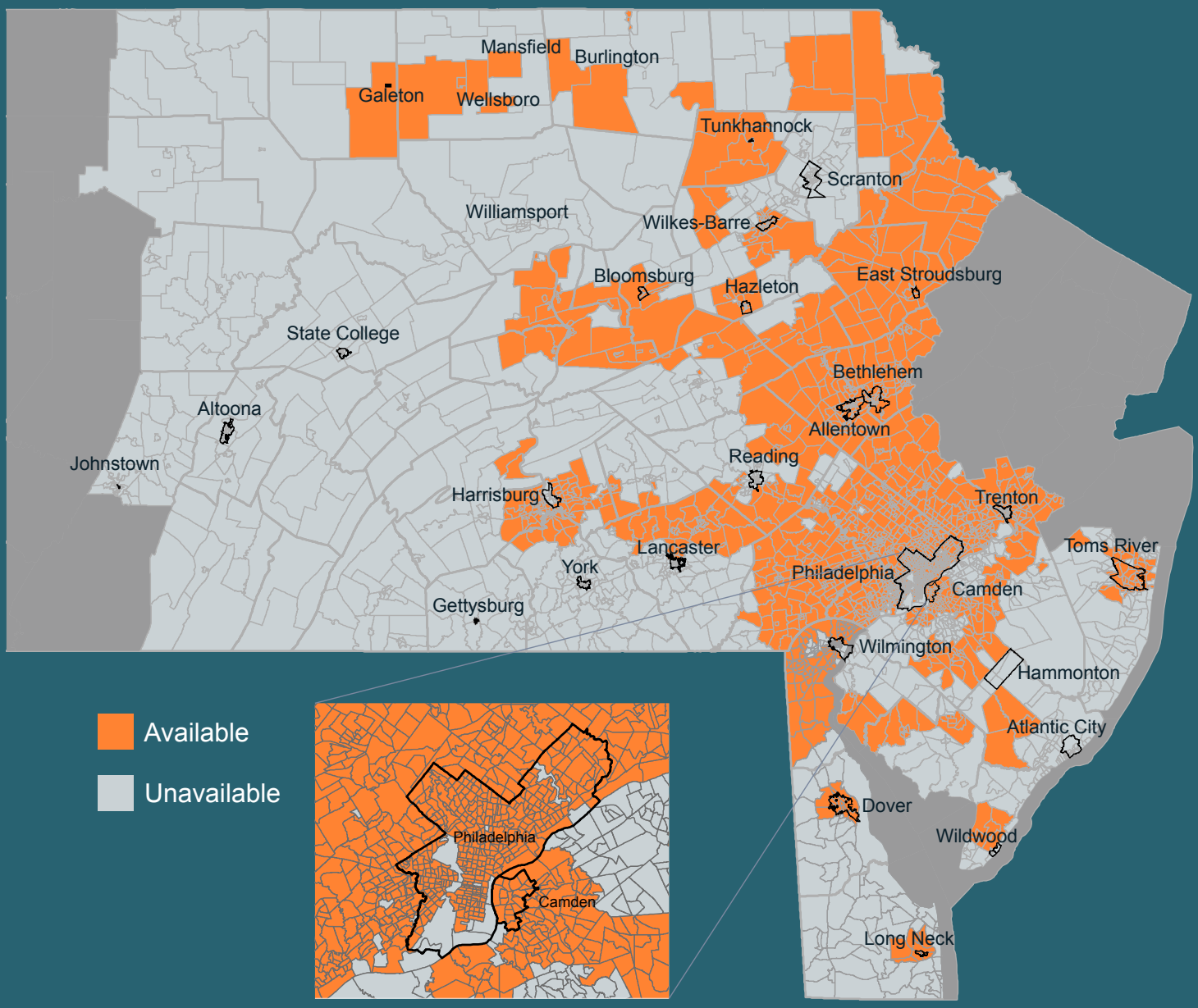
Trends in Technology Availability

Broadband availability is dependent on the deployment of infrastructure throughout communities. The built environment must be equipped with the right technology to deliver high-speed internet for consumers to get connected. Certain technologies, such as cable, fiber optic cable, and DSL are more likely to deliver high-speed internet than others, such as wireless broadband and satellite technology. Fiber optic cable is favored and considered the best technology to deploy

FIGURE 2: BROADBAND AVAILABILITY AT 25/3 MBPS BY TECHNOLOGY



Map 1: Third District Fiber Optic Availability at 25/3 Mbps



FIBER OPTIC COVERAGE IN THE THIRD DISTRICT'S NONMETROPOLITAN AREAS

As a next-generation technology, fiber optic cable coverage provides fast, reliable, and symmetric broadband internet to consumers. However, there are entire nonmetropolitan regions in the Third District that are unserved. Map 1 identifies the geographic coverage area of fiber optic infrastructure that provides broadband at 25 Mbps throughout the Third District at the tract level. Several patterns emerge from the data. First, fiber optic technology is concentrated in and around heavily urbanized areas of the Third District. In particular, Philadelphia and its surrounding suburban counties and the northeast corridor are almost completely covered by fiber optic infrastructure.

Medium-sized cities, such as Harrisburg, Reading, and Bloomsburg, PA, show a similar pattern of concentrated coverage in the most densely populated areas of their respective regions. However, fiber optic service is unavailable in rural areas around those medium-sized cities, which can noticeably yield intraregional disparities in access. Last, when looking at regions situated further from the more densely populated parts of the District, gaps in access appear: entire nonmetropolitan regions — and some midsized MSAs — lack fiber optic coverage, particularly in western Pennsylvania.

Table 1: Regional Population Share

Region	Number	Share
East Stroudsburg, PA MSA	167,306	100%
Allentown-Bethlehem-Easton, PA-NJ MSA	717,344	99%
Trenton, NJ MSA	366,755	98%
Pike County, PA*	51,010	92%
Northumberland County, PA	80,586	87%
Philadelphia-Camden-Wilmington, PA-NJ-DE-MD MSA**	5,132,323	86%
Wayne County, PA	41,106	80%
Snyder County, PA	24,152	60%
Harrisburg-Carlisle, PA MSA	335,139	59%
Union County, PA	26,526	59%
Bloomsburg-Berwick, PA MSA	49,601	58%
Vineland-Bridgeton, NJ MSA	86,250	56%
Tioga County, PA	18,209	44%
Ocean County, NJ*	252,300	43%
Reading, PA MSA	169,936	41%
Schuylkill County, PA	55,504	38%
Lancaster, PA MSA	202,547	38%
Scranton–Wilkes-Barre–Hazleton, PA MSA	208,133	37%
Dover, DE MSA	60,860	35%
Susquehanna County, PA	14,193	34%
Bradford County, PA	20,496	33%
Lebanon, PA MSA	32,697	24%
Ocean City, NJ MSA	18,623	20%
Sussex County, DE*	25,370	12%
Potter County, PA	2,004	12%
Atlantic City-Hammonton, NJ MSA	31,674	12%
York-Hanover, PA MSA	40,331	9%
Altoona, PA MSA	0	0%
Bedford County, PA	0	0%
Cameron County, PA	0	0%
Chambersburg-Waynesboro, PA MSA	0	0%
Clearfield County, PA	0	0%
Clinton County, PA	0	0%
Elk County, PA	0	0%
Fulton County, PA	0	0%
Gettysburg, PA MSA	0	0%
Huntingdon County, PA	0	0%
Johnstown, PA MSA	0	0%
Juniata County, PA	0	0%
Mc Kean County, PA	0	0%
Mifflin County, PA	0	0%
State College, PA MSA	0	0%
Sullivan County, PA	0	0%
Williamsport, PA MSA	0	0%

*Part of an MSA that falls primarily outside of the Third Federal Reserve District; **Cecil County, MD falls outside the Third Federal Reserve District and is not included in the Philadelphia MSA statistic.

Source: Author's calculations using 2013–2017 American Community Survey (ACS) and FCC Form 477 data.

TABLE 2: MEDIAN MAXIMUM ADVERTISED DOWNLOAD/UPLOAD SPEEDS

Geography	Cable Modem (Mbps)	Fiber Optic (Mbps)	DSL (Mbps)	All Technologies (Mbps)
Third District	350/35	940/880	10/1	120/10
MSAs	350/35	940/880	7/1	200/10
Non-MSAs	200/10	1,000/1,000	10/1	50/5

Source: Author's calculations using December 2017 FCC Form 477 data.

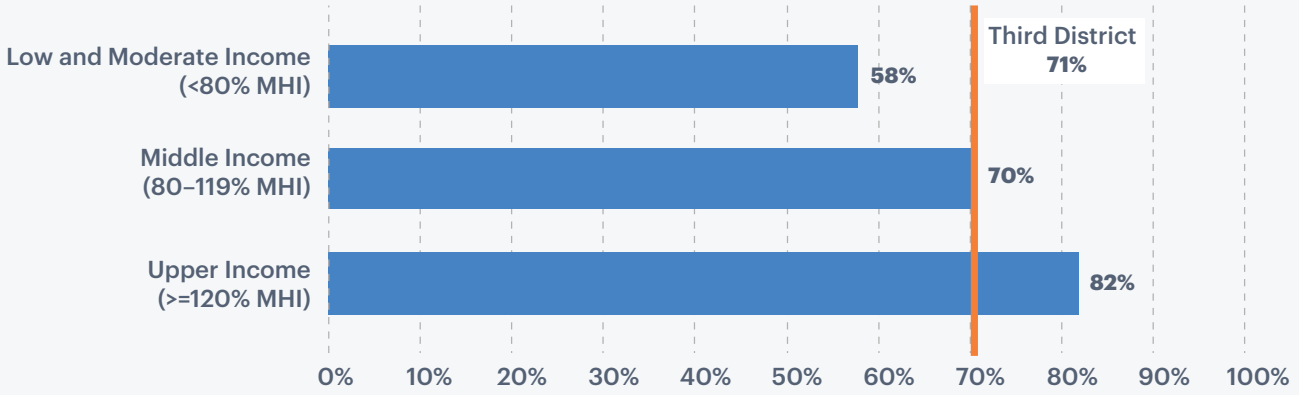
broadband at the fastest speeds to consumers, if it is available. However, cost constraints limit the deployment of the infrastructure necessary to support fiber optic networks, especially when existing technologies, such as cable and DSL, are already serving customers (Parsons and Stegeman 2018). Figure 2 displays the share of the Third District, MSA, and nonmetropolitan populations that have cable, fiber optic cable, and DSL broadband infrastructure available at 25 Mbps. Cable is an option for 98 percent of the Third District overall, the highest of all three technologies included in this study. Fiber optic broadband is available to a majority (62 percent) of Third District residents but substantially fewer than cable. Only 2 percent of Third District residents have DSL available, the lowest rate of any technology.

Once again, MSA and nonmetropolitan populations experience a disparity in availability by technology for both cable and fiber optic cable. However, a greater share of nonmetropolitan residents (8 percent) have access to DSL than those who live in MSAs (2 percent). It is particularly striking that fiber optic cable is available to just 31 percent of nonmetropolitan area residents, compared with 65 percent of MSA residents. The expansion and updates of advanced broadband technologies, such as fiber optic cable, can promote digital inclusion for residents of nonmetropolitan regions.

Median Advertised Speeds

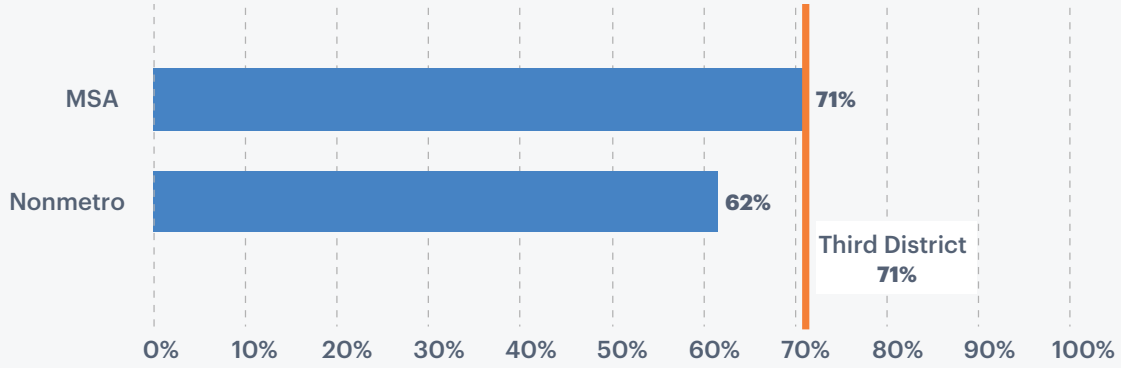
Table 2 shows the median advertised download and upload speeds of each technology by geography. The median advertised broadband speed for all technologies in the District is 120/10 Mbps, with the median for nonmetropolitan areas (50/5 Mbps) falling below the median for the District's MSAs (200/10 Mbps). Across all geographies, DSL has the lowest median download and upload speeds (10/1 Mbps), while cable (350/35 Mbps) and fiber optic cable (940/880 Mbps) provide substantially higher median bandwidth to the District's residents overall. Furthermore, fiber optic cable consistently delivers higher download and upload speeds at the MSA (940/880 Mbps) and nonmetropolitan (1,000/1,000 Mbps) levels. Cable provides slower median speeds to nonmetropolitan areas (200/10) relative to MSAs and the Third District overall (350/35). Implementing network upgrades to increase bandwidth, where such a project is feasible for technologies like DSL, is a strategy that can expand the population that broadband serves.

FIGURE 3: HOUSEHOLD SUBSCRIPTION RATE BY NEIGHBORHOOD INCOME LEVEL



Source: Author's calculations using 2013–2017 American Community Survey (ACS) data. The tracts included in this figure are restricted to those that fall within the Third Federal Reserve District.

FIGURE 4: HOUSEHOLD SUBSCRIPTION RATE BY METRO/NONMETRO STATUS



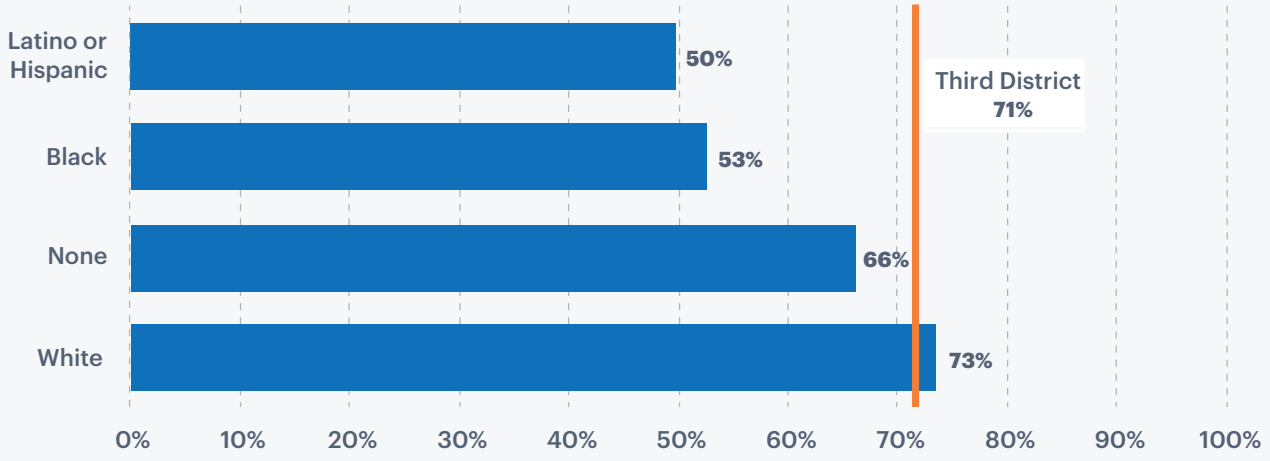
Source: Author's calculations using 2013–2017 American Community Survey (ACS) data. The tracts included in this figure are restricted to those that fall within the Third Federal Reserve District.

Household Subscription Rates

Although broadband infrastructure may be available to consumers, the extent to which disparities in access persist reflects an ongoing challenge in the adoption of high-speed internet. Wireless broadband subscriptions, often delivered through mobile devices, such as smartphones or WiFi hotspots, have increased in popularity and provide an alternative to fixed broadband service like DSL, cable, and fiber optic cable.[9] However, wireless broadband is not a substitute for fixed broadband services to the home, which augment the capability of mobile devices through WiFi, unlimited data, and higher connection speeds (Rappoport, Kridel, and Taylor 2003). The literature shows that certain demographic groups are at a disadvantage regarding fixed wireline broadband adoption, including blacks and Hispanics, as well as residents of LMI and rural communities (Prieger and Hu 2008, Tomer, Kneebone, and Shivaram 2017). To determine the extent to which households subscribe to broadband in different neighborhoods, not conditional on whether broadband is available at the FCC benchmark, I estimate subscription rates in the findings below.

[9] The Pew Research Center reports that the vast majority of American's (81 percent) own a smartphone, which is a substantial increase from its first measurement of 35 percent in 2011 (Pew Research Center 2019).

FIGURE 5: HOUSEHOLD SUBSCRIPTION RATE BY PREDOMINANT TRACT RACIAL AND ETHNIC GROUP



Source: Author's calculations using 2013–2017 American Community Survey (ACS) data. The tracts included in this figure are restricted to those that fall within the Third Federal Reserve District.

Subscription Patterns by Income, Place, and Predominant Racial and Ethnic Group

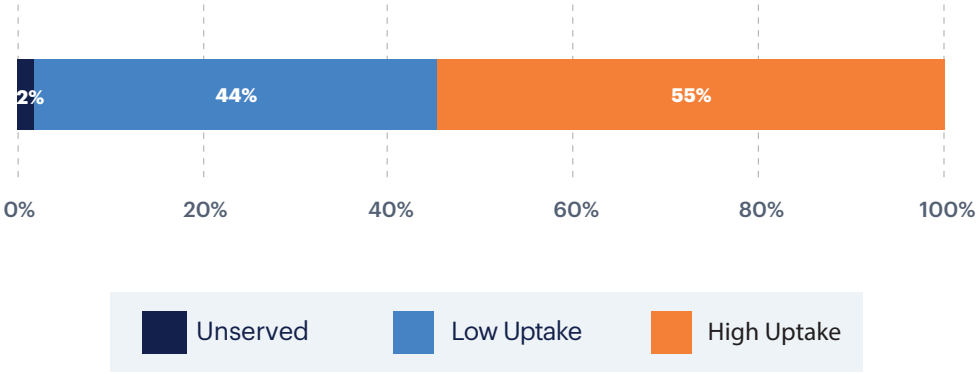
Patterns of household broadband subscription by neighborhood income level are displayed in Figure 3.[10] To assess the income level of a neighborhood, census tracts were sorted into three groups. A census tract is considered LMI if its median household income (MHI) falls below 80 percent of the median household income (MHI) in its MSA or nonmetropolitan county, middle income if its MHI is 80–119 percent of the MHI, and upper income if its MHI is 120 percent or more of the MHI. Overall, 71 percent of Third District households subscribe to broadband, compared with only 58 percent of households in LMI tracts. Households in both middle- (70 percent) and upper-income (82 percent) tracts display a larger rate of subscriptions than their LMI counterparts, and the upper-income tracts' subscription rate exceeds that of the Third District overall.

Figure 4 displays differences in broadband subscription rates between households in MSAs and nonmetropolitan regions. Households located in MSAs (71 percent) have higher subscription rates than those in nonmetropolitan regions (62 percent). Generally, it is clear that broadband adoption lags in sparsely populated areas, especially outside MSAs and urban communities. This finding is not surprising, given these areas are also more likely to lack availability. Later in this report, I will use a broadband typology to discuss neighborhood subscription conditional on access.

Figure 5 displays household broadband subscription rates for tracts by predominant racial and ethnic groups. Predominantly white neighborhoods have the highest broadband subscription rate (73 percent) and are the only group to exceed the Third District average. Census tracts without a predominant racial or ethnic group have the next-highest subscription rate of 66 percent, followed by households in predominantly black neighborhoods at 53 percent. Broadband subscription rates are lowest in predominantly Latino or Hispanic tracts, with just 50 percent of households reporting a subscription. Low rates of fixed broadband adoption in predominantly black and Latino or Hispanic neighborhoods may be supplemented by mobile phone use. Research has shown that blacks and Hispanics own smartphones at similar rates as whites, despite subscribing to fixed wireline broadband at lower rates, which likely explains some of the disparity in subscription rates (Perrin

[10] A detailed table of broadband subscription rates by MSAs and nonmetropolitan regions can be found in Appendix B.

FIGURE 6: SHARE OF THIRD DISTRICT POPULATION BY TYPOLOGY



Note: Percentages do not sum to 100 percent because of rounding.

Source: Author's calculations using 2013–2017 American Community Survey (ACS) and FCC Form 477 data. The tracts included in this figure are restricted to those that fall within the Third Federal Reserve District.

and Turner 2019). However, cellular service cannot fully supplement the benefits fixed wireline broadband provides households, particularly in terms of reliability, data caps, and data processing speeds.

Regression Analysis

To contextualize the findings related to subscription rates while controlling for additional variables of interest, I apply a regression analysis in which tract-level household subscription rates are regressed on tract-level characteristics (See Appendix B for full results). The analysis was applied to observe how associations with neighborhood-level subscription rates change, considering additional variables of interest, such as race, income, and rural and urban status. Neighborhoods without broadband availability at 25 Mbps are not included in the regression analysis.

Two ordinary least squares regression models were fit. Model 1 includes subscription rates regressed on resident and household characteristics, while Model 2 introduces the share of households with a home computer. The results from Model 1 indicate that both resident and household characteristics are statistically significantly correlated with subscription rates and explain a reasonable amount of subscriptions. The neighborhood share of nondegree holders, the nonwhite share of residents, the share of residents ages 65 and up, the share of family households, the share of households receiving public assistance, and poverty rates have statistically significant, negative associations with subscription rates, independent of other neighborhood characteristics. Moreover, median household income (expressed as the log of the MHI), the share of owner occupied units, and the inclusion of an MSA status indicator share statistically significant positive associations with subscription rates. In Model 2, the proportion of households reporting a desktop or a laptop being present shares a positive association with neighborhood subscription rates. Finally, Model 2 indicates that when considering the presence of technology and neighborhood characteristics together, many associations change or disappear altogether. For example, the association between subscription and median household income weakens considerably, the association with the share of nondegree holders falls to -2.62, and the association with the nonwhite population share flips from -3.15 to 2.45. While these results are meant to contextualize the subscription findings from above and should not be interpreted as causal, they nevertheless suggest

that differences in home computer use across neighborhoods helps to explain some of the differences in home subscription rates between different income, education, and racial and ethnic groups.

Broadband Typology

To more carefully distinguish between differences in access that are due to differences in availability and differences in adoption (even where broadband is available from at least one provider), I construct a new typology of neighborhood broadband access with three types. Unserved neighborhoods are census tracts where broadband at 25 Mbps is not available to at least half of neighborhood residents. Low-uptake neighborhoods represent census tracts where broadband is available to half of neighborhood residents but subscription rates fall below the Third District average. High-uptake neighborhoods are places where broadband infrastructure is available to half of neighborhood residents and subscription rates exceed the District average. Figure 6 displays the distribution of Third District residents who live in each type of neighborhood. District-wide, 2 percent of residents (225,283 people) live in unserved neighborhoods, 44 percent (5,768,898 people) live in low-uptake neighborhoods, and 55 percent (7,243,116 people) reside in high-uptake neighborhoods.

TABLE 3: CHARACTERISTICS OF NEIGHBORHOOD BROADBAND TYPOLOGY

Characteristic	Unserved	Low Uptake	High Uptake
Share of population:			
Nonmetro	53%	12%	1%
MSA	47%	88%	99%
White	87%	62%	78%
Black	6%	19%	8%
Latino or Hispanic	4%	13%	7%
Under 18 Years	18%	23%	21%
18 to 64 Years	65%	61%	62%
65 Years and Older	17%	16%	17%
No Bachelor's Degree	85%	81%	60%
Poverty Rate	12%	20%	7%
Foreign Born	3%	8%	9%
Share of Households:			
Low and Moderate Income	9%	48%	6%
Middle Income	79%	46%	43%
Upper Income	12%	5%	51%
Owner Occupied	80%	61%	76%
Renter Occupied	20%	39%	24%
Families	70%	62%	69%
Receive Public Assistance	2%	5%	2%
Own a Desktop or Laptop	73%	68%	86%
Own a Smartphone	54%	61%	74%

Source: Author's calculations using 2013–2017 American Community Survey (ACS) and FCC Form 477 data. The tracts included in this figure are restricted to those that fall within the Third Federal Reserve District.

Demographic Composition of Broadband Typology

The demographic characteristics of each neighborhood typology group are included in Table 3. The socioeconomic composition of neighborhoods changes substantially between unserved, low-uptake, and high-uptake tracts. A majority of residents in unserved neighborhoods (53 percent) live in nonmetropolitan counties, with a predominantly white (87 percent) population, and with most adults over the age of 25 years of age (85 percent) lacking a

TABLE 4: REGIONAL SHARE OF POPULATION LIVING IN UNSERVED TRACTS

Region	Number	Share
Sullivan County, PA	6,192	100%
Fulton County, PA	9,715	66%
Susquehanna County, PA	18,866	45%
Union County, PA	14,862	33%
Bradford County, PA	17,289	28%
Potter County, PA	4,719	28%
Tioga County, PA	11,453	28%
Snyder County, PA	10,820	27%
Wayne County, PA	10,550	20%
Bloomsburg-Berwick, PA MSA	14,660	17%

TABLE 5: REGIONAL SHARE OF POPULATION LIVING IN LOW-UPTAKE TRACTS

Region	Number	Share
Bedford County, PA	48,891	100%
Mifflin County, PA	46,452	100%
McKean County, PA	42,070	100%
Clinton County, PA	39,321	100%
Cameron County, PA	4,754	100%
Camden City, NJ	75,550	100%
Huntingdon County, PA	43,954	96%
Wilmington City, DE	66,155	93%
Juniata County, PA	22,614	92%
Clearfield County, PA	73,144	91%

TABLE 6: REGIONAL SHARE OF POPULATION LIVING IN HIGH-UPTAKE TRACTS

Region	Number	Share
Pike County, PA*	51,967	93%
East Stroudsburg, PA MSA	127,268	76%
Ocean County, NJ*	415,283	70%
Ocean City, NJ MSA	66,431	70%
Trenton, NJ MSA	259,945	70%
Philadelphia-Camden-Wilmington, PA-NJ-DE-MD MSA**	4,050,463	68%
Atlantic City-Hammonton, NJ MSA	177,278	65%
Dover, DE MSA	99,967	58%
State College, PA MSA	91,040	57%
Allentown-Bethlehem-Easton, PA-NJ MSA	410,171	57%

*Part of an MSA that falls primarily outside of the Third Federal Reserve District; **Cecil County, MD falls outside of the Third Federal Reserve District and is not included in the Philadelphia MSA statistic.

Source: Author's calculations using 2013–2017 American Community Survey (ACS) and FCC Form 477 data.

bachelor's degree. Unserved neighborhoods also have the highest share of households located in middle-income tracts (79 percent). Low-uptake communities have the largest share of black and Latino or Hispanic residents (19 and 13 percent, respectively), a high rate of nondegree holders (81 percent), and the highest share of households located in LMI neighborhoods (48 percent). Moreover, 20 percent of residents in low-uptake tracts live below the poverty level, the highest share of any neighborhood. High-uptake neighborhoods have a substantial majority of residents living in MSA tracts (99 percent), a predominantly white population (78 percent), the lowest share of adults without a bachelor's degree (60 percent), and a majority of households located in upper-income tracts (51 percent). Last, in unserved low- and high-uptake neighborhoods a majority of households are owner occupied (80, 61, and 76 percent, respectively), though less so in low-uptake neighborhoods where nearly 40 percent of households are renter occupied.

Regional Population Share of Typology

Throughout the Third District, the regions with the greatest share of their residents living in unserved and low-uptake neighborhoods are almost entirely nonmetropolitan counties, while MSAs tend to

have the greatest share of people living in high-uptake tracts[11]. These nonmetropolitan regions are the rural and less densely populated areas of the Third District. Table 4 lists the 10 regions with the greatest share of residents living in unserved neighborhoods, nine of which are nonmetropolitan regions. The entirety of Sullivan County, Pennsylvania's population (100 percent) lacks broadband internet service, followed by a list of counties exclusively in Pennsylvania. Table 5 lists the 10 regions with the greatest share of residents living in low-uptake neighborhoods. Similarly, these regions tend to be nonmetropolitan areas in Pennsylvania, except for the cities of Wilmington, DE and Camden, NJ. Six of the 10 regions included on the list have 100 percent of their populations living in low-uptake neighborhoods, including Bedford, Mifflin, McKean, Clinton, and Cameron counties in Pennsylvania, and the city of Camden, NJ. The top 10 regions with the greatest share of their populations living in high-uptake neighborhoods are exclusively MSAs that have an urbanized core or a densely populated city.

Conclusion

This report finds gaps in fixed wireline broadband availability and adoption in the Third District that are associated with neighborhood level characteristics, such as income, race, and MSA or nonmetropolitan status of a tract. Broadband availability consistently lags in nonmetropolitan regions relative to MSAs at most speed thresholds. As broadband network upgrades become necessary, additional consideration toward the upkeep of the District's aging infrastructure will be important in maintaining availability at the FCC benchmark and greater bandwidths. Additional studies on broadband reliability through user-generated speed tests can indicate where network upgrades or extensions are necessary to maintain aging infrastructure (Meinrath et al. 2019).

Even conditional on availability, adoption can be low in certain neighborhoods. Thus, bridging the digital divide should also include trying to better understand low household subscription. Broadband adoption rates in nonmetropolitan, LMI, and predominantly black and Hispanic neighborhoods consistently fall behind their urban, upper-income, and predominantly white neighborhood counterparts. This report shows that some disparities in fixed wireline broadband adoption can be explained by differences in home computer use. However, although some policies may be able to address these issues, there would still be lower adoption in LMI, nonwhite, and populations with lower educational attainment. Future research should attempt to better understand what causes these differences in order to better target policy solutions to bridge the digital divide. Moreover, promoting an array of strategies that increase broadband adoption for residents of nonmetropolitan and LMI communities is an approach that can foster digital inclusion. For instance, educational services that provide consumers with opportunities to develop digital literacy can assist with reaching those in low-uptake neighborhoods where low subscription may not be related to cost.

Broadband will continue to have a substantial influence on daily life as the world becomes more connected. For residents of unserved and low-uptake neighborhoods, access to online information networks can make a difference in finding good-paying jobs, taking online courses, and interacting with banks and other financial institutions remotely. This report suggests that broadband, and the benefits it provides community members, is less accessible for residents of certain neighborhoods. ■

[11] See Appendix B for a full list of regional population shares by typology.

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Appendix A: Methodology

Broadband Availability

To assess availability, the FCC's Form 477 Fixed Broadband Deployment data were used. These data provide a list at the census block level of all fixed wireline technologies and the maximum advertised speeds that ISPs report deploying them. The resulting rows in the data set represent providers within a census block that deploy services that exceed advertised speeds of 200 kilobits per second in one direction. Therefore, there are often multiple rows per census block that indicate different broadband providers. If the same ISP provides multiple technologies (i.e., cable, satellite, and fiber optic to the home) in the same block, then it is listed multiple times to indicate each technology it offers in that geography. It is important to note that compliance with Form 477 states that ISPs can report service if they do or could deploy broadband within a period that is typical for that particular connection to an end-user premises within the block (Federal Communications Commission 2016). Based on that response, providers that report serving a block may not necessarily cover the entirety of the area. However, the Form 477 data do indicate whether a census block has any service and can provide insight on how many ISPs deploy broadband at various speed thresholds in that geography. The FCC produces a separate data set on mobile broadband availability that is not included in this analysis.

The analysis of broadband availability in this report adapts a methodology used by Tomer, Kneebone, and Shivaram (2017) and Martin (2019). Notably, there is a mismatch of the geographic level of data between broadband coverage and other demographic characteristics, including subscription rates, which necessitates the aggregation of Form 477 data up to the census tract level. First, I reduce the data to a block file that indicates if broadband service is provided in that area at various speeds. The speeds I consider are the FCC benchmark of 25/3 Mbps, and 50/5 Mbps, 100/10 Mbps, 250/25 Mbps, and 1,000/100 Mbps. These speed thresholds were of interest because various internet bandwidths are necessary to operate small businesses, schools, and hospitals and the FCC monitors broadband access at higher speed thresholds, such as 50/5 Mbps, 100/10 Mbps, and 250/25 Mbps. Additionally I restrict my analysis of broadband to three technologies — cable, DSL, and fiber optic cable to the home — to create a merge-ready data set with the ACS subscription data. When analyzing the coverage area of individual technologies, I restrict the data to consider only that type of technology, as opposed to all three concurrently.

Once the block-level data set indicating broadband availability based on the above criteria is created, I use 2010 decennial census population estimates, which are the only population counts available at the block level, to aggregate up to the census tract level. I then calculate the total number of people in each block of a census tract that has broadband service. If 50 percent or more of the population of the census tract's blocks has service, the tract is determined to be covered by broadband. Otherwise, if more than 50 percent has no broadband ISP, then the census tract is considered to have no broadband service. Afterward, 2013–2017 ACS five-year estimates are merged with the tract-level file to calculate neighborhood-level characteristic estimates, including subscription rates.[12]

Broadband Subscription

Broadband adoption data come from the 2013–2017 ACS five-year estimates, table B28002. This is an annual survey distributed by the U.S. Census Bureau that provides information on economic,

[12] The available data limit the ability to calculate service provision more accurately without additional granular population estimate data at the block level. Furthermore, because the Form 477 data qualify a block as served if one ISP provides service somewhere in that area, this leads to the likely overestimation of availability in a block.

Appendix A: Methodology

demographic, and housing characteristics for the country. I use census tract estimates from the ACS on household internet subscription. The ACS asks respondents to indicate whether they do or do not subscribe to internet at home, and if so, to what services. For the purposes of this analysis, I use the survey's high-speed broadband category, which includes cable, fiber optic, and DSL connections. This category is considered to provide service at the FCC's broadband benchmark, relative to satellite and other technologies (Martin 2019). The ACS does not ask for what speed households subscribe to broadband; however, these technologies do provide high-capacity service to consumers where they are available. From these data, I calculate the share of households that subscribe to broadband in the Third District overall or based on the metro and nonmetropolitan status of tracts, the income level of the tracts, or the predominant race or ethnic group of the tracts.

Neighborhood-Level Demographic Factors

The ACS also provides demographic characteristics on median household income (table B19013), educational attainment (table S1501), age (tables B01001 and B01002), racial or ethnic composition (table B03002), household owner or renter status (table B25003), the year homes were built (tables B25034 and B25035), poverty rates (table S1701), families (table S1101), types of computers in households (table B28002), foreign born status (table B05002), and public assistance (table B19057). The predominant racial and ethnic groups of tracts were determined using table B03002 and calculating the share of the population of the tract that belongs to each group. If 50 percent or more of a tract's residents belonged to a particular racial ethnic group, then that tract was listed as having that group as the predominant population. Income status was determined by calculating the ratio of the median household income of each tract to the median household income of the neighborhood's corresponding MSA or nonmetropolitan county, where less than 80 percent of the MHI is considered LMI, 80–119 percent is considered middle income, and 120 percent or more is considered upper income. At the geographic level applicable, neighborhood level shares of other characteristics were created for analysis.

Typologies

The three typologies created for this study were created using availability and subscription rate statistics in congruence with one another. Neighborhoods where less than 50 percent of the tract population has service provision were considered unserved neighborhoods, or areas where broadband is not available. Neighborhoods where 50 percent or more of residents have broadband availability but tract-level subscription rates fall below the Third District average are considered low-uptake neighborhoods. Communities where 50 percent or more of residents have broadband availability and tract-level subscription rates exceed the Third District average are considered high-uptake neighborhoods. Indicators that designated each tracts status were created and used to determine the share of each region's population that lives in each typology.

Appendix B: Additional Figures and Tables

SUBSCRIPTION RATES BY REGION

Region	Overall	LMI	Middle Income	Upper Income	White	Black	Latino or Hispanic	None
Pike County, PA*	79%	78%	79%	NA	78%	NA	NA	89%
Ocean City, NJ MSA	74%	69%	74%	78%	74%	NA	NA	61%
Ocean County, NJ*	74%	56%	79%	84%	74%	NA	NA	74%
Philadelphia-Camden-Wilmington, PA-NJ-DE-MD MSA**	74%	57%	76%	85%	80%	53%	44%	66%
East Stroudsburg, PA MSA	74%	72%	74%	78%	73%	NA	NA	77%
Trenton, NJ MSA	74%	56%	78%	85%	80%	51%	45%	76%
Atlantic City-Hammonton, NJ MSA	73%	60%	75%	80%	77%	NA	66%	69%
Allentown-Bethlehem-Easton, PA-NJ MSA	72%	61%	72%	81%	74%	50%	59%	62%
State College, PA MSA	72%	71%	64%	85%	72%	NA	NA	100%
Susquehanna County, PA	72%	65%	72%	75%	72%	NA	NA	NA
Harrisburg-Carlisle, PA MSA	70%	58%	69%	82%	72%	47%	NA	61%
Dover, DE MSA	70%	66%	69%	79%	70%	76%	NA	69%
Reading, PA MSA	69%	51%	70%	79%	73%	NA	49%	63%
Wayne County, PA	68%	54%	71%	61%	68%	NA	NA	NA
Elk County, PA	67%	NA	67%	NA	67%	NA	NA	NA
Lancaster, PA MSA	67%	58%	67%	76%	68%	NA	43%	67%
Gettysburg, PA MSA	67%	60%	67%	79%	67%	NA	NA	NA
Lebanon, PA MSA	67%	56%	66%	76%	68%	NA	46%	NA
York-Hanover, PA MSA	66%	55%	66%	74%	68%	NA	36%	48%
Chambersburg-Waynesboro, PA MSA	66%	60%	66%	71%	66%	NA	NA	NA
Bradford County, PA	66%	66%	65%	73%	66%	NA	NA	NA
Vineland-Bridgeton, NJ MSA	65%	57%	67%	74%	71%	57%	56%	62%
Scranton–Wilkes-Barre–Hazleton, PA MSA	65%	56%	65%	73%	65%	NA	56%	58%
Sussex County, DE*	65%	55%	63%	74%	65%	NA	NA	52%
Union County, PA	64%	NA	59%	76%	64%	NA	NA	100%
Williamsport, PA MSA	63%	62%	64%	64%	64%	NA	NA	58%
McKean County, PA	63%	52%	65%	68%	63%	NA	NA	NA
Cameron County, PA	63%	NA	63%	NA	63%	NA	NA	NA
Tioga County, PA	63%	NA	63%	NA	63%	NA	NA	NA
Clinton County, PA	63%	61%	63%	65%	63%	NA	NA	NA
Schuylkill County, PA	63%	54%	65%	67%	63%	NA	NA	NA
Altoona, PA MSA	63%	50%	63%	70%	63%	NA	NA	NA
Sullivan County, PA	62%	NA	62%	NA	62%	NA	NA	NA
Johnstown, PA MSA	61%	47%	61%	69%	61%	NA	NA	NA
Bloomsburg-Berwick, PA MSA	60%	60%	59%	65%	60%	NA	NA	NA
Potter County, PA	60%	NA	60%	NA	60%	NA	NA	NA
Snyder County, PA	60%	NA	57%	74%	60%	NA	NA	NA
Huntingdon County, PA	60%	52%	60%	62%	60%	NA	NA	NA
Juniata County, PA	59%	49%	60%	NA	59%	NA	NA	NA
Northumberland County, PA	58%	51%	60%	62%	58%	NA	NA	NA
Bedford County, PA	58%	NA	58%	NA	58%	NA	NA	NA
Clearfield County, PA	58%	NA	56%	80%	58%	NA	NA	NA
Fulton County, PA	56%	NA	56%	NA	56%	NA	NA	NA
Mifflin County, PA	56%	59%	55%	60%	56%	NA	NA	NA

*County is located in an MSA that falls primarily outside of the Third District; **Cecil County, Maryland falls outside of the Third Federal Reserve District and is not included in the Philadelphia MSA statistics.

Source: Author's calculations using 2013–2017 American Community Survey (ACS) data.

Appendix B: Additional Figures and Tables

REGRESSION RESULTS

	Model 1			Model 2		
	Coefficient	**Standard Error**		**Coefficient**	**Standard Error**	
(Intercept)	-0.62	0.18	***	-0.66	0.13	***
MSA Dummy Variable	0.03	0.01	***	0.02	0.00	***
Average Number of Internet Service Providers	0.01	0.00	***	0.01	0.00	***
Resident Characteristics						
Population Density	0.00	0.00	***	0.00	0.00	**
Population Black or Hispanic (%)	-3.15	1.08	**	2.45	0.85	**
Nondegree Holders (%)	-18.29	1.87	***	-2.62	1.47	
Population Ages 65 and Up (%)	-29.57	4.59	***	-7.50	-2.96	*
Log Median Age of Population	0.02	0.03		0.04	0.02	*
Poverty Rate (%)	-14.68	3.68	***	-6.93	2.37	**
Foreign-Born Population (%)	13.71	2.32	***	6.24	1.63	***
Household Characteristics						
Log Median Household Income	0.13	0.01	***	0.06	0.01	***
Owner-Occupied Units (%)	8.19	2.10	***	-2.50	1.41	
Homes Built in Year 2000 or Later (%)	0.12	1.48		-4.50	0.90	***
Family Households (%)	-10.98	3.29	***	-3.02	2.38	
Population with Public Assistance (%)	-20.07	7.23	**	2.15	4.92	
Households with Desktop or Laptop Present (%)				82.31	2.03	***
N		3046			3046	
R2		0.75			0.86	

*** p < 0.001; ** p < 0.01; * p < 0.05.

Each model is an ordinary least squares regression of tract-level neighborhood subscription rates on tract-level predictor variables. Both models are conditioned on broadband availability and weighted by tract population. The variable for average number of internet providers (ISP) is a measure of the average number of ISPs across blocks in a Census tract. Standard errors are heteroskedasticity robust. Source: Author's calculations based on 2013–2017 American Community Survey (ACS) and FCC Form 477 data.

Source: Author's calculations based on 2013–2017 American Community Survey (ACS) and FCC Form 477 data.

Appendix B: Additional Figures and Tables

METROPOLITAN STATISTICAL AREA SHARE OF TYPOLOGY

	Unserved		Low Uptake		High Uptake	
Region	**Number**	**Share**	**Number**	**Share**	**Number**	**Share**
Scranton–Wilkes–Barre–Hazleton, PA MSA	20,068	4%	403,044	72%	134,830	24%
Bloomsburg-Berwick, PA MSA	14,660	17%	55,911	66%	14,346	17%
State College, PA MSA	11,057	7%	58,549	36%	91,040	57%
Philadelphia-Camden-Wilmington, PA-NJ-DE-MD MSA**	10,583	0%	1,899,800	32%	4,047,134	68%
Lancaster, PA MSA	10,577	2%	280,759	52%	245,158	46%
Chambersburg-Waynesboro, PA MSA	9,032	6%	94,363	62%	49,608	32%
Vineland-Bridgeton, NJ MSA	7,870	5%	104,859	68%	42,223	27%
Williamsport, PA MSA	6,803	6%	99,442	86%	9,153	8%
Harrisburg-Carlisle, PA MSA	6,075	1%	257,885	46%	301,048	53%
Ocean County*	3,081	1%	171,335	29%	415,283	70%
Dover, DE MSA	2,867	2%	70,311	41%	99,967	58%
Atlantic City-Hammonton, NJ MSA	2,313	1%	93,335	34%	177,278	65%
Ocean City, NJ MSA	0	0%	28,118	30%	66,431	70%
Sussex County*	0	0%	137,540	64%	78,011	36%
Altoona, PA MSA	0	0%	109,845	88%	14,891	12%
Johnstown, PA MSA	0	0%	113,253	83%	22,618	17%
Lebanon, PA MSA	0	0%	87,849	64%	49,767	36%
York-Hanover, PA MSA	0	0%	276,081	62%	166,135	38%
Gettysburg, PA MSA	0	0%	63,331	62%	38,258	38%
Reading, PA MSA	0	0%	182,078	44%	233,422	56%
Allentown-Bethlehem-Easton, PA-NJ MSA	0	0%	315,531	43%	410,171	57%
Trenton, NJ MSA	0	0%	112,587	30%	259,945	70%
East Stroudsburg, PA MSA	0	0%	40,038	24%	127,268	76%
Pike County*	0	0%	3,720	7%	51,967	93%

*Part of an MSA that falls primarily outside of the Third District; **Cecil County, Maryland falls outside of the Third Federal Reserve District and is not included in the Philadelphia MSA statistic.

Source: Author's calculations using 2013–2017 American Community Survey (ACS) and FCC Form 477 data.

Appendix B: Additional Figures and Tables

NONMETROPOLITAN COUNTY SHARE OF TYPOLOGY

	Unserved		Low Uptake		High Uptake	
Region	**Number**	**Share**	**Number**	**Share**	**Number**	**Share**
Susquehanna County, PA	18,866	45%	6,788	16%	16,062	39%
Bradford County, PA	17,289	28%	36,926	60%	7,331	12%
Union County, PA	14,862	33%	25,309	56%	4,885	11%
Tioga County, PA	11,453	28%	30,097	72%	0	0%
Snyder County, PA	10,820	27%	23,795	59%	5,955	15%
Wayne County, PA	10,550	20%	16,301	32%	24,805	48%
Fulton County, PA	9,715	66%	4,916	34%	0	0%
Clearfield County, PA	7,395	9%	73,144	91%	0	0%
Sullivan County, PA	6,192	100%	0	0%	0	0%
Northumberland County, PA	4,870	5%	84,491	91%	3,677	4%
Potter County, PA	4,719	28%	12,351	72%	0	0%
Juniata County, PA	1,834	8%	22,614	92%	0	0%
Huntingdon County, PA	1,732	4%	43,954	96%	0	0%
Bedford County, PA	0	0%	48,891	100%	0	0%
Cameron County, PA	0	0%	4,754	100%	0	0%
Clinton County, PA	0	0%	39,321	100%	0	0%
McKean County, PA	0	0%	42,070	100%	0	0%
Mifflin County, PA	0	0%	46,452	100%	0	0%
Elk County, PA	0	0%	25,677	83%	5,104	17%
Schuylkill County, PA	0	0%	114,942	80%	29,345	20%

Source: Author's calculations using 2013–2017 American Community Survey (ACS) and FCC Form 477 data.

Appendix B: Additional Figures and Tables

CITIES' SHARE OF TYPOLOGY

	Unserved		Low Uptake		High Uptake	
Region	**Number**	**Share**	**Number**	**Share**	**Number**	**Number**
Philadelphia, PA	1,650	0%	1,106,452	71%	459,019	29%
Camden, NJ	0	0%	75,550	100%	0	0%
Wilmington, DE	0	0%	66,155	93%	5,121	7%

Source: Author's calculations using 2013–2017 American Community Survey (ACS) and FCC Form 477 data.

Federal Reserve Bank
of Philadelphia