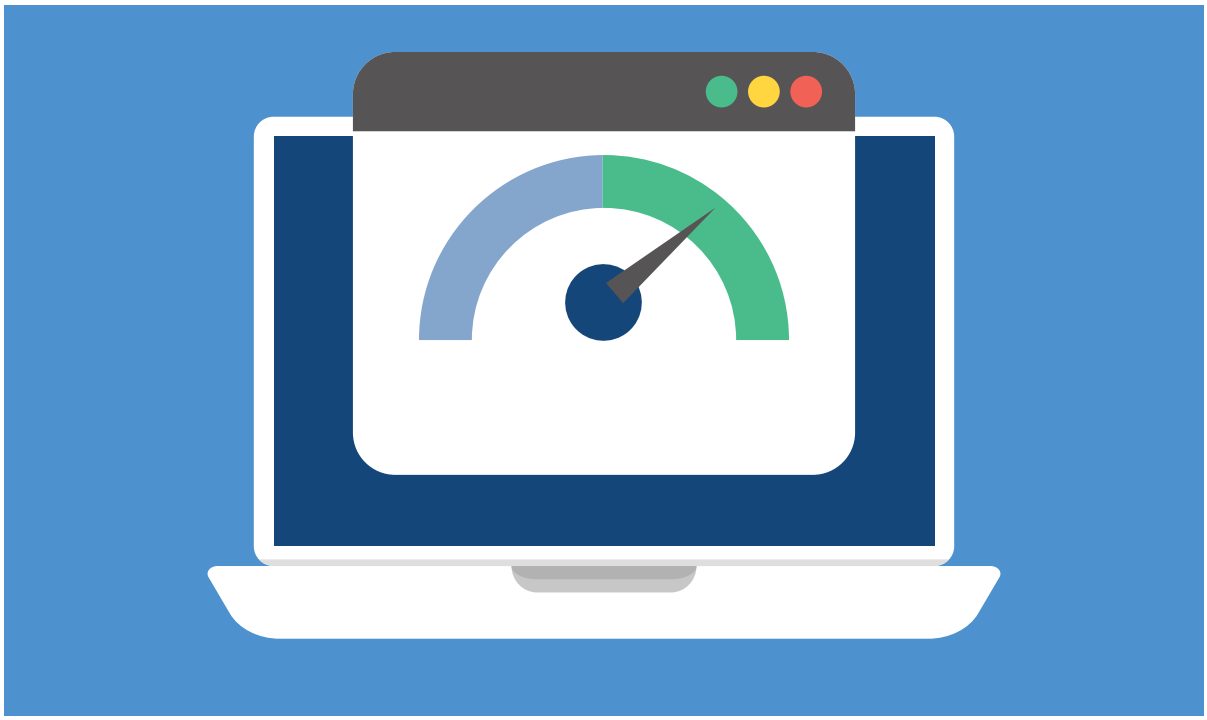
# How will Expanding Broadband Internet Access Benefit Knox County, TN?

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## Executive Summary

As part of a modernization effort, KUB plans to upgrade its electrical grid by installing an extensive fiber system, which will provide a more reliable electricity service, better efficiency, and shorter downtimes in the event of power outages. The fiber system would also enable KUB to offer cheaper, ultra-fast internet to all households and businesses in its electric grid service area. This report documents the various benefits associated with expanding access to ultra-fast internet connections.

Under KUB's current proposal, residential internet plans would offer internet upload and download speeds of 1 gigabits-per-second (Gbps) at roughly $65 per month. Assuming that 35% of KUB households adopt the new internet plan, we estimate that the cost savings of switching from their current provider would lead to a $18.5 to $85.7 million increase[1] in Tennessee incomes per year, depending on the cost of their current internet plan (these estimates also include multiplier effects, as discussed in **Section 3**). KUB's proposed download speeds are equivalent to the top-speed residential plan currently offered to some Knox County residents by Comcast/Xfinity (hereafter Xfinity), but KUB's proposed upload speeds are more than 25-times faster than anything currently offered by Xfinity. Increased upload speeds could provide a substantial benefit to workers and businesses who create online content. As an example, a local plumber might market his/her business by uploading a short 500 megabytes (MB) video to YouTube, which demonstrates how to fix a leaking toilet. Or a teacher might upload a short video to complement a homework assignment. According to allconnect.com, it would take between 1.5-2 minutes to upload the short video clip with a 30 Mbps upload connection, which is comparable to the fastest residential upload speed currently offered by Xfinity. For those needing to upload multiple files, the time commitment could add up relatively quickly. By comparison, an internet plan with upload speeds of 500 megabits-per-second (Mbps) (half the speed of KUB's proposed plan) could upload the video clip in just 8 seconds.

Based on both the cost and time-savings, KUB's plan would certainly provide consumer surplus for its customers. Consumer surplus measures the benefit that buyers receive for purchasing a good or service at a lower price than they are willing to pay. In recent studies, Brynjolfsson et al. (2019) found that the average person benifited from having access to broadband services, and Lobo (2020) found that ultra-fast internet connections in Hamilton County raised consumer surplus by $128 million per year. Furthermore, Lobo (2015) found that current internet service providers (ISPs), such as Xfinity and AT&T, reduced their prices after ultra-fast municipal broadband was brought to Hamilton County in 2010. In the most extreme case, Xfinity reduced the price of its 105 Mbps plan by 55% between 2010 and 2014, which would increase our cost-savings estimate if we were able to account for it. Thus, increased competition should provide a strong positive benefit to consumers.

In addition to the direct household benefits of KUB's plan, access to high-speed internet at the home provides a number of significant economic and social benefits to the region as a whole. Previous research has found that ultra-fast broadband can boost a region's gross domestic product (GDP) by 1.1%, and reduce an unemployed person's job search time by roughly 25% (Sosa, 2014; Kuhn and Mansour, 2014). In general, greater connectivity leads to quicker information dissemination and the ability to process more information overall, which can aid unemployed workers in their job search, help firms find strongly-suited job candidates, and for already employed workers, it can result in increased wages. Increased broadband availability can also lead to growth in the number of small firms in a region, and has been shown to reduce rural depopulation trends (Shideler and Badasyan, 2012; Briglauer et al., 2019; Lehtonen, 2020). While Knox County is not rural, KUB's business plan proposes the expansion of ultra-fast broadband through its entire electric grid, which includes sizable portions of Grainger, Union, and Jefferson counties as well–three counties where population growth has been slower than the state average.[2]

High-speed internet access also has important

[1] These range of estimates are the cost savings of 200,000 (35% take up rate) customers switching from either Xfinity's 100Mbps or 1,000Mbps to KUB's plan.

[2] Population growth for 2010-2019.

social benefits through increased educational attainment and better health outcomes. Both of which also have implications for economic growth, as good healthcare makes for a more productive workforce and improved education offers long-term benefits for productivity growth, higher incomes, and lower unemployment rates. Research has shown that students with high-speed internet access have higher grade point averages (GPAs), perform better on standardized tests, and apply to more colleges (Dettling et al., 2018; Bauer et al., 2020; Hampton et al., 2020). Research also indicates that internet speed matters. For example, Grimes and Townsend (2018) find that providing ultra-fast broadband connections to schools leads to a 1 percentage point increase in standardized test pass rates among elementary school students. Similarly, Sanchis-Guarner et al. (2021) find that increasing home internet speeds by 1 Mbps (1,000 Mbps is equal to 1 Gbps) increases test scores by 1.37 percentile ranks.

With regards to healthcare, those with broadband access are more likely to use the internet to gather health-related information, and broadband can deliver healthcare services remotely through telehealth (Rains, 2008; Kim et al., 2021). For these reasons, broadband access is viewed as a "super-determinant" of health (Bauerly et al., 2019). However, telehealth services are underutilized in many communities due to no or slow internet access and internet affordability issues (Kourvelas et al., 2021).

The importance of high-speed home internet connections was made glaringly obvious during the COVID-19 pandemic. In the spring of 2020, large portions of the state economy were shut down to limit the spread of COVID-19. As a result, many workers and students shifted to remote work and virtual learning, while physicians and health insurance companies made telehealth more widely available and reimbursable. However, these online tools were only available to those with a reliable high-speed internet connection. On the education front, Knox County Schools closed on March 13, 2020, due to the pandemic, and remained closed for the remainder of the academic school year. Virtual learning was not offered for the second half of the spring 2020 semester due to gaps in internet access and device availability, preventing many Knox County students from accessing formal education. For the following school year (academic year 2020/21), families were able to choose between in-person schooling or at-home virtual learning for their school-aged children. However, the latter was only a viable option for those with reliable internet access. Furthermore, as shown in **Section 2**, the majority of Knox County residents without home internet connections are those in lower-income households. Lower-wage workers were also the group that suffered the brunt of the pandemic-related job losses. Providing high-speed internet connections to these households could have helped many retain employment, through telework, or could have aided them in their job search to find new employment faster.

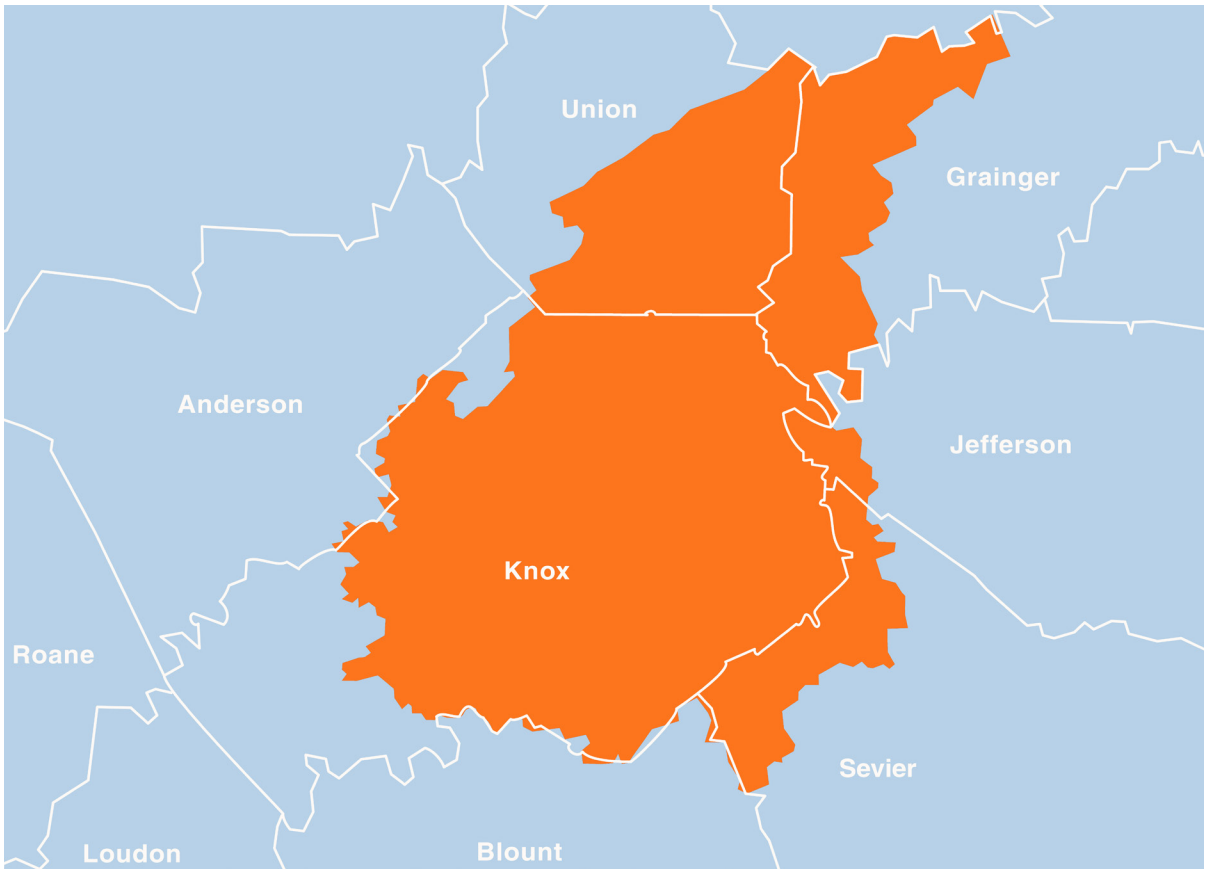
# How will Expanding Broadband Internet Access Benefit Knox County, TN?

## 1. Introduction

The Knoxville Utilities Board (KUB) provides electricity to over 200,000 households in Knox County and portions of six surrounding counties. KUB's electric grid spans nearly 700 square miles and utilizes over 5,000 miles of service lines. As part of a modernization effort, KUB plans to upgrade its electrical grid by installing an extensive fiber system, which will provide a more reliable electricity service, better efficiency, and shorter downtimes in the event of power outages. The fiber system would also enable KUB to offer ultra-fast internet, with direct fiber to the home connections (FTTH), to all households and businesses in its electric service area (see **Figure 1**).

In this report, we discuss the various benefits associated with KUB's *Fiber to the Home* Business Plan, which aims to provide cheaper ultra-fast internet to all households and businesses in KUB's electric grid service area.[3] To provide some background, **Section 2** reports key demographic and economic indicators of Knox County, as well as information on current broadband infrastructure and availability in the county. Direct economic benefits of KUB's proposal are then discussed in **Section 3**, with a focus on the cost savings associated with switching to a cheaper monthly internet plan as well as time savings associated with faster upload and download speeds. These direct economic benefits will be enjoyed by the individual households and businesses

**Figure 1: KUB Electric Service Area**




Source: https://www.kub.org/about/about-kub/kub-service-areas/.

[3] As discussed further in Section 3, KUB's proposed plan would offer upload and download speeds of 1 gigabits-per-second (Gbps) at a price of $65 per month.

who switch to the proposed KUB internet plan, but these benefits will have a strong positive economic effect on the region as a whole as more households hook into KUB's ultra-fast internet. Assuming that 35% of KUB households adopt the new internet plan, we estimate that the cost savings of switching from their current provider would lead to a $18.5 to $85.7 million increase in Tennessee incomes per year, depending on the cost of their current internet plan.[4,5] In addition to cost savings, KUB's proposed plan would provide consumer surplus for its customers. Consumer surplus measures the benefit that buyers receive for purchasing a good or service at a lower price than they are willing to pay. Given the current prices of available internet plans in Knox County (some of which are documented in **Section 3**), KUB's broadband plan would provide a significant boost in consumer surplus. In recent studies, Brynjolfsson et al. (2019) estimated that the average person gained roughly $32,000 per year from having access to broadband services, and Lobo (2020) found that ultra-fast internet connections in Hamilton County raised consumer surplus by $128 million per year. The $32,000 estimate is very high, but demonstrates that consumers place high value on faster and stronger internet speeds. Furthermore, Lobo (2015) found that current internet service providers (ISPs), such as Xfinity and AT&T, reduced their prices after ultra-fast municipal broadband was brought to Hamilton County in 2010. In the most extreme case, Xfinity reduced the price of its 105 megabits-per-second (Mbps) plan by 55% between 2010 and 2014. Thus, increased competition should provide a strong positive benefit to consumers.

Regional economic benefits of broadband internet are discussed in **Section 4**. Access to high-speed internet at the home has a number of important economic and social benefits. In **Section 4**, we review the various strands of literature focused on the benefits of broadband, including the positive economic effects on gross domestic product (GDP), employment outcomes, firm activity, and rural migration, as well as the social benefits tied to education and health. For example, Sosa (2014) finds that providing ultra-fast broadband to metropolitan statistical areas (MSAs) leads to a 1.1% increase in GDP per capita, while Hjort and Poulsen (2019) found that when fast internet becomes available, the probability of individual employment increases by at least 3.1%. International research has also shown that the expansion of broadband to rural communities has led to reductions in rural depopulation (Briglauer et al., 2019; Lehtonen, 2020). While on the education-front, research has shown that students with high-speed internet access have higher grade point averages (GPA), perform better on standardized tests, and apply to more colleges (Dettling et al., 2018; Bauer et al., 2020; Hampton et al., 2020). Furthermore, Kolko (2009) shows that people switching from dial-up to broadband connections spend more time using the internet, indicating a strong consumer preference for high-speed connections. Broadband is also used as a tool for entertainment, social networking, job searches, shopping, banking, and newsgathering. However, Coren (2016) notes that many mobile data plans and slow internet connections cannot adequately handle the bandwidth needed for many of these applications. As a result, those without a reliable high-speed internet connection may find themselves at a severe economic and social disadvantage.[6]

The majority of studies focused on the benefits of broadband were performed prior to the COVID-19 pandemic, and the pandemic has certainly magnified the importance of high-speed home internet connections. In the spring of 2020 large swaths of the state economy were shutdown to limit the spread of COVID-19. As a result, many workers and students shifted to telework and online learning, while physicians and health insurance companies made telehealth more widely available and reimbursable. However, these online tools were only available to those with a reliable high-speed internet connection. Furthermore, as shown in **Section 2**, the majority of Knox County residents without home internet connections are those in lower-income households. Lower-wage workers were also the group that suffered the brunt of the pandemic-related job losses. Providing high-speed internet connections to these households could have helped many retain employment, through telework, or could have aided them in their job search to find new employment faster.

[4] This 35% take-up rate assumption is taken straight from KUB's "Fiber to Home Business Plan." However, as noted in Section 3, other municipalities with broadband services have seen residential take-up rates of 50% or higher.

[5] These estimates also include multiplier effects, which are discussed in more detail in Section 3.

[6] As discussed in Section 2, nearly 16% of Knox County households do not have an internet connection in their home (Table 3).

### *Defining Broadband Internet*

With the signing of the Telecommunications Act of 1996, the Federal Communications Commission (FCC) updated its universal service objective to include "advanced" services (i.e., broadband internet).[7] In the same way that telephone service was made available to every household in the twentieth century, expanding broadband service nationwide at affordable rates in the twenty-first century is among the FCC's chief policy objectives. Broadband allows users to access high-speed internet from desktops, laptops, smartphones, and other electronic devices. Compared to "dial-up" service, broadband offers faster download/upload speeds, lower latency, and higher bandwidth.[8] Since 2015, the minimum standard for broadband requires download/upload speeds of 25/3 Mbps.

Broadband can be provided over different platforms. Most common are digital subscriber lines (DSL), which transmit data over the existing infrastructure of copper telephone lines, and cable modems, which deliver high-speed internet through the same coaxial cables used to deliver content to TV sets. Broadband can also be achieved through a wireless (Wi-Fi) connection, which uses radio signals as opposed to telephone lines or cable. In rural areas, satellite connections are more common. Increasingly, however, ultra-fast internet can be achieved through fiber technology, whereby fiber optics carry data via pulses of light through strands of fiber to the end user. Fiber technology is able to transmit data at speeds that far exceed DSL or cable and offers greater reliability than satellite.

Establishing a high-speed internet connection using fiber technology can be achieved through a few transmission methods: fiber-to-the-node (FTTN), fiber-to-the-curb (FTTC), and fiber-to-the-home (FTTH). Providers that offer FTTN run fiber lines to a node or neighborhood. From there, the "last mile" of transmission is achieved through existing coaxial cable or copper telephone lines. FTTC brings fiber optic strands within 1,000 feet of the end user, to the curb, or closet that houses the communications device. Providers that offer FTTH run fiber directly to the end user's home, eliminating the need for "last mile" transmission. Because FTTH is a pure-fiber technology, it offers higher bandwidth compared to FTTC and FTTN. KUB's proposed plan would run FTTH fiber throughout its entire electric grid, providing high bandwidth fiber internet to its customers–even those where current ISPs deemed it infeasible or cost prohibitive to run "last mile" fiber lines.

## 2. Knox County, TN

### *Demographic and Economic Profile*

Knox County, with a population of 470,313, is the third largest county in Tennessee. Over the last decade, the county has seen strong population growth, advancing by 8.8% between 2010 and 2019. Population growth in Knox County was much faster than the nation as a whole, which grew by 6.3% over the same period. **Table 1 Panel A** reports key demographic indicators for Knox County, as compared to the state of Tennessee, and the nation as a whole. Knox County's population is much less diverse than both the state and national average; 81.8% of the county's population is White, 8.2% is Black, and 4.6% is Hispanic. The county has higher rates of educational attainment than both the state and nation, with 92% of adults (aged 25 years and older) having graduated high school and 38% having a bachelor's degree or higher. Median household income in the county was $57,470 in 2019, which was higher than the state average but well below the national average.

**Table 1 Panel B** presents some economic indicators of the county, state, and nation. Knox County's inflation-adjusted gross domestic product (real GDP in 2012 Dollars) was $24.5 billion in 2019, representing 7.5% of all economic activity in the state. As of February 2020 (prior to the pandemic), there were over 409 thousand workers in the Knoxville MSA, representing 13% of all workers in the state of Tennessee. Throughout the country, the labor force continues to recover from the pandemic, however, Knox County and the Knox MSA have seen a quicker rebound than both the state and

[7] For a brief history of the FCC's universal service objective, see https://www.fcc.gov/general/universal-service#:~:text=The%20Telecommunications%20Act%20of%201996,just%2C%20reasonable%20and%20affordable%20rates.

[8] Latency refers to the amount of time it takes for a signal to travel to and from its destination. Bandwidth measures the amount of data that can be transferred in a network.

**Table 1: Knox County Profile**

| Panel A. Demographics & Household Profile | Knox County | Tennessee | U.S. |
|---|---|---|---|
| Population (July 1, 2019) | 470,313 | 6,829,174 | 328,239,523 |
| Population, growth (2010-2019) | 8.80% | 7.60% | 6.30% |
| Median Age | 37.4 | 38.7 | 38.1 |
| Population by age group: | | | |
| *18 and under* | 20.90% | 22.10% | 22.20% |
| *18-24* | 11.70% | 9.10% | 9.30% |
| *25-54* | 38.80% | 39.00% | 39.00% |
| *55-64* | 12.50% | 13.10% | 13.00% |
| *65 and over* | 16.10% | 16.70% | 16.50% |
| Population by gender: | | | |
| *Male* | 48.60% | 48.80% | 49.20% |
| *Female* | 51.40% | 51.20% | 50.80% |
| Population by race/ethnicity: | | | |
| *White* | 81.80% | 73.30% | 60.00% |
| *Black or African American* | 8.20% | 16.60% | 12.40% |
| *American Indian and Alaska Native* | 0.40% | 0.30% | 0.70% |
| *Hispanic* | 4.60% | 5.70% | 18.40% |
| *Asian* | 2.10% | 1.80% | 5.60% |
| *Native Hawaiian and Other Pacific Islander* | 0.00% | 0.00% | 0.20% |
| *Other Race* | 0.30% | 0.20% | 0.30% |
| *Two or More Races* | 2.70% | 2.10% | 2.50% |
| High school graduate or higher, percent of persons age 25+, 2019 | 91.70% | 87.50% | 88.00% |
| Bachelor's degree or higher, percent of persons age 25+, 2019 | 37.60% | 27.30% | 32.10% |
| Number of households (2019) | 187,319 | 2,597,292 | 120,756,048 |
| Average household size (2018) | 2.40 | 2.52 | 2.62 |
| Median household income (in 2019 dollars), 2019 | $57,470 | $53,320 | $62,843 |
| Poverty rate 2019 (%) | 13.40% | 13.90% | 10.50% |
| **Panel B. Economic Indicators** | **Knox County** | **Tennessee** | **U.S.** |
| Real GDP 2019 (2012 Dollars) | $24.5 billion | $328.4 billion | $19.1 trillion |
| Total Non-Farm employment (Pre-pandemic, February 2020) * | 409,300 | 3,153,700 | 152,523,000 |
| Unemployment rate (Pre-pandemic, February 2020) * | 3.60% | 3.90% | 3.50% |
| Unemployment rate (Current, March 2021) * | 4.50% | 5.00% | 6.10% |

Source: U.S. Census, Bureau of Labor Statistics, Bureau of Economic Analysis, * Knoxville MSA.

nation as a whole. As of March 2021, Knoxville's (MSA) unemployment rate was 4.5%, which is less than a percentage point higher than the pre-pandemic unemployment rate from February 2020.

**Table 2** presents a snapshot of employment by sector for the Knoxville MSA, as of 2019. The two largest sectors in the MSA were the Trade, Transportation, and Utilities sector, and the Professional and Business Services sector. Together, these two sectors employed more than one-third of all Knoxville MSA workers. Following Dingel and Neiman (2020) and Lobo (2020), **Table 2** also identifies the sectors where at least 50% of the jobs can be performed remotely (with an asterisk).[9] Dingel and Neiman (2020) found that 37% of all U.S. jobs could be performed remotely. According to the same study, 35% of all jobs in the Knoxville MSA could be performed remotely. Knoxville is more heavily concentrated in industries that lend themselves to remote work than the rest of Tennessee but is less invested than the nation as a whole. However, Knoxville continues to see its industry profile shift more towards jobs that can be done remotely. **Figure 2** shows that since 2010, Knoxville has seen a steady increase in the share of jobs that can be performed remotely. **Figure 3** further illustrates this point, showing that employment growth over the last decade (2010 to 2019) was particularly strong in the Knoxville sectors that are more readily able to shift to remote work. These figures show that, even before the pandemic, remote work was trending upward in Knox County. However, COVID has certainly accelerated this trend.

### *Broadband Availability in Knox County, TN*

For broadband infrastructure to generate economic gains, it must be (1) made available by providers and (2) used by households and businesses. To understand the extent to which households in Tennessee subscribe to internet services, we first turn to the FCC's Form 477 dataset. Made available twice per year for the reference monts of June and December, these

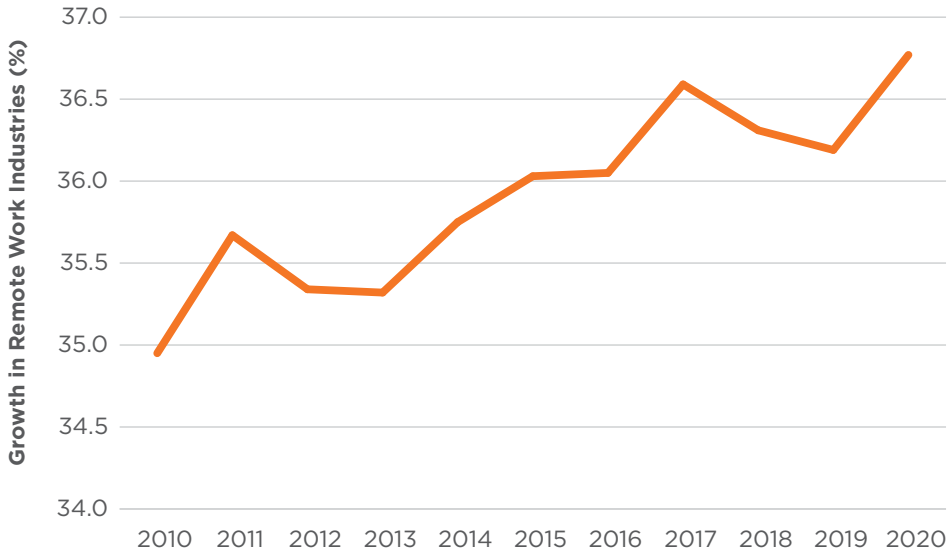
**Table 2 Industry Snapshot – % of Jobs by Major Sector (2019)**

| | Knoxville MSA | Tennessee | U.S. |
|---|---|---|---|
| Industry | | % of Total | |
| Total Nonfarm Employment | 405,400 | 3,122,900 | 150,905,000 |
| Trade, Transportation, and Utilities | 19.50% | 20.40% | 18.40% |
| Professional and Business Services* | 16.10% | 13.70% | 14.10% |
| Government | 14.60% | 14.00% | 15.00% |
| Education and Health Services* | 13.70% | 14.30% | 16.00% |
| Leisure and Hospitality | 11.00% | 11.10% | 11.00% |
| Manufacturing | 10.20% | 11.40% | 8.50% |
| Financial Activities* | 4.90% | 5.50% | 5.80% |
| Mining, Logging, and Construction | 4.70% | 4.30% | 5.40% |
| Other Services | 4.00% | 3.90% | 3.90% |
| Information* | 1.50% | 1.50% | 1.90% |

Source: Bureau of Labor Statistic; * are industries and occupations where at least 50% of all jobs can be done from home based on estimate from Dingel and Neiman (2020).

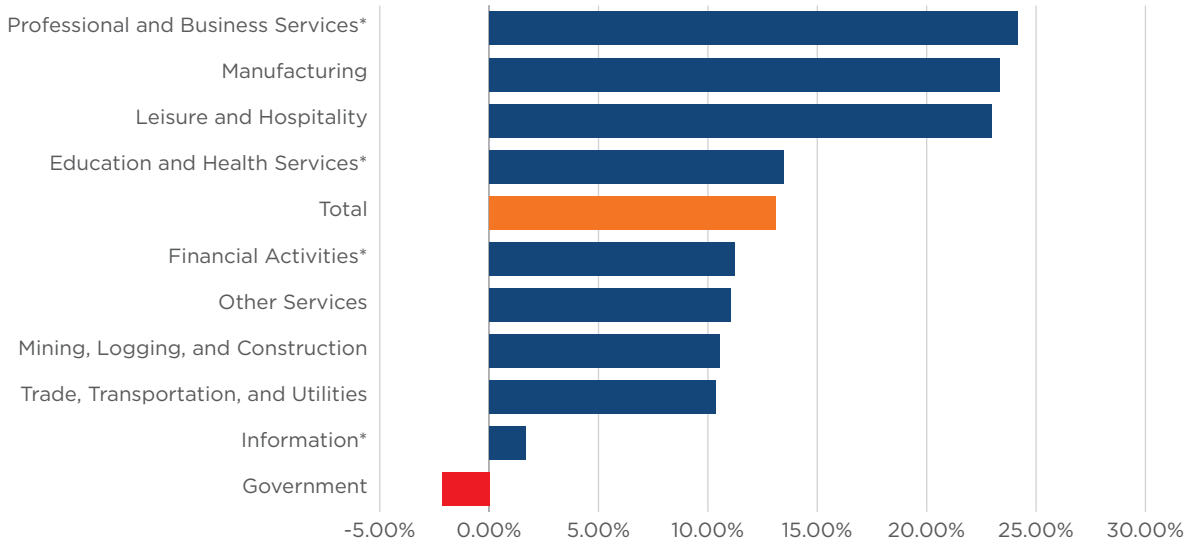
[9] Using survey data, Dingel and Neiman (2020) classify the feasibility of working remotely for occupations and industries based on the nature of their workday. Lobo (2020) then applies Dingel and Neiman's estimates to the employment profile of Hamilton County, TN.

**Figure 2: Knoxville MSA, Growth in Remote Work Industries.**




Source: Bureau of Labor Statistics; Knoxville MSA
Note: The figure represents growth in the share of Knoxville MSA jobs in the following sectors: Professional and Business Services, Education and Health Services, Financial Activities, and Information.

**Figure 3: Knoxville MSA, Growth Rates by Major Sector (2010-2019)**




Note: * denote sectors where at least 50% of all jobs can be done from home based on estimate from Dingel and Neiman (2020).
Source: Bureau of Labor Statistics; Knoxville MSA

data report the number of fixed consumer (i.e., household) internet connections by county, an estimate of the number of households in each county, and the share of households with internet access.[10] To be sure, the data report connections that offer download and/or upload speeds of at least 200 kilobits-per-second (kbps), which falls far below the FCC's current broadband benchmark of 25 Mbps.[11] Therefore, the Form 477 data only provide a snapshot of internet access but not necessarily *high-speed* internet access at the county level. This is important because internet speeds of 200 kbps are not sufficient for many common internet uses such as (but not limited to) video streaming, telehealth services, and video conferencing. This divergence also highlights the severe gap in data availability on household broadband coverage throughout the nation.

**Figure 4** reports the share of households with fixed internet access connections (200 kbps or higher) in December 2018 (the most-recent data available) for all counties in Tennessee. In Knox County, 84% of households had some form of fixed internet access offering download and/or upload speeds of at least 200 kbps. This measure of internet availability ranks Knox County tenth among all 95 counties in the state of Tennessee.[12] Of the three counties in Tennessee with internet connectivity rates above 90%, two are located in the Nashville MSA (Williamson and Rutherford) and one shares a border with the Knoxville MSA (Sevier). Not surprisingly, the I-40 corridor connecting the two regions also reports above-average connectivity rates.[13] Still, 22 counties, many of which are small and located in the more rural parts of the state, reported internet connectivity rates below 60%.

In recent years, rates of internet connectivity have increased steadily in Knox County and other parts of Tennessee. Again examining Form 477 data, **Figure 5** plots the evolution of internet connectivity rates in Knox County, the Knoxville MSA, the state of Tennessee, and the United States throughout recent history. Between June 2016 and December 2018, an additional 3.5% of households in the United States gained fixed internet access offering download and/or upload speeds of at least 200 kbps. Knox County started below the national average, but of particular note are the stronger trends seen for Tennessee and its constituent areas. During the same time period, internet connectivity rates increased from 77.5% to 84.0% in Knox County, nearly double the gains made at the national level. In fact, Knox County's internet connectivity rate surpassed the national average in December 2018. The Knoxville MSA and the state of Tennessee reported similar growth at slightly lower levels of overall connectivity. Again however, these data include internet connection speeds as low as 200 kbps.

For a more complete picture of Knox County's connectivity rate, we turn to American Community Survey (ACS) data published by the U.S. Census Bureau, which provides data on actual broadband access. **Table 3** presents statistics on household use of computers and broadband for Knox County in 2015 and 2019, the most recent year available. While more than 94% of households in Knox County had some sort of computing device (e.g., desktop, laptop, smartphone, or tablet) in 2019, only 84.3% maintained an internet subscription. Diving into the details, more than 76% of households had either a desktop or laptop computer, 88.5% had a smartphone, and only 5.9% reported having no computing device at all. Of note is the nearly 6 percentage point increase in the share of households with a computing device that occurred between 2015 and 2019, owing entirely to an increase in smartphones.

Whereas only 5.9% of households in Knox County do not own a computing device, nearly 16% do not maintain an internet subscription. That's equivalent to roughly 30,000 households. **Table 4** shows that disconnected homes are not distributed uniformly across the income

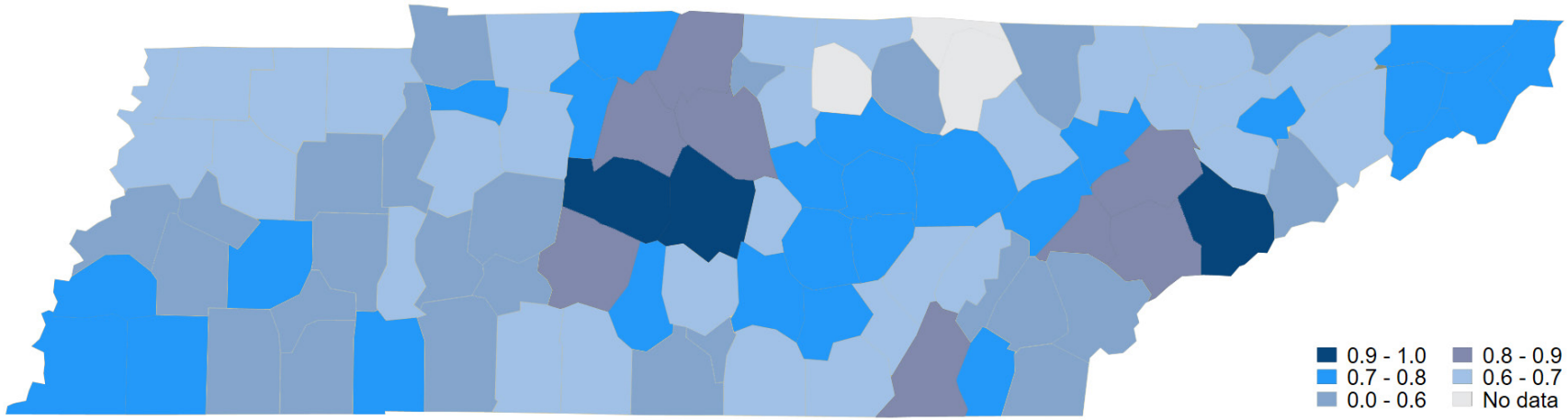
[10] The data also provide an estimate of the number of non-consumer (i.e., business) fixed Internet connections by county, but do not provide an estimate of the number of businesses per county.

[11] The FCC definition of broadband has evolved significantly over the years. In 1996 the broadband benchmark was 200 kbps, but was updated in 2008, 2010, and again in 2015 to its current benchmark of 25 Mbps. The current 25 Mbps benchmark is equivalent to 25,000 kbps, and is therefore 125 faster than the threshold used in the FCC Form 477 data.

[12] In Union County, where KUB serves about half (geographically) of the county with electric service, only 64% of households had fixed Internet access, ranking the county 60th out of all 95 counties in the state.

[13] I-40 travels through eight counties between Knoxville and Nashville. These include: Knox, Loudon, Roane, Cumberland, Putnam, Smith, Wilson, and Davidson. On average, these counties report a connectivity rate of 80%, significantly higher than the overall state average of 68%.

**Figure 4: Share of Households with Fixed Internet Access in Tennessee, as of December 2018**




Notes: Broadband data are from FCC Form 477, available at https://www.fcc.gov/form-477-county-data-internet-access-services. Household broadband connections offer upload and/or download speeds of at least 200 kbps. Note, however, that the current definition of broadband requires download/upload speeds of 25/3 Mbps. County-level household estimates come from the 5-year American Community Survey (ACS). Counties shaded gray are censored for confidentiality.

**Table 3: Household Use of Computers and Broadband in Knox County, TN**

| | 2015 | | 2019 | |
|---|---|---|---|---|
| | Total | Percent | Total | Percent |
| **Households with Computing Device** | **159,872** | **88.2** | **180,570** | **94.1** |
| Desktop or Laptop | 142,629 | 78.7 | 146,600 | 76.4 |
| *Smartphone* | 143,607 | 79.2 | 169,787 | 88.5 |
| *Tablet* | N/A | N/A | 122,411 | 63.8 |
| *Other Computer* | 15,111 | 8.3 | 5,711 | 3.0 |
| *No Computer* | 21,420 | 11.8 | 11,355 | 5.9 |
| **Households with Internet Subscription** | **138,537** | **76.4** | **161,869** | **84.3** |
| *Dial-up* | 462 | 0.3 | 177 | 0.1 |
| *Broadband* | 138,075 | 76.2 | 161,692 | 84.2 |
| *No Internet* | 42,755 | 23.6 | 30,056 | 15.7 |

Notes: Data are from the American Community Survey (ACS) table ID: S2801. In 2015, the survey did not differentiate between smartphones and tablets. Instead, the survey asked whether a household had a "handheld device." These results are presented alongside the smartphone category above. In the survey, broadband is only defined as "high speed internet service such as cable, fiber optic, or DSL..."

**Table 4: Internet Subscriptions by Household Income in Knox County, TN**

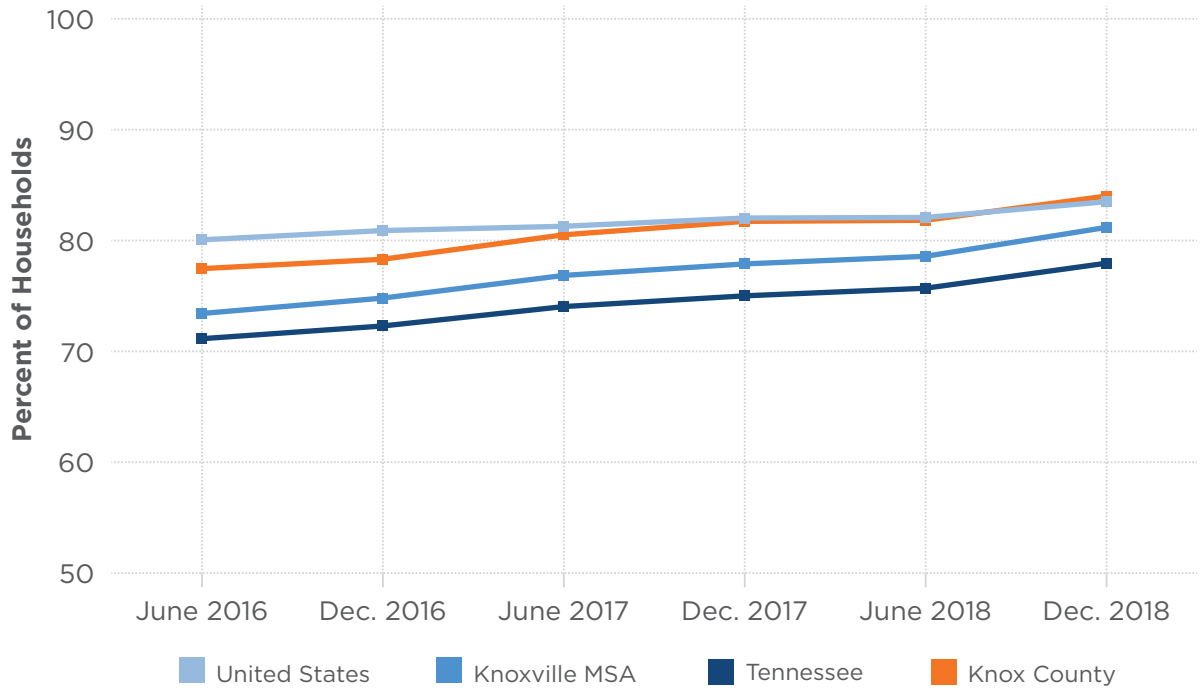
| | 2015 | | 2019 | |
|---|---|---|---|---|
| | Total | Percent | Total | Percent |
| **Household Income: Less than $20,000** | **31,172** | **N/A** | **29,612** | **N/A** |
| *Dial-up* | 0 | 0.0 | 0 | 0.0 |
| *Broadband* | 14,406 | 46.2 | 17,905 | 60.5 |
| *No Internet* | 16,766 | 53.8 | 11,707 | 39.5 |
| **Household Income: $20,000 to $74,999** | **88,987** | **N/A** | **85,181** | **N/A** |
| *Dial-up* | 424 | 0.5 | 69 | 0.1 |
| *Broadband* | 67,118 | 75.4 | 69,263 | 81.3 |
| *No Internet* | 21,445 | 24.1 | 15,849 | 18.6 |
| **Household Income: More than $75,000** | **61,113** | **N/A** | **77,132** | **N/A** |
| *Dial-up* | 38 | 0.1 | 108 | 0.1 |
| *Broadband* | 56,551 | 92.5 | 74,524 | 96.6 |
| *No Internet* | 4,544 | 7.4 | 2,500 | 3.2 |

Notes: Data are from the 2015 and 2019 American Community Survey (ACS) table ID: S2801. In the survey, broadband is only defined as "high speed internet service such as cable, fiber optic, or DSL..."

distribution in Knox County. In 2015, less than half of all households with annual incomes below $20,000 maintained a broadband subscription. By 2019, this rate of connectedness had risen to 60.5%, but still remains well below households with annual incomes above $20,000. Indeed, only 3.2% of households making more than $75,000 per year do not have a broadband subscription.

The exact extent to which this disparity in household connectivity is a function of supply (i.e., the availability of broadband) or demand (i.e., the propensity of a household to subscribe to broadband service) is not entirely clear. On one hand, internet service providers (ISPs) have historically found it cost-prohibitive to expand broadband infrastructure into remote

**Figure 5: Share of Households with Fixed Internet Access**




Notes: Internet access data are from FCC Form 477, available at https://www.fcc.gov/form-477-county-data-internet-access-services. Household internet connections offer upload and/or download speeds of at least 200 kbps. Note that the current definition of broadband requires much faster download/upload speeds of 25/3 Mbps. County-level household estimates come from the 5-year ACS. In aggregating counties to the MSA, state, and national levels, censored counties were omitted from the sample. The Knoxville MSA includes the following counties and FIPS codes: Anderson (47001), Blount (47009), Campbell (47013), Grainger (47057), Knox (47093), Loudon (47105), Morgan (47129), Roane (47145), and Union (47173).

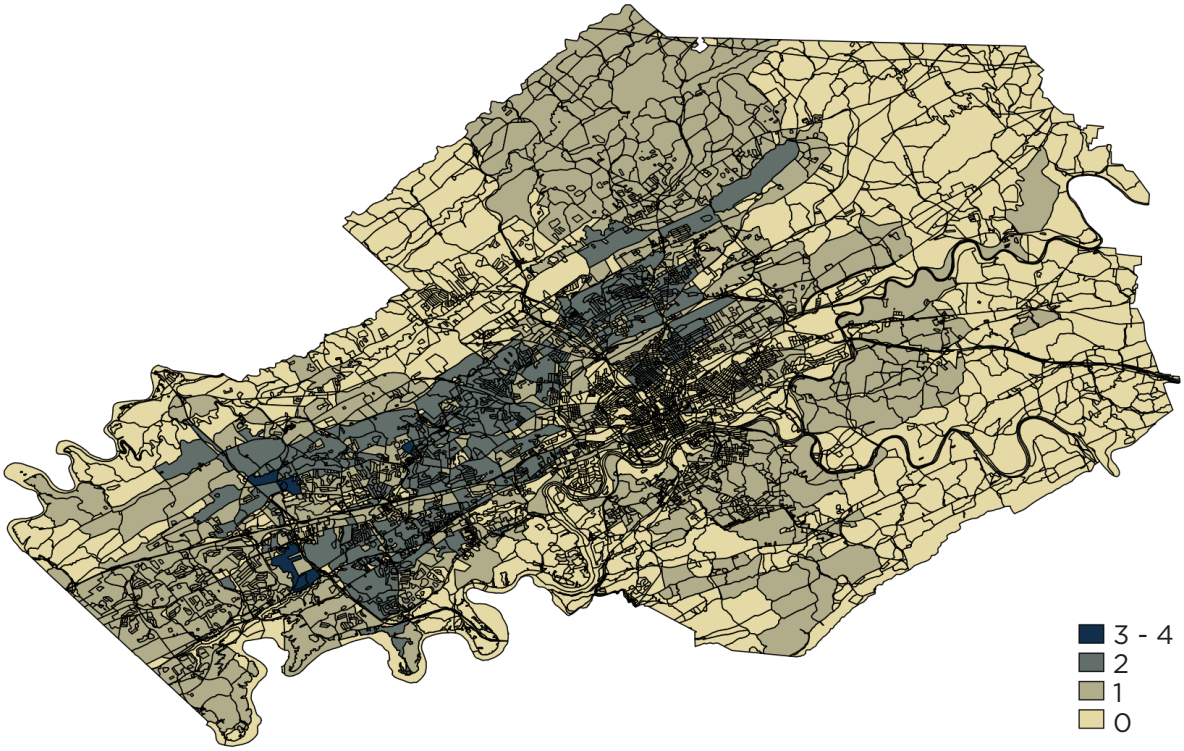
communities. Challenging terrain and greater distances between households have meant that many rural communities have been kept under-connected relative to urban communities that have higher housing densities and telecommunication infrastructure already in place. On the other hand, low-income households might not view broadband as a necessity. This view, however, has been challenged recently. With the rise of remote work, telehealth, and online learning (for grades K-12 and beyond), having a stable broadband connection with sufficient bandwidth has become increasingly important.

To address the supply-side question of whether high-speed internet is *available* uniformly across Knox County, we return to Form 477 data. This time, we examine data reporting the number of ISPs offering fiber internet connections at the census-block level. To be sure, an ISP is said to offer a fiber internet connection to a census block if it is serviced by at least one internet connection. Especially true for larger census blocks, these data should be viewed as an upper bound of ISP availability since not all households in a census block may have access to a provider's internet service type. Nevertheless, the data provide a descriptive view of where ISPs offer high-speed internet service at a very granular level. **Figure 6** reports the distribution of ISPs offering fiber to households (Panel A) and businesses (Panel B) in June 2020, and shows that there are still many census blocks in Knox County without a fiber connection.

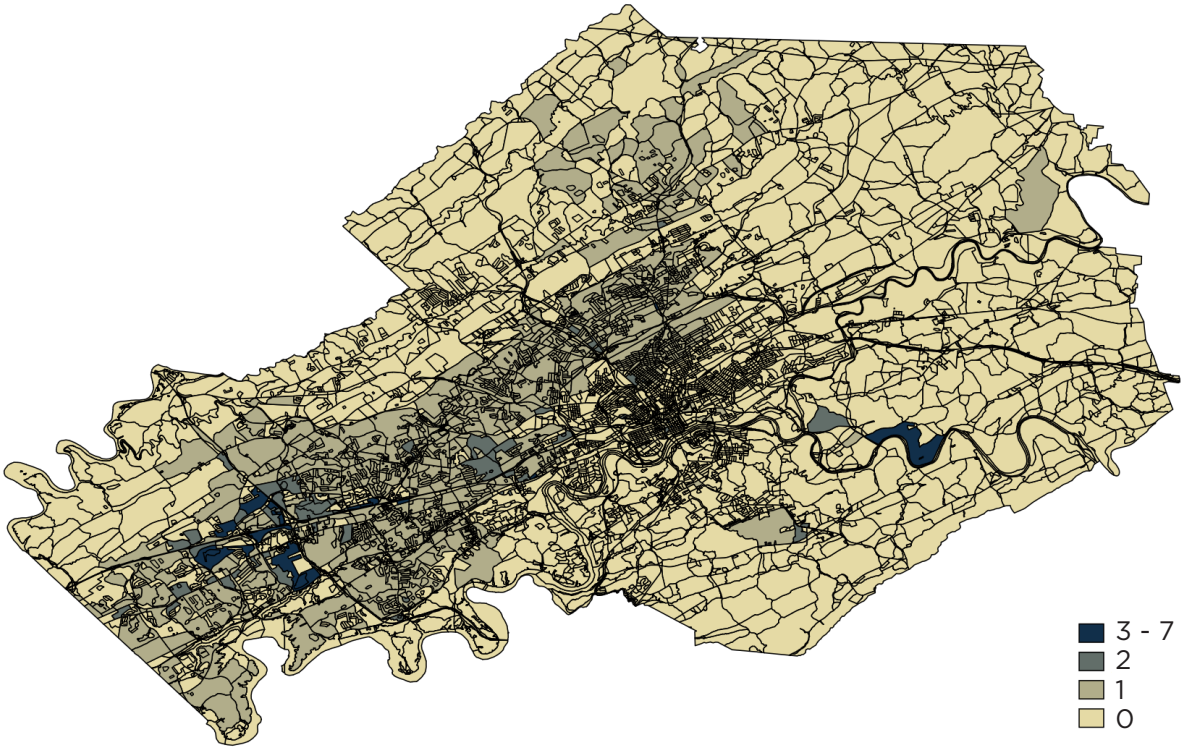
Across all broadband technologies, how does Knox County compare to the rest of Tennessee with regard to download and upload speeds? Examining census-block-level Form 477 data for the state of Tennessee, **Figure 7** shows that ISPs in Knox County advertise maximum download speeds of 233 Mbps, on average. This is 56 Mbps faster than the state average. However, it is important to note that *advertised* download speeds are not necessarily *realized* speeds. Furthermore, Knox County only ranks 15th out of all Tennessee counties, which is troubling given that it's the third-largest county (population-wise) in the state.

**Figure 6: Number of Internet Service Providers by Census Block in Knox County, TN in June 2020**

Panel A. Fiber Available to Households

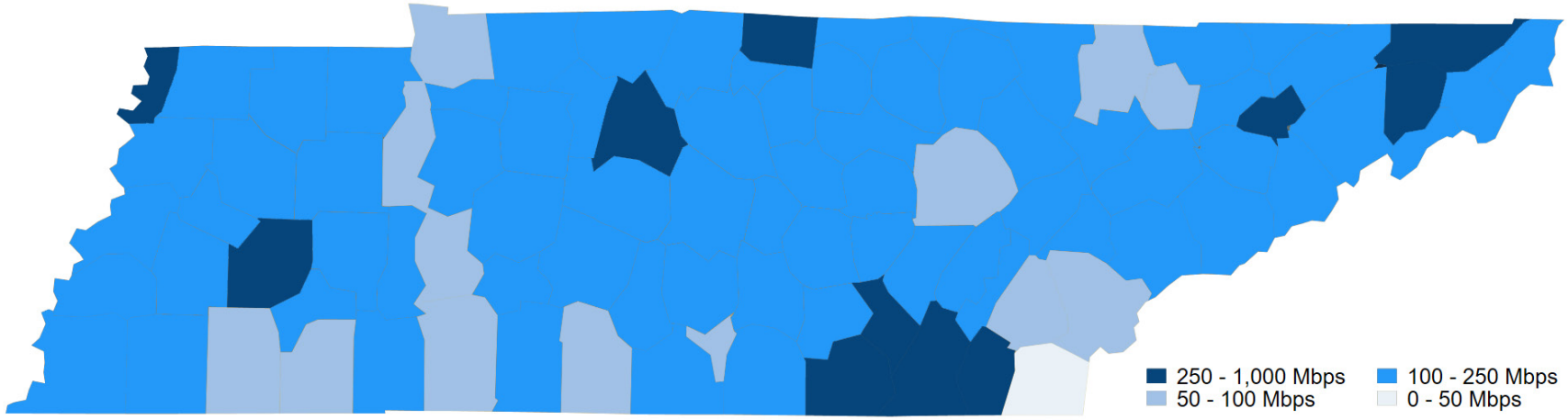



Panel B. Fiber Available to Businesses




Notes: Fixed internet access data data are from FCC Form 477, available at https://www.fcc.gov/general/broadband-deployment-data-fcc-form-477. As per Form 477, twice per year, providers file lists of the census blocks in which they can or do offer service to at least one location at download and/or upload speeds of at least 200 kbps. Fiber is defined as fiber to the end user (i.e., FTTH, FTTB) and not fiber to the curb (FTTC).

**Figure 7: Average Maximum Download Speeds in Tennessee as of June 2020**




Notes: Fixed internet access data are from FCC Form 477, available at https://www.fcc.gov/general/broadband-deployment-data-fcc-form-477. Average maximum download speeds are based on advertised speeds. Internet service providers (ISPs) not offering broadband to residential customers are excluded from the calculation of average download speeds.

As with most broadband data, the more granular, the better. Knowing exactly where homes and business are connected (or not connected) is of great interest and importance to policy makers. To limit reliance on federal maps that tend to overstate the availability of broadband, especially in rural areas, the Associated Press recently reported that Tennessee officials are moving forward with their own broadband map.[14] The plan involves collecting and validating data from ISPs for one year to produce a detailed map of where broadband does and does not exist in the state. The map is expected to be completed by the summer of 2022.

## 3. KUB's plan and its economic effects

Under KUB's current proposal, residential internet plans would offer internet speeds of 1 gigabits-per-second (Gbps, equivalent to 1,000 Mbps) at much lower prices than existing internet providers in Knox County. This would provide a substantial cost savings to customers. **Table 5** presents a prospective product comparison for residential internet between the proposed KUB plan and some of those offered by Xfinity, which is currently the largest residential internet provider in Knox County. Aside from their 25 Mbps plan – with download speeds that are 1/40 as fast as KUB's proposed plan – Xfinity's other offerings are all at a higher monthly price than KUB's proposed plan. Based on **Table 5**, the proposed KUB 1 Gbps plan would cost $11-$51 less per month than the Xfinity 100 Mbps and 1 Gbps plan respectively. Thus, switching from one of these current plans to the proposed KUB plan would lead to yearly savings ranging from $132-$612.[15]

**Table 6** shows how these savings can have a sizable economic impact in Tennessee. Specifically, KUB will offer this internet plan to its roughly 200,000 electric customers. If 35% of those

**Table 5: Prospective Plan Comparisons**

| | Xfinity 25Mbps | Xfinity 100Mbps | Xfinity 1Gbps (1000Mbps) | KUB 1Gbps (1000Mbps) |
|---|---|---|---|---|
| Download Speed | 25Mbps | 100Mbps | 1Gbps | 1Gbps |
| Upload Speed | 3Mbps | 10Mbps | 35Mbps | 1Gbps |
| Data Cap | 1.2 TB | 1.2 TB | 1.2 TB | Unlimited |
| Cost per month | $56 | $76 | $116 | $65 |

Source: KUB Resolution 1433 Presentation, March 11, 2021.
Note: Figures were collected by KUB in the winter of 2021 and do not include promotional discounts or other fees.

**Table 6: Total Cost Savings & Economic Effects from Switching from Current Xfinity Plan to KUB Proposed Plan**

| | Xfinity 100Mbps | Xfinity 1Gbps (1000Mbps) |
|---|---|---|
| Cost savings per household, per month | $11 | $51 |
| Cost savings per household, per year | $132 | $612 |
| Total cost savings per year 200,000 customers with take up rate 35%* | $9,240,000 | $42,840,000 |
| Total Income Effect** | $18,480,000 | $85,680,000 |

*Assumes a 35% take-up rate among the 200,000 eligible households (i.e. 70,000 households)
**Assumes a multiplier of 2

[14] See https://apnews.com/article/tennessee-business-technology-9f06aca4b8e0c2f0a652872c81461ef7.

[15] Switching from the Xfinity 100 Mbps plan would lead to an annual savings of $132, and switching from the Xfinity 1 Gbps plan would save consumers $612 per year.

customers switched from one of these existing providers to the KUB plan, this would lead to an aggregate consumer savings of $9.2-$42.8 million per year. Furthermore, households could then use these savings to make purchases at other Tennessee businesses. Those purchases will then create additional income for other Tennesseans. This is known as the multiplier effect, whereby money is spent and re-spent elsewhere in Tennessee, such that each dollar can generate more than one dollar of economic activity. Assuming a (conservative) multiplier effect of 2, this would generate $18.5-$85.7 million of additional income to Tennesseans every year.

These estimates are of course based on a number of assumptions. We assume that 35% of Knox County households within KUB's coverage area currently have broadband access, like the Xfinity plans we described, and will switch to KUB's broadband offerings resulting in cost savings. While other internet plans exist, such as AT&T, WOW!, Spectrum, and TDS, we assume that all of those that switch are switching from the two Xfinity broadband plans mentioned above, as other providers service smaller portions of the county. However, Xfinity does have the largest ISP market share in the County, and this assumption simplifies our discussion of the results and provides reasonable estimates on consumer cost savings. KUB's 35% take-up rate is likely conservative, as other areas and municipalities with broadband services have seen residential take-up rates of 50% or higher (Lobo, 2020; highlandil.gov).[16] In this regard, our estimates can be seen as a lower bound in consumer cost savings.

An examination of the broadband literature on consumer surplus also suggests that our estimates can be considered a lower bound. Consumer surplus is measured as the difference between the price that consumers pay and the price they are willing to pay. That is, consumer surplus measures the benefit that buyers receive for purchasing a good or service at a lower price than they were willing to pay. Given the current prices of available internet plans in Knox County, KUB's broadband plan would substantially increase the consumer surplus of its customers – and the increase in consumer surplus is not fully captured by our cost-savings estimates above. Previous studies have concluded that the expansion of broadband provides tremendous amounts of consumer surplus. For example, Greenstein and McDevitt (2009) found that broadband access in the United States generated $8.3 billion to $10.6 billion in consumer surplus between 1999 and 2006. More recently, and in one of the most extensive studies on broadband and consumer surplus, Brynjolfsson et al. (2019) used massive online choice experiments and found that the average person gained roughly $32,000 per year from having access to broadband services. More related to KUB's proposed plan, Lobo (2020) examined the impact of ultra-fast broadband on consumer surplus in Hamilton County. Using similar methodology as Brynjolfsson et al. (2019), Lobo (2020) found that the implementation of ultra-fast broadband led to a $128 million increase in consumer surplus for Hamilton County households. In addition to cost savings, Zuo (2019) finds that broadband pricing can have a strong positive effect on labor market outcomes among lower-income households.

The KUB internet plan would also offer both download and upload speeds that are much faster than the majority of residential internet plans currently on the market. This could lead to profound gains in both productivity and leisure time, as outlined in **Table 7**. For example, allconnect.com provides information on how long it takes to download a file of a specific size with varying download speeds.[17] For internet plans with a maximum download speed of 1 Mbps (which is still 5-times faster than the 200 kbps threshold used in the FCC Form 477 data from **Figures 4 and 5**), it would take more than 9.5 hours to download a 4 gigabyte (GB) file (a typical size for a standard high definition quality movie). By comparison, it would take nearly 23 minutes to download the same file with a 25 Mbps connections, but only 34 seconds with KUB's proposed 1,000 Mbps connection (equivalent to 1 Gbps).

The gains from upload times are even more substantial, as upload speeds from current ISP plans are much slower than download speeds. Increased upload speeds under KUB's proposed plan will also be a great benefit to workers and

[16] https://www.highlandil.gov/departments/technology_and_innovation/our_story.php. Accessed on May 19, 2021.

[17] https://www.allconnect.com/blog/internet-speed-classifications-what-is-fast-internet

**Table 7: Download and Upload Times at Various Internet Speeds**

| Speed | 1Mbps | 10Mbps | 25Mbps | 50Mbps | 100Mbps | 200Mbps | 400Mbps | 1,000Mbps |
|---|---|---|---|---|---|---|---|---|
| Time to download a 4GB file | 9h 32m 39s | 57m 15s | 22m 54s | 11m 27s | 5m 43s | 2m 51s | 1m 25s | 34s |
| **Speed** | **1Mbps** | **3Mbps** | **5Mbps** | **10Mbps** | **30Mbps** | **50Mbps** | **100Mbps** | **500Mbps** |
| Time to upload a 500MB file | 1h 9m 54s | 23m 18s | 13m 58s | 6m 59s | 2m 19s | 1m 23s | 41s | 8s |

Source: https://www.allconnect.com/blog/internet-speed-classifications-what-is-fast-internet
Note: 1,000 Mbps is equivalent to KUB's proposed 1 Gbps plan.

businesses who create online content. As an example, a local plumber might market his/her business by uploading a short video to YouTube, which demonstrates how to unclog a sink. Or a teacher might upload a short video to complement a homework assignment. Supposing these videos were 500 megabytes (MB) each, it would take over an hour to upload with a 1 Mbps upload connection, and 23 minutes with a 3 Mbps upload connection (the current upload speed in Xfinity's 25 Mbps plan). Even under Xfinity's ultra-fast 1 Gbps plan, they currently only offer upload speeds of 35 Mbps. According to allconnect.com, it would take more than 2 minutes to upload the short video clip with a comparable 30 Mbps upload connection. This is a very respectable speed/time, but for those needing to upload multiple files, the time commitment could add up relatively quickly. By comparison, an internet plan with upload speeds of 500 Mbps (half the speed of KUB's proposed plan) could upload the video clip in just 8 seconds.

Furthermore, KUB would offer internet plans with no data caps. Private ISPs have implemented home internet data caps in recent years and then charge overage fees to customers exceeding their imposed data caps. As a municipal utility company, KUB would not impose data caps, allowing customers to avoid both overage fees and the need to worry about limiting their home internet usage – especially at the end of each month/billing cycle.

## 4. Economic Effects of Broadband

This section provides an overview of the literature focused on the benefits of broadband access as well as increased internet speeds. The benefits of broadband are numerous, including significant economic effects on GDP and productivity, labor market outcomes, firm activity, and rural migration patterns, as well as strong social benefits tied to improved educational and health outcomes. These benefits are discussed separately, but they interact so that the whole is more than the sum of the parts. For example, good healthcare makes for a more productive workforce and improved education offers long-term benefits for productivity growth, higher incomes, and lower unemployment rates.

### *Economic Growth and Productivity*

Since the arrival of broadband, economists and policy makers have been keenly interested in what value broadband brings to the economy. From the beginning, many studies examined the impact of broadband access and adoption in comparison to much slower dial-up connections. It was immediately clear that the adoption of broadband brought economic gains. Qiang et al. (2009) found that a 10 percentage point increase in fixed broadband penetration would increase GDP growth by 1.21% in developed economies. Likewise, Czernich et al. (2011) and Zaballos and López-Rivas (2012) found that the introduction of broadband increased GDP per capita growth by 2.7-3.9% and 3.19% respectively. These studies, and many others (Koutroumpis, 2009; Katz et al., 2010; Scott 2012; Feng and Ma, 2013), demonstrate that access and adoption of broadband generates GDP growth across countries.

KUB's broadband infrastructure plan is not limited to expanding broadband coverage but will also dramatically increase broadband speeds for the coverage area. The limited research on ultra-fast broadband shows promising effects. For example, Sosa (2014) identified 14 MSAs in the United States that provided ultra-fast broadband

to at least 50% of their residents and found that GDP per capita was 1.1% higher in these MSAs than in their control group of 41 similarly sized MSAs where ultra-fast broadband was not widely available. Similarly, Briglauer and Gugler (2019) found that a 1% increase in the adoption of ultra-fast broadband generated a 0.004–0.005% increase in GDP.

In addition to GDP growth, broadband has been shown to have strong positive effects on productivity (i.e. output per worker). For example, Tyson (2013) reports that a study by Sandisk found that firms with slow internet connections saw productivity losses of 4.9 workdays per employee per year. Similarly, Grimes et al (2016) found that the adoption of broadband leads to a 7-10% increase in firm productivity. These results are consistent with more recent research by Dalgic & Fazlioglu (2020), who found that faster broadband speeds had a significant impact on firm productivity.

The impacts of broadband on GDP and productivity have been widely documented and the literature converges to show that broadband has a strong and significant impact on economic growth (see Bertschek et al., 2015). While, the research is robust and conclusive on the relationship between broadband access and economic growth, fewer studies have specifically examined the impacts of ultra-fast broadband. Although, the emerging literature does suggest that ultra-fast broadband has strong positive effects on economic growth as well.

### *Labor Market*

The impact of broadband availability and usage on labor markets, is also important to local economies. Indeed, greater connectivity has the potential to aid unemployed workers in their job search. It can also help firms enjoy enhanced labor-market matching, and for already employed workers, it can result in increased wages. Underlying all of these potential outcomes are the common mechanisms of quicker information dissemination and the ability to process more information overall.

Not surprisingly, many studies have examined the impact of broadband availability, diffusion, and adoption on various labor market outcomes. On the labor supply side, the literature generally finds that broadband access improves the labor market outcomes of unemployed workers. Examining the National Longitudinal Survey of Youth (NLSY97), Kuhn and Mansour (2014) found that unemployed workers who used the internet to search for work were re-employed about 25% faster than comparable workers who did not search for work online.

This reduction in search frictions is also evident on the labor demand side. Using individual-level data from Norway, Bhuller et al. (2019) found that greater broadband availability not only increased the number of job openings online, but also lowered the average duration of vacancies, and reduced the share of business establishments with unfilled positions. Furthermore, the results revealed that unemployed workers were able to find employment at establishments located farther from home, perhaps generating better labor-market matching between employers and employees.

Of particular interest to KUB and its plan to expand fiber to its electric grid customers, Lobo et al. (2020) examined the effect of broadband *speed* on county-level unemployment rates in Tennessee. The results from their study showed that counties with fast internet (with download speeds of at least 100 Mbps) boasted lower unemployment rates by roughly 0.26 percentage points relative to counties without fast internet. Furthermore, rural counties seemed to benefit disproportionately from faster broadband than did urban areas. In a related study, Hjort and Poulsen (2019) found that when fast internet becomes available (where it was previously unavailable), the probability of an individual being employed increases by at least 3.1%.[18] The results from these studies are particularly helpful in attempting to foresee the economic outcomes from KUB's fiber expansion plan.

In several other studies, this association between broadband and employment holds. Atasoy (2013) found that employment rates increased by 1.8 percentage points after counties gained access to broadband, with this effect being larger in rural counties and in counties with a larger share of college graduates. In another study, Dettling (2013) examined the impact of high-speed internet use on labor force participation. The results concluded that labor force participation rates of

[18] In some instances, the probability of an individual being employed increased by as much as 13.2%.

married women rose by 4.1 percentage points due to high-speed internet use, suggesting potential heterogeneous effects by gender and marital status. Especially after the dramatic fall in the labor force participation of women due to the COVID-19 pandemic, this result provides optimism for a recovery in employment among women as labor markets heal.

Referring back to **Table 4**, which displayed the breakdown of household connectivity by household income for Knox County, how are low-income localities affected after the introduction/expansion of broadband? Examining the discount broadband program Internet Essentials, which was launched by Xfinity in 2012, Zuo (2019) found that PUMA-wide broadband availability increased the probability of a low-income individual being employed by 0.9 percentage points; incomes also increased by 1.3%.[19]

### *Firm Activity*

It is not hard to imagine how broadband might impact firm activity. Greater broadband connectivity made available to firms could possibly lead to increased efficiencies in production processes, create greater collaboration with offices/firms in other states or countries, or allow products to be marketed to a wider set of consumers. Broadband connectivity could also help nascent firms with the business application process, which is a necessary component of operating a business.

In a similar vein as the literature examining the impact of broadband and labor markets, there are many studies that investigate how firm activity responds to greater broadband availability. In general, broadband is associated with gains in firm activity. In examining the Department of Agriculture's Broadband Loan Program (BLP), Kandilov and Renkow (2010) found that loans made during the Pilot BLP generated gains in not only employment, but annual payroll, and the number of business establishments.[20] In a follow-up study, which examined the subsequent BLP, Kandilov and Renkow (2020) also reported small gains in payroll per worker.

In some studies, small firms have been found to be disproportionately affected by broadband. Indeed, Shideler and Badasyan (2012) examined the ConnectKentucky broadband deployment program of the early 2000s and found that increased broadband availability led to growth in the number of small firms (with fewer than 100 employees). Especially in rural areas, small firms tend to be strong economic contributors and essential strands in the larger economic fabric. To that end, Kim and Orazem (2016) examined the impact of broadband on new-firm location decisions in rural Iowa and North Carolina, finding gains in new-firm activity, especially among large rural areas and those within close proximity to a metropolitan statistical area (MSA).

Especially relevant to KUB's broadband expansion plan, the Government Accountability Office (2014) found that small businesses reported improvements in the speed and reliability of their broadband service after using either federally funded or *municipal* networks. Small businesses also reported efficiency gains, which allowed for improvements to business operations (also see Bertschek et al., 2013). And in predominantly minority areas, broadband availability facilitates entrepreneurship and decreases dependence on local banks, which may be sparsely located in minority communities (Prieger, 2020).

### *Education*

High-speed internet access has become an increasingly important tool for teaching and learning. National data indicate that 70% of teachers assign homework that requires broadband access, and 30% of school districts included technology in their curricula even before COVID-19 (Consortium for School Networking, 2016; Bauer et al., 2020). Furthermore, survey data from middle school students in Michigan show that the majority of students with high-speed connections use the internet for a variety of educational activities including: checking grades, conducting research, turning in homework, emailing teachers, and working with classmates on

[19] A PUMA is a Public Use Microdata Area. As per the U.S. Census Bureau's description, PUMAs are "non-overlapping, statistical geographic areas that partition each state or equivalent entity into geographic areas containing no fewer than 100,000 people each." See https://www.census.gov/programs-surveys/geography/guidance/geo-areas/pumas.html#:~:text=Public%20Use%20Microdata%20Areas%20(PUMAs)%20are%20non%2Doverlapping%2C,and%20the%20U.S.%20Virgin%20Islands. For another study examining the effect of broadband deployment and wages, see Akerman, Gaarder, and Mogstad (2015).

[20] McCoy et al. (2018) also find that broadband deployment in Ireland increased the number of firms in operation.

school projects (Hampton et al., 2020). However, a 2018 survey finds that 17% of teenagers in the U.S. say that they are often unable to finish their homework due to unreliable computer or internet access at home (Anderson and Perrin, 2018). This issue disproportionately affects rural and lower-income communities, where high-speed internet access is less prevalent (Zuo, 2019; Lai and Widmar, 2021). Therefore, students with poor or no home internet connectivity are at a severe academic disadvantage.

Research over the past decade has consistently shown that high-speed internet access at the home has educational effects through a number of different dimensions. For example, students with no or slow internet access have significantly lower GPAs, perform worse on the SATs, apply to fewer colleges, and are less likely to be interested in STEM-related careers (Dettling et al., 2018; Bauer et al., 2020; Hampton et al., 2020). Research also indicates that internet speed matters. For example, Sanchis-Guarner et al. (2021) examine test score data in England, and find that increasing home internet speeds by 1 Mbps (by moving closer to a telephone local exchange station) increases test scores by 1.37 percentile ranks. Similarly, Grimes and Townsend (2018) find that providing ultra-fast broadband connections to schools leads to a 1 percentage point increase in standardized test pass rates among elementary school students.

These effects have important economy-wide implications, as higher educational attainment is linked to higher wages (**Figure 8**) and lower unemployment (**Figure 9**). The relationship of the latter was greatly magnified during the pandemic, when lower-wage workers suffered the brunt of the pandemic-related job losses. Furthermore, expanding broadband access, which has positive educational effects, seems like a natural complement to the community-wide resources and forward-thinking educational initiatives already in place in both Knox County and the state of Tennessee (e.g. Knox Achieves, Tennessee Promise, the Drive to 55, and many others).

The importance of community-wide broadband access has been magnified during the COVID-19 pandemic. Knox County schools closed on March 13, 2020, due to the pandemic, and remained closed for the remainder of the academic school year. Distance learning was not offered for the second half of the spring 2020 semester due to gaps in internet access and device availability, preventing many Knox County students from accessing formal education. For the following school year (academic year 2020/21), families were able to choose between in-person schooling or at-home virtual learning for their school-aged children. However, the latter was only a viable option for those with reliable internet access.[21]

### *Health*

As discussed in previous sections, broadband access has positive effects on education and employment outcomes, both of which have indirect positive impacts on health outcomes (Marmot and Allen, 2014). In addition, those with broadband access are more likely to use the internet to gather health-related information (Friedan, 2010; Rains, 2008; Kim et al., 2021),[22] and broadband can deliver healthcare services remotely through telehealth. For these reasons, broadband access is viewed as a "super-determinant" of health (Bauerly et al., 2019). However, telehealth services are underutilized in many communities due to no or slow internet access and internet affordability issues (Kourvelas et al., 2021).

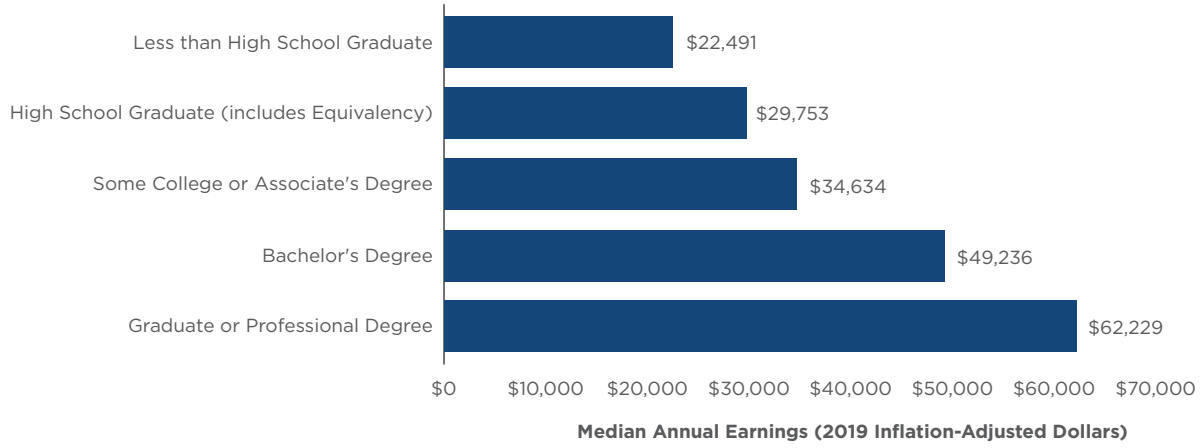
Telehealth became an even more important tool during the pandemic, as healthcare professionals could virtually communicate with symptomatic patients, while helping to reduce the spread of COVID-19. Furthermore, telehealth allowed asymptomatic healthcare staff to work remotely while in quarantine (Wosik et al., 2020). This was especially important during the pandemic-related surges in hospitalizations. As a result, telehealth usage skyrocketed at the onset of the pandemic, with BlueCross BlueShield of Tennessee seeing an 18-fold increase in telehealth claims between mid-March and mid-April of 2020 as compared to the same period of 2019 (Wicklund, 2020).

Telehealth can continue to play a vital role in healthcare services after the pandemic due

[21] Parents of course had to consider a number of factors when choosing between in-person schooling and the virtual option, but internet access was a critical component in that decision-making process.

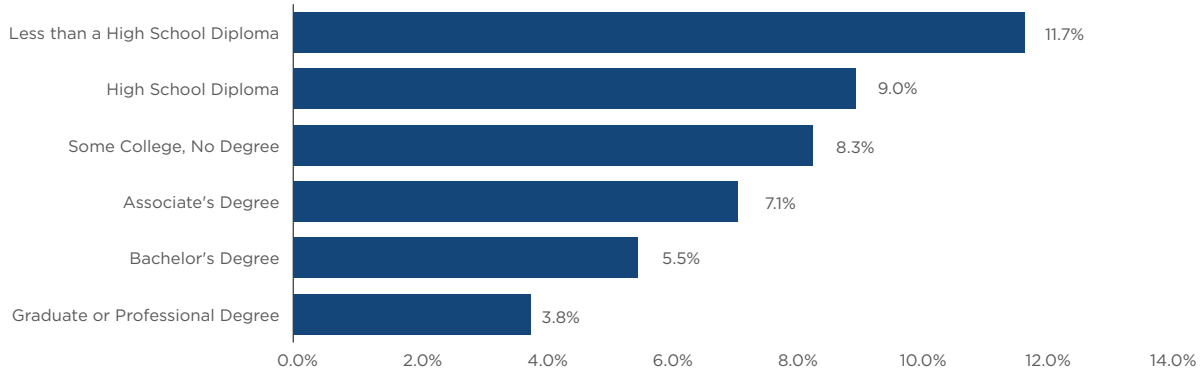
[22] This can, of course be a double-edged sword due to the rapid sharing of misinformation on the internet. However, information from the internet is commonly used as a complement rather than a replacement for medical professional advice (Rains, 2008; Hand et al., 2013).

**Figure 8: Median Annual Earnings Increase Rapidly with Higher Educational Attainment**




Source: U.S. Census Bureau, American Community Survey, 2019 5-Year Estimates

**Figure 9: Higher Educational Attainment is Linked to Lower Rates of Unemployment**




Source: Bureau of Labor Statistics, Current Population Survey, 2020

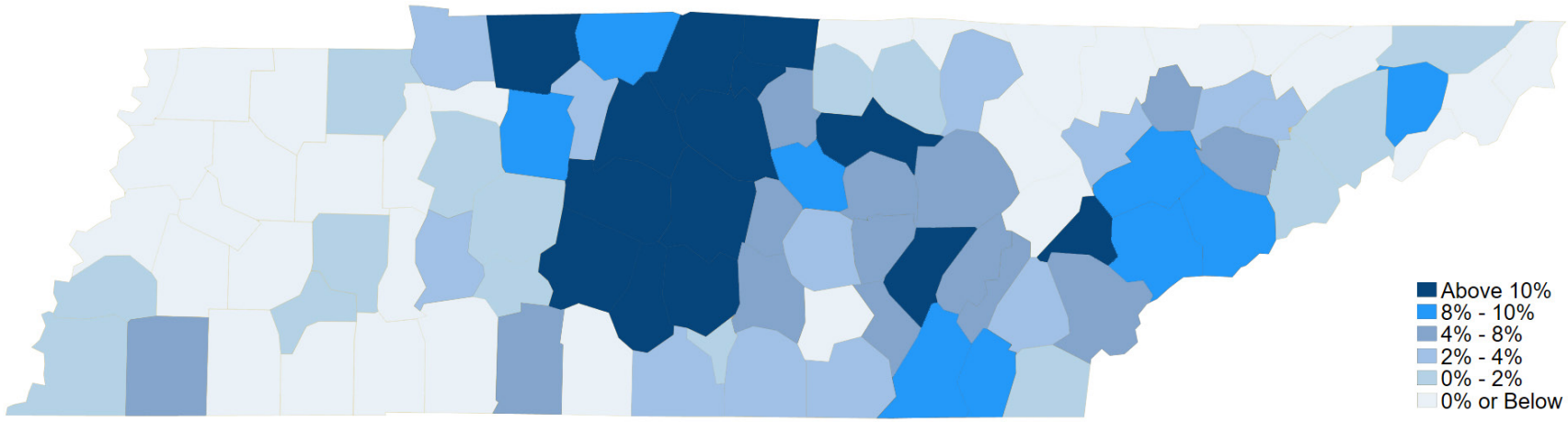
to its convenience, reduced costs of travel, and potential gains in efficiency. However, this is only possible for those with reliable and high-speed internet connections.

### *Rural Migration Patterns*

Rural economic development has been a key focal point by Tennessee policymakers, and rightfully so, as rural counties face higher unemployment rates and lower average incomes (Boyd Center, 2020). Tennessee's rural counties have also faced declining population or slower population growth over the last decade as compared to their metropolitan counterparts (see **Figure 10**). The expansion of broadband should be part of any strategic plan aiming at the advancement of rural communities. A key benefit of broadband infrastructure is connecting people from remote or rural areas to information that would otherwise be costly to obtain. Furthermore, it would be difficult to attract new businesses to communities with no or poor internet connections.

Limited research has been done on broadband expansion in rural communities, and it has generally focused on European communities, where major state aid programs directed funds towards upgrading internet speeds in rural areas. However, this research offers promising insights. For example, Briglauer et al., (2019) examine the effect of increased broadband coverage in Bavaria, Germany, and find positive effects on employment rates among affected residents and reductions in rural depopulation. Lehtonen (2020) examines the effects of a comparable program in Finland, and

**Figure 10: Tennessee County Population Growth, 2010 to 2019**

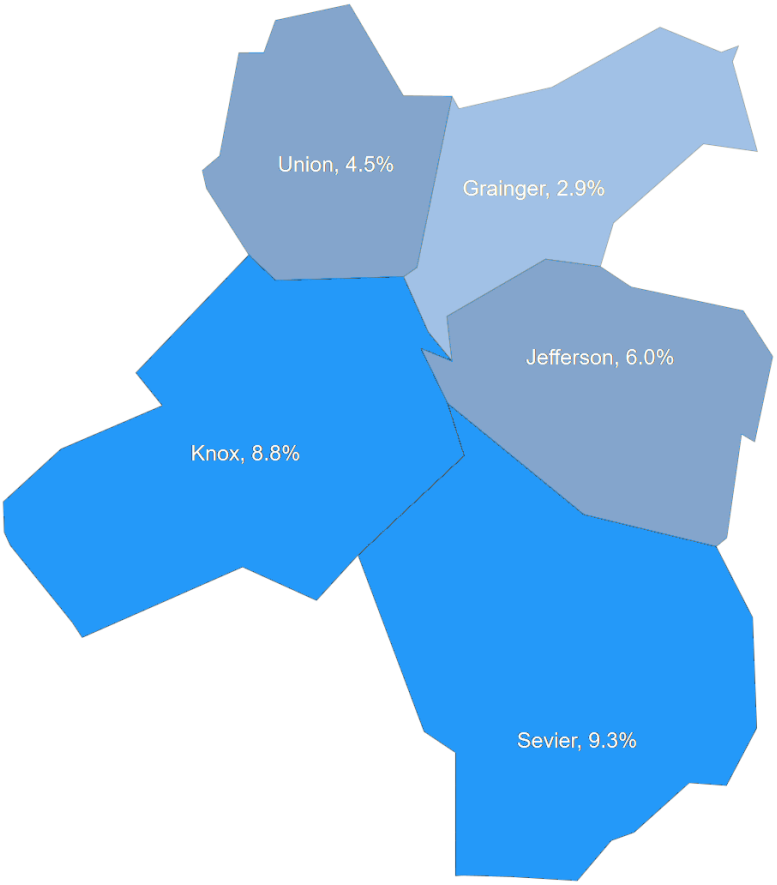



Source: U.S. Census Bureau, Annual Estimates of the Resident Population for Counties in Tennessee.

also finds that broadband availability protects rural areas from depopulation.

KUB's business plan proposes the expansion of ultra-fast broadband through its entire electric grid, which includes all of Knox County, as well as sizable portions of Grainger, Union, Jefferson, and Sevier counties. **Figure 11** shows that population growth over the last decade was much slower in Grainger, Union, and Jefferson counties than in Knox or Sevier. Furthermore, while these surrounding counties are included in the Knox MSA due to commuting patterns, some of these counties could be considered rural based on population density and the percentage of the county population classified as rural. According to the 2010 Census, Knox County has a population density of 850 residents per square mile and only 10.9% of its population is classified as rural. By comparison, in both Grainger and Union counties, 100% of the population is classified as rural, with population densities of 80.8 and 85.5 people per square mile respectively (Roehrich-Patrick et al., 2016). Jefferson and Sevier counties also have more than 50% of their populations classified as rural and population densities below 200 residents per square mile. There is no perfect delineation between rural and urban counties, but based on thresholds developed in Isserman (2007), Grainger and Union would be classified as rural counties and Jefferson and Sevier would be classified as "mixed rural."[23] Therefore, KUB's proposal could spur population growth in these surrounding counties.

**Figure 11: Population Growth among Counties in KUB Electric Grid, 2010 to 2019**




Source: U.S. Census Bureau, Annual Estimates of the Resident Population for Counties in Tennessee.

[23] Table 9 of Roehrich-Patrick et al. (2016) outlines Isserman's thresholds, which are based on population density and rural population classifications, and applies these thresholds to all Tennessee counties.

## 5. Conclusion

This report discusses the various economic benefits of KUB's *Fiber to the Home* business plan, which would provide cheaper ultra-fast internet to all households in its electric grid service area. The benefits of increased broadband access and increased internet speeds are numerous, including positive economic effects on GDP, productivity, labor market outcomes, firm activity, and rural migration, as well as strong social benefits related to educational and health outcomes. In addition, under KUB's proposal, residential internet plans would be offered at a lower monthly cost than current competitors, with download speeds that are comparable to the top residential plans and upload speeds that are significantly faster than internet plans currently on the market. This would lead to significant cost and time savings for consumers who switch to the proposed KUB internet plan. Assuming that 35% of KUB households adopt the new internet plan, we estimate that the cost savings of switching from their current provider would lead to a $18.5 to $85.7 million increase in Tennessee incomes per year, depending on the cost of their current internet plan.

The importance of high-speed internet access became glaringly obvious during the COVID-19 pandemic, as large swaths of the population shifted important day-to-day activities to the digital world, through online learning, remote work, and telehealth. However, these opportunities were only available to those with a fast and reliable internet connection, and according to the U.S. Census Bureau, more than 30,000 households in Knox County do not even have an internet connection (**Table 3**).

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