Economic Benefits of Expanding Broadband in Missouri

Carter and Shannon Counties

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Executive Summary

Drivers of economic benefits

Understanding the economic impact of broadband—in terms of jobs, gross domestic product and other economic measures—can be difficult due to broadband's benefits intertwining with gains that stem from computing advances and improved digital literacy. Additionally, benefits like quality-of-life improvements from broadband are easy to recognize but harder to quantify. Moreover, since broadband installation and adoption occur gradually, the economic benefits take time to unfold.

Despite these measurement challenges, recent research offers practical insights into understanding how broadband expansion benefits local economies. Economic gains tied to broadband expansion include the following:

- **Broadband investment:** Installing broadband infrastructure to previously unserved households will stimulate construction-related economic activity for several years.
- **Telemedicine:** Virtual healthcare reduces household costs by minimizing emergency room visits and doctor's office trips, and saves income associated with travel and missed work.
- **Education productivity:** Access to online resources increases teacher productivity.
- **Income:** Broadband technology enables more effective job matching, online training and access to goods and services that can increase incomes. It also improves productivity, potentially raising household and farm incomes.
- **Employment:** Community job growth, especially in knowledge-intensive service industries, fosters entrepreneurial, investment and productivity gains.

Although necessary, broadband access alone is not sufficient to stimulate economic growth. To realize broadband's economic benefits, community residents and businesses must increasingly adopt broadband service and gain skills in using broadband-related technologies. **Increased broadband adoption and utilization drive long-term economic gains.**

About this study

This study estimates the 10-year economic benefits that would result from expanding fixed broadband adoption in two Missouri counties: Carter and Shannon. Fixed broadband includes fiberoptic, cable or DSL (digital subscriber line) technologies, known for their reliability compared to other broadband connections. The study considered minimum and maximum broadband adoption growth scenarios to capture the range of potential economic outcomes in a 10-year period. The minimum scenario assumes a 10 percentage point increase in household fixed broadband adoption for the two counties. In the maximum scenario, household fixed broadband adoption increases by 30 percentage points.

Key study findings

The following discussion describes how jobs, labor income and gross domestic product would change assuming the minimum and maximum broadband adoption gains.

Job and labor income growth are the most tangible economic benefits expected from expanded broadband adoption:

- In both scenarios, Carter and Shannon counties see sizable employment growth in the 10-year period. Exhibit 1 shows these counties' job gains by year 10 when assuming the minimum adoption scenario: Carter (67) and Shannon (68). Job gains double in the maximum scenario. These gains may seem modest but are more substantial when considering past employment trends and the smaller workforces – roughly 3,000 – in these counties.
- For context, Exhibit 1 shows the annual average number of new jobs per year as a percent of 2022 employment and compares these rates to county job growth trends from 2017 to 2022. The minimum scenario shows annual job growth between 2.1% and 2.3% of 2022 employment for the two counties. In the maximum scenario, job growth averages over 3% per year for both counties. These gains substantially exceed the annual 2017-22 employment growth rates of Carter (1.0%) and Shannon (1.4%).
- Labor income would also increase as broadband use expands, as shown in Exhibit 1. From $13 million in income gains for Shannon County in the minimum scenario to $35 million for Carter County in the maximum scenario, these gains would increase spending in local communities and benefit businesses and residents alike.

Gross domestic product (GDP) communicates the value of all final goods and services produced in a county. It represents the most comprehensive measure of economic benefits from broadband expansion.

- The study projects that GDP would increase significantly under both

How Significant is GDP Growth?

Gross domestic product (GDP) measures the final value of goods and services sold in a county, contributing to new income and profits circulating within the community.

Under the minimum growth scenario, annual, inflation-adjusted GDP would increase by 1.0% for Shannon and 2.0% for Carter.

These gains allow significant economic expansion compared to recent years. For example, Carter County experienced a mere 0.1% annual GDP growth rate from 2017 to 2022. The minimum scenario provides an annual boost of 2.0% in new GDP over 10 years. For context, Missouri's annual GDP growth rate from 2017 to 2022 averaged 1.6%.

Adding 2.0% to Carter County's annual GDP over 10 years, all else equal, would grow the county's economy by

20%

as compared to 2022.

minimum and maximum scenarios; see Exhibit 1. For example, Carter County gains $33 million in total GDP over 10 years in the minimum scenario and nearly $50 million in the maximum scenario. Shannon County would have a GDP increase ranging from $19 million to $33 million, depending on the scenario.

- With modest 10 percentage point broadband adoption gains, Carter County would increase its annual GDP by 2.0% relative to its 2022 GDP levels. Shannon County GDP would see an annual gain of 1.0%. In the maximum scenario, annual GDP gains increase to 3.1% and 1.7% for Carter and Shannon, respectively.
- Exhibit 1 shows how the two counties benefit from fixed broadband expansion in terms of county employment, labor income and GDP growth under the two scenarios.

Exhibit 1. Employment, Labor Income and GDP Benefits of Fixed Broadband Adoption, Minimum and Maximum Adoption Scenarios

	Carter	Shannon
Minimum Scenario: 10 Percentage Point Increase in Fixed Broadband Adoption		
10-Year Total Economic Benefits of Broadband Expansion		
Employment Gain in Year 10	67	68
Total Labor Income *(in millions)*	$23.7	$13.2
Total Gross Domestic Product *(in millions)*	$32.9	$19.5
Avg. Annual Gains of Broadband Expansion Compared to 2022 and Prior 5-Year Trends		
Annual Avg. Employment as % of 2022 Emp.	2.3%	2.1%
*Reference: Annual Employment % Change, 2017-22**	*1.0%*	*1.4%*
Annual Avg. GDP as % of 2022 GDP	2.0%	1.0%
*Reference: Annual GDP % Change, 2017-22**	*0.1%*	*1.3%*
Maximum Scenario : 30 Percentage Point Increase in Fixed Broadband Adoption		
10-Year Total Economic Benefits of Broadband Expansion		
Employment Gain in Year 10	136	137
Total Labor Income *(in millions)*	$35.1	$22.5
Total Gross Domestic Product *(in millions)*	$49.5	$32.8
Avg. Annual Gains of Broadband Expansion Compared to 2022 and Prior 5-Year Trends		
Annual Avg. Employment as % of 2022 Emp.	3.6%	3.2%
*Reference: Annual Employment % Change, 2017-22**	*1.0%*	*1.4%*
Annual Avg. GDP as % of 2022 GDP	3.1%	1.7%
*Reference: Annual GDP % Change, 2017-22**	*0.1%*	*1.3%*

**Notes: Reference source is U.S. Bureau of Economic Analysis, 2017-22. Average annual employment and GDP are divided by 2022 county figures to show the percentage of that figure compared with 2017-22 growth trends. Annual GDP % change for 2017-22 is the compound annual growth rate in real dollars. Income and GDP figures reported in 2024 dollars.*

Economic Benefits of Broadband Expansion

This analysis documents the economic benefits of expanded broadband availability and adoption in a community. We begin by defining important terms in this study.

The term "broadband" or "fixed broadband" is used interchangeably in this analysis, and it refers to moderate-to-high speed broadband services delivered by fiberoptic, cable or DSL (digital subscriber line) technologies. This "fixed broadband" definition excludes satellite, wireless or cellular technologies currently considered less dependable.

High-speed "broadband services" are defined by the Federal Communications Commission (FCC) as broadband speed of at least 100 Mbps (transfer of "megabits per second") of download speed and 20 Mbps of upload speed, often referred to as 100/20. This definition, updated in March 2024, is an increase from the prior broadband specification of 25/3 Mbps speed. For this study, locations in the county that are unserved by either 25/3 or 100/20 are used to estimate the share of households with no fixed broadband service as even the lower level of broadband speed is sufficient for communities to benefit economically.

"Broadband availability" refers to the presence of broadband infrastructure so that a household or business can request and receive that service. The FCC provides 2023 broadband availability information that is viewable through a Missouri Office of Broadband Development mapping portal.

"Broadband adoption" refers to the number or percentage of households that subscribe to fixed broadband services. This figure typically comes from the U.S. Census Bureau's American Community Survey (ACS) 2018-2022 5-Year estimates.[1] The household fixed broadband adoption level is an important driver of economic benefits. If consumers perceive that broadband service is too costly, they will not adopt the service even if it is available. Other reasons for non-adoption include digital illiteracy or simply not wanting broadband services.

Since the U.S. Census broadband adoption figures represent a 5-year period (2018-22), it is less ideal as a baseline measure given the renewed interest in internet access during and following the COVID-19 pandemic. This study uses the more recent 2023-24 FCC information as a baseline for determining current broadband access. While broadband access is different from adoption–adoption levels will be lower than access figures–the FCC information serves as a more accurate starting point to analyze economic gains. The rise or change in adoption levels is what generates economic benefits in this study, so using access figures as a starting point has minimal impact.

For more information on defining broadband, availability and access, see the University of Missouri Extension guide DM601, Broadband Technologies: A Primer on Access and Solutions.

Economic Benefits by Category

This section reviews the different economic benefits researchers have found after the introduction of broadband services. Several studies document the relationships, or correlation, between broadband adoption and economic gains. However, causal research findings statistically isolate those

relationships, to suggest cause-and-effect. These studies are particularly useful in a broadband economic benefit analysis.

Telemedicine

Telemedicine creates many benefits for healthcare providers and the patients they serve. Healthcare providers benefit from rural hospital cost savings due to outsourcing services and increased lab and pharmacy work that can be performed locally.[2] Telemedicine allows patients to reduce travel time and the associated lost work income. Virtual health care consultations can also save patients money, as these services cost less and can reduce the number of emergency room visits.[3,4]

Enabled by broadband adoption, telemedicine gains to patients are easy to understand from a cost perspective. However, the benefits to healthcare providers and communities are more complex as local spending can be transferred in different directions. For example, a rural hospital can reduce costs by contracting with a larger city hospital to provide specialized services. That spending would in turn benefit the urban community while reducing the need for doctors at the rural location. This can lower the overall cost for a rural hospital and keep it financially viable, but it does mean less high-income employment in the community. Moreover, a rural community can benefit from spending at local labs or pharmacies because the telemedicine patient is less likely to travel to a larger city hospital for diagnosis. In these instances, urban labs and pharmacies lose income.

Education Productivity

The COVID-19 pandemic brought urgent attention to the need for remote learning. It highlighted how learning losses resulting from school closures have disadvantaged students, especially those from lower-income families, perhaps diminishing their lifetime earnings.[5] While broadband service is a basic requirement for remote learning, many rural school districts in 2020 struggled to help students who lacked home broadband access.[6] COVID-19 created a large experiment on the benefits and costs of remote learning that will take years to understand. Before the pandemic, research on causal educational benefits from broadband expansion largely focused on cost savings to schools to provide education or in teachers' time to find information.[7]

Research has also demonstrated that having broadband access to learning resources positively correlates with better school outcomes for students.[8] However, quantifying the benefits in a causal manner has proven difficult.

Household Income

The potential to raise incomes with broadband adoption seems intuitive, as people can bolster their pay with greater access to online educational resources, productivity tools and the ability to find more job opportunities. Yet isolating income gains from broadband adoption can prove challenging as gains are strongly linked with other factors such as educational attainment and job selection. One often-cited study estimated household income gains from increased broadband adoption that can be interpreted as causal.[9] The research shows that as nonmetro counties move from moderate to higher levels of broadband adoption, the median household income rises by 1.3% over 10 years.

The reasons for income increases are complex and related to other benefits used to measure economic gains from broadband. Educational attainment, employment opportunities, productivity and other factors are intertwined with income so estimating separate gains from these factors can risk overestimating economic benefits. Conversely, including modest income gains with other related measures can serve as a proxy for benefits, such as quality of life or the ability to work remotely, which are harder to quantify.

Farm Income

Broadband access is becoming increasingly important for agricultural producers. An early study of farming-related broadband benefits suggested that economic gains came from real-time information on weather, pricing and management practices. [10] This 2011 study found that U.S. Department of Agriculture broadband loans administered in the early 2000s had a positive impact on farm profits of 3%, driven mainly by increased crop sales. Livestock or animal production operations were less sensitive to broadband access. Many agricultural producers now have access to real-time market and weather data using smartphones, so many of these benefits are already integrated into the farm economy.

However, a more recent study of farming gains confirmed the ongoing benefit of broadband to crop production. [11] The 2020 study found that broadband availability had a small, but statistically significant, impact—a 1% increase in broadband access caused a 0.1% increase in crop yields. Explanations for these gains include the use of precision farming techniques and machinery.

Employment

Installing broadband infrastructure in a community spurs immediate, but temporary, employment gains in construction and supply-chain industries. While important, these short-term job gains can be minimal as much of the spending for specialized workers and materials goes to firms outside the community. However, increased broadband adoption creates lasting employment gains for the local economy.

Employment gains from broadband expansion encompass the positive impacts that this technology has on business growth, investment, entrepreneurship, and productivity gains. Whether broadband facilitates a new business location or enables the expansion of current commercial activities, employment increases are tangible economic benefits that can be seen, and by extension, can lower unemployment levels. While research shows a correlation between broadband and economic development, a handful of studies attempt to isolate the cause-and-effect, or causal, relationship between greater access and specific business and workforce gains.

Business formation is an important benefit arising from broadband expansion. Several studies have found that broadband expansion has positive impacts on new firm creation in rural counties.[12] Another study found that the number of knowledge-intensive professional and business service firms grew as the number of broadband providers increased.[13] Similar findings from 2012 research confirmed that the benefits of broadband expansion can be seen in service industries that rely most heavily on information technology.[14] The research indicated that even though broadband expansion

is associated with employment growth, it does not increase average pay. One explanation is that the draw of employment opportunities increased the population, and therefore the labor supply, which suppressed wage increases.

New and expanding firms increase employment, but growth from broadband expansion can be harder to detect in urban areas. A 2014 study found that employment gains from broadband adoption are seen in nonmetro counties, with no meaningful relationship uncovered in metropolitan counties.[15] One reason may be that the gains in urban areas are already incorporated into the economy or that other factors contribute to job growth. Lower unemployment levels, expected when employment increases, were also found in this research and, more recently, from a 2020 study of high-speed broadband benefits.[16]

Broadband productivity benefits in knowledge-intensive industries have also been documented, along with a dilemma for rural areas with less educated or skilled workers.[17] A 2013 study found that broadband produces positive productivity impacts when used by a highly educated or skilled workforce. Rises in productivity also impact income as more productive employees can be paid more. The research suggests that rural areas with broadband availability, but with lower workforce education/skill levels, may see employment losses as businesses outsource work to other areas or use technology to substitute for workers. That is the other impact of productivity; while it benefits businesses and worker income, it can mean less employment in the local area.

A 2020 study also found productivity benefits from broadband that were influenced by factors such as distance to metropolitan areas and educational attainment.[18] The research supported similar findings from other studies that a more educated workforce, in closer proximity to a metropolitan area, is related to higher productivity gains.

Other Benefits

Expanded broadband adoption spurs additional gains that are harder to quantify. They are not explicitly captured in this economic benefit analysis but are nevertheless important to recognize as attempts to measure their influences will likely be the work of future research.

A 2020 study of high-speed broadband in Chattanooga, Tennessee, highlights several important benefits found in the metro community over 10 years.[19] Many of these gains are difficult to measure, but the study discusses potential benefits that include improvements to:

- **Civic services:** The city utility implemented "smart grid" technologies to reduce outages from major weather events, lower long-term operating costs and lower rates to customers. Other potential benefits included more efficient transportation services and increased public safety.
- **Quality-of-life:** The ability to shop online and learn skills remotely, such as fixing a broken faucet, can provide cost savings and convenience to consumers.
- **Remote work/learning:** Telecommuting gives some workers the ability to earn income during events like COVID-19. Over the long term, it can also reduce traffic congestion and lower costs

for both workers and businesses. Similarly, the ability of students to learn from home enabled the continuation of learning during the pandemic.

There is certainly no way to capture all the positive and, sometimes disruptive, effects of broadband expansion. The challenges of COVID-19 illustrate how quickly technologies, like broadband, can shift benefits to different populations, businesses and places. Over the long term the impact of broadband, just like highways and other connecting technologies, will benefit and shape the economy to create new jobs, industries and institutions. However, the pandemic has shown that those unable to access broadband—either by their location, type of work or financial situation—are quickly at a comparative disadvantage as the economy evolves.

The appendix provides details on how the research noted in this section influenced the methods and assumptions used in this analysis.

Selected County Characteristics and Direct Model Inputs

The two counties in this study, Carter and Shannon, are in the southeastern Ozark region of Missouri. The Ozarks are characterized by hilly terrain and, in most places, poor broadband access. This region is more economically distressed, with higher poverty and unemployment rates than most other Missouri communities. Below are additional details regarding the population and economy of these two counties.

Carter County

Carter County had a population of 5,268 in 2022. This is 16% less than their 2012 population of 6,271. Median household income was $45,737 according to 2018-22 five-year Census estimates. This compares to a Missouri median household income of $65,920.

2022 total employment in Carter County was just over 2,600. The government sector was the largest employer in Carter County, providing jobs for 437 people in 2022. Health Care and Social Assistance jobs followed closely, with 302 individuals working in that sector. Manufacturing came in third, employing 244 individuals. Top employers in Carter County include local public schools, Royal Oak Enterprises and the U.S. Interior Department.

Shannon County

Shannon County has a population of 7,193 and, like Carter, has seen its population decline over the past decade (-14%). In 2012, the county population was 8,333. Median household income was $46,767 according to 2018-22 five-year Census data and well below the Missouri median ($65,920).

County total employment was 3,221 in 2022. Manufacturing was the largest industry in Shannon County, employing 504 people in 2022. The government was the second largest employer (325). Accommodation and Food Services employed 201 people. Top employers in Shannon County include Paramount Apparel, Missouri Hardwood Company and Birch Tree Nursing Center.

Exhibit 2 provides baseline 2022 characteristics and model inputs for the two counties. The minimum scenario assumes a broadband adoption gain of **10 percentage points** over 10 years. The maximum scenario assumes an adoption gain of **30 percentage points** over 10 years.

Exhibit 2. 2022 County Characteristics and 10-Year Model Inputs

2022 County Characteristics	Carter	Shannon
Population	5,268	7,193
Employment	2,637	3,221
Labor Income *(in millions)*	$88.3	$100.7
GDP *(in millions)*	$161	$195
Households	1,925	2,753
Household Broadband Access	15.6%	58.4%
Minimum Scenario: 10-Year Household Fixed Broadband Adoption		
10-Year Direct Model Inputs		
10-Year Broadband Adoption Gain (in pp)	10.0%	10.0%
Broadband Investment *(in millions)*	$25.0	$23.0
Total Direct Income Gains *(in millions)*	$2.1	$2.5
Direct Employment Gain by Year 10	45	55
Maximum Scenario : 30-Year Household Fixed Broadband Adoption		
10-Year Direct Model Inputs		
10-Year Broadband Adoption Gain *(in pp)*	30.0%	30.0%
Broadband Investment *(in millions)*	$25.0	$23.0
Total Direct Income Gains *(in millions)*	$5.7	$7.6
Direct Employment Gain by Year 10	90	110

Notes: Input dollar values represent 10-year total benefit in nominal figures. Adoption gains are in percentage points (pp) from 2022 access levels.

The direct model inputs show the total broadband investment, income gains and employment used in the analysis under each scenario. These direct inputs spur additional, indirect spending in the county economy that generates further economic benefits.

Broadband investment costs are customized to each county based on a 2024 Finley USA engineering study. Direct income gains are derived from the telemedicine, education productivity, household and farm income benefits derived from the number of new households adopting fixed broadband. Direct employment gains represent an annual employment increase that scales up over 10 years for minimum (1.7%) and maximum (3.4%) gains from the base year depending on the scenario. The employment gains are sensitive to the base household broadband adoption level.

The appendix provides additional details on investment cost and direct gain assumptions.

Economic Benefits Summary

Four measures show the total gains to each county in: employment, county taxes, labor income and gross domestic product (see Exhibit 3). The average annual gain in jobs, income and gross domestic product (GDP) is compared to 2022 figures for context. The annual average increase in GDP is also compared to the 2017 to 2022 annual average growth rate.

Employment gains

Under the minimum scenario, by the tenth year employment increases by 67 and 68 jobs in Carter and Shannon counties, respectively. The annual average increase in jobs during the 10 years represents a 2.3% employment gain over 2022 levels in Carter County and 2.1% in Shannon County. Employment gains are greater in the maximum scenario. Jobs increase in the tenth year by 136 and 137 in Carter and Shannon counties, respectively. The job gains represent an annual average increase of 3.6% over 2022 levels in Carter County and 3.2% in Shannon County.

Exhibit 3. 10-Year Total Economic Benefits Summary

	Carter	Shannon
Minimum Scenario: 10 Percentage Point Increase in Household Adoption		
10-Year Total Economic Benefits of Broadband Expansion		
Employment Gain in Year 10	67	68
Total County Taxes *(in millions)* *	$1.0	$0.7
Total Labor Income *(in millions)*	$23.7	$13.2
Total Gross Domestic Product *(in millions)*	$32.9	$19.5
Avg. Annual Gains of Broadband Expansion Compared to 2022 and Prior 5-Year Trends		
Annual Avg. Employment as % of 2022 Emp.	2.3%	2.1%
Annual Avg. Labor Income as % of 2022 Income	2.7%	1.3%
Annual Avg. GDP as % of 2022 GDP	2.0%	1.0%
*Reference: Annual GDP % Change, 2017-2022***	*0.1%*	*1.3%*
Maximum Scenario: 30 Percentage Point Increase in Household BAdoption		
10-Year Total Economic Benefits of Broadband Expansion		
Employment Gain in Year 10	136	137
Total County Taxes *(in millions)* *	$1.6	$1.1
Total Labor Income *(in millions)*	$35.1	$22.5
Total Gross Domestic Product *(in millions)*	$49.5	$32.8
Avg. Annual Gains of Broadband Expansion Compared to 2022 and Prior 5-Year Trends		
Annual Avg. Employment as % of 2022 Emp.	3.6%	3.2%
Annual Avg. Labor Income as % of 2022 Income	4.0%	2.2%
Annual Avg. GDP as % of 2022 GDP	3.1%	1.7%
*Reference: Annual GDP % Change, 2017-2022***	*0.1%*	*1.3%*

*Notes: All income and GDP totals are in 2024 dollars. *County tax estimates based on state-level sales and property tax data from the U.S. Census Bureau that is allocated to counties. **Reference source is U.S. Bureau of Economic Analysis, 2017-22. GDP is the compound annual growth rate in real dollars.*

County tax gains

Under the minimum scenario, Carter County will have $1.0 million in sales and property tax gains over the 10 years. Shannon County would see $0.7 million more in tax collections. Under the maximum scenario, tax collections increase to $1.6 million for Carter County and $1.1 million for Shannon County. Tax estimates are based on U.S. Census Bureau state-level data that are allocated by the economic model to counties using a variety of factors, so figures should be considered a broad estimate.

Labor income gains

Labor income gains over the 10 years include all employee compensation and proprietor income. Income gains are estimated at $24 million in Carter County and $13 million in Shannon County, under the minimum broadband adoption scenario. In the maximum scenario, labor income gains totaled $35 million for Carter and $22.5 million for Shannon.

Gross domestic product gains

Gross domestic product (GDP) is a key indicator showing the total economic gains a community is expected to see from fixed broadband adoption. The minimum scenario estimates GDP gains of $33 and $19.5 million over 10 years for Carter and Shannon counties, respectively. Under the maximum scenario, GDP increases by $49.5 million for Carter County and $33 million for Shannon County.

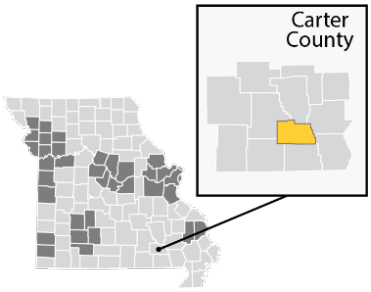
The annual average GDP growth rate puts these gains in context. In the minimum scenario, the annual GDP growth rate is expected to be between 1.0% and 2.0% higher than 2022 GDP levels. For the maximum scenario, the growth rates increase from 1.7% to 3.1% of 2022 GDP levels.

Annual GDP increases are especially significant over time. For example, Carter County experienced an annual GDP increase of 0.1% from 2017 to 2022. Even under the minimum scenario, the expected annual GDP gains of 2.0% would greatly accelerate economic growth. Shannon County had a higher annual GDP growth rate of 1.3% over the 2017-22 period but would gain 1.0 percentage points of additional growth under the minimum scenario.

Individual County Summaries

The following pages provide a two-page summary of each county to include the two fixed broadband adoption scenarios, direct model inputs by category, and the economic benefits by year for the study period.

Carter County Broadband Expansion Economic Benefit Analysis



Carter County is in the southeastern Ozarks region of Missouri. It has an extremely low percentage of locations (15.6%) with fixed broadband service. Carter County's 2022 population totaled 5,268, ranking it 107th in Missouri for population.

Two 10-year expansion scenarios estimate the benefits to Carter County if it increased broadband adoption by 10 (minimum) and 30 (maximum) percentage points. Exhibit C1 shows the number and percent of households assumed to have fixed broadband by year 10. Exhibit C2 shows the total benefit model inputs for each scenario.

Exhibit C1. 10-Year Fixed Broadband Household Adoption Scenarios

Characteristic	Base Value	Minimum Scenario	Maximum Scenario
Households without Fixed Broadband Service	1,625	1,432	1,047
Households with Fixed Broadband Service	300	493	878
Percent of Households with Fixed Broadband Service	15.6%	25.6%	45.6%

Source: FCC 2024 serviceable location data used as proxy for household base adoption levels.

Exhibit C2. 10-Year Economic Benefit Direct Model Inputs

Basic Assumptions	Minimum Scenario	Maximum Scenario
Percent of Households that Adopted Broadband by Year 10	25.6%	45.6%
Broadband Installation Investment to Serve Remaining Households	$24,955,069	$24,955,069
Telemedicine Benefits		
Patient Savings from Reduced Use of Emergency Departments	$860,469	$2,581,407
Patient Savings from Initial Health Consultation via Internet	$346,286	$1,038,858
Patient Transportation Savings due to Telemedicine	$22,920	$68,760
Missed Work Income Savings to Patient	$21,701	$65,104
Education Productivity Benefits		
K12 Teacher Productivity Savings	$548,875	$548,875
Income and Employment Benefits		
Household Income Increases	$222,339	$1,336,108
Farm Income Changes	$34,343	$103,028
Annual Average Direct Employment Increases by Year 10	45	90

Notes: See appendix section for additional methodology details. Dollar values represent 10-year benefit in nominal figures.

Carter County 10-Year Broadband Expansion Benefit Results

Benefits arise from both fixed broadband infrastructure construction and broadband adoption. Construction investment benefits start in year one and household adoption benefits begin in year two. The temporary construction activity, and associated jobs, conclude in year five. In each scenario, new jobs, labor income and GDP include the total impact of direct inputs (from Exhibit C2) and indirect purchases, such as new local spending in the county spurred by those inputs.

Minimum Scenario: 10 Percentage Point Gain in Fixed Broadband Adoption over 10 Years

In the minimum scenario, the annual average increase of 67 jobs is realized in year 10. On average, annual employment is 2.3% higher than 2022 county employment. Annually, this scenario adds 2.7% and 2.0% to county labor income and GDP, respectively, on average compared with 2022 levels.

Exhibit C3. Minimum Scenario – Total Economic Benefits by Year

Characteristic	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8	Year 9	Year 10	10-Year Total*	Avg. Annual Change**
New Annual Average Employment	12	58	80	90	99	38	45	52	60	67	**67**	**2.3%**
New Labor Income *(in millions)*	$0.6	$2.6	$3.6	$3.9	$4.3	$1.3	$1.5	$1.7	$2.0	$2.2	**$23.7**	**2.7%**
New GDP *(in millions)*	$0.8	$3.5	$4.8	$5.3	$5.8	$1.9	$2.2	$2.6	$2.9	$3.3	**$32.9**	**2.0%**

*Notes: All income and GDP figures in 2024 dollars. *Total employment is for year 10 as jobs are not cumulative, and other figures are cumulative totals. **Average annual change compared to 2022 county employment, income and GDP totals.*

Maximum Scenario: 30 Percentage Point Gain in Fixed Broadband Adoption over 10 Years

In the maximum scenario, the annual average increase of 136 jobs is seen in year 10. On average, annual employment is 3.6% higher than 2022 county employment. This scenario adds an annual average of 4.0% and 3.1% to labor income and GDP, respectively, compared with 2022 levels.

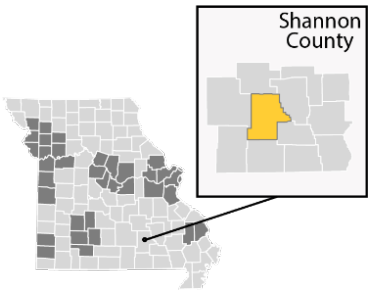
Exhibit C4. Maximum Scenario – Total Economic Benefits by Year

Characteristic	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8	Year 9	Year 10	10-Year Total*	Avg. Annual Change**
New Annual Average Employment	12	66	95	113	130	76	91	106	121	136	**136**	**3.6%**
New Labor Income *(in millions)*	$0.6	$2.9	$4.1	$4.7	$5.3	$2.5	$3.0	$3.5	$4.0	$4.5	**$35.1**	**4.0%**
New GDP *(in millions)*	$0.8	$3.9	$5.5	$6.4	$7.3	$3.7	$4.4	$5.1	$5.9	$6.6	**$49.5**	**3.1%**

*Notes: All income and GDP figures in 2024 dollars. *Total employment is for year 10 as jobs are not cumulative, and other figures are cumulative totals. **Average annual change compared to 2022 county employment, income and GDP totals.*

Shannon County Broadband Expansion Economic Benefit Analysis

Shannon County is in the southeastern Ozarks region of Missouri. Just over 58% of county locations have fixed broadband service. Shannon County's 2022 population totaled 7,193 people, ranking it 101st in Missouri for population.



Two 10-year expansion scenarios estimate the benefits to Shannon County if it increased broadband adoption by 10 (minimum) and 30 (maximum) percentage points. Exhibit S1 shows the number and percent of households assumed to have broadband by year 10. Exhibit S2 shows the total benefit model inputs for each scenario.

Exhibit S1. 10-Year Fixed Broadband Household Adoption Scenarios

Characteristic	Base Value	Minimum Scenario	Maximum Scenario
Households without Fixed Broadband Service	1,145	870	319
Households with Fixed Broadband Service	1,608	1,883	2,434
Percent of Households with Fixed Broadband Service	58.4%	68.4%	88.4%

Source: FCC 2024 serviceable location data used as proxy for household base adoption levels.

Exhibit S2. 10-Year Economic Benefit Direct Model Inputs

Basic Assumptions	Minimum Scenario	Maximum Scenario
Percent of Households that Adopted Broadband by Year 10	68.4%	88.4%
Broadband Installation Investment to Serve Remaining Households	$22,981,391	$22,981,391
Telemedicine Benefits		
Patient Savings from Reduced Use of Emergency Departments	$1,149,445	$3,448,335
Patient Savings from Initial Health Consultation via Internet	$495,234	$1,485,702
Patient Transportation Savings due to Telemedicine	$30,617	$91,851
Missed Work Income Savings to Patient	$26,566	$79,698
Education Productivity Benefits		
K12 Teacher Productivity Savings	$385,894	$385,894
Income and Employment Benefits		
Household Income Increases	$325,135	$1,953,840
Farm Income Changes	$60,531	$181,594
Annual Average Direct Employment Increases by Year 10	55	110

Notes: See appendix section for additional methodology details. Dollar values represent 10-year benefit in nominal figures.

Shannon County 10-Year Broadband Expansion Benefit Results

Benefits arise from both fixed broadband infrastructure construction and broadband adoption. Construction investment benefits start in year one and household adoption benefits begin in year two. Temporary construction activity, and associated jobs, conclude in year five. In each scenario, new jobs, labor income and GDP include the total impact of direct inputs (from Exhibit S2) and indirect purchases, such as new local spending in the county spurred by those inputs.

Minimum Scenario: 10 Percentage Point Gain in Fixed Broadband Adoption over 10 Years

In the minimum scenario, the annual average increase of 68 jobs is realized in year 10. On average, annual employment is 2.1% higher than 2022 county employment. This scenario annually adds 1.3% and 1.0%, respectively, on average to county labor income and GDP compared with 2022 levels.

Exhibit S3. Minimum Scenario – Total Economic Benefits by Year

Characteristic	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8	Year 9	Year 10	10-Year Total*	Avg. Annual Change**
New Annual Average Employment	16	72	99	109	119	38	46	53	60	68	**68**	**2.1%**
New Labor Income *(in millions)*	$0.2	$1.0	$1.4	$1.6	$1.9	$1.0	$1.2	$1.4	$1.6	$1.8	**$13.2**	**1.3%**
New GDP *(in millions)*	$0.3	$1.5	$2.2	$2.5	$2.9	$1.5	$1.7	$2.0	$2.3	$2.6	**$19.5**	**1.0%**

*Notes: All income and GDP figures in 2024 dollars. *Total employment is for year 10 as jobs are not cumulative, and other figures are cumulative totals. **Average annual change compared to 2022 county employment, income and GDP totals.*

Maximum Scenario: 30 Percentage Point Gain in Fixed Broadband Adoption over 10 Years

In the maximum scenario, the annual average increase of 137 jobs is seen in year 10. On average, annual employment is 3.2% higher than 2022 county employment. Annually, this scenario adds 2.2% and 1.7%, respectively, on average to county labor income and GDP compared with 2022 levels.

Exhibit S4. Maximum Scenario – Total Economic Benefits by Year

Characteristic	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8	Year 9	Year 10	10-Year Total*	Avg. Annual Change**
New Annual Average Employment	16	80	114	133	151	77	92	107	122	137	**137**	**3.2%**
New Labor Income *(in millions)*	$0.2	$1.2	$1.8	$2.3	$2.7	$2.1	$2.5	$2.9	$3.3	$3.7	**$22.5**	**2.2%**
New GDP *(in millions)*	$0.3	$1.8	$2.8	$3.4	$4.1	$2.9	$3.5	$4.1	$4.6	$5.2	**$32.8**	**1.7%**

*Notes: All income and GDP figures in 2024 dollars. *Total employment is for year 10 as jobs are not cumulative, and other figures are cumulative totals. **Average annual change compared to 2022 county employment, income and GDP totals.*

Conclusion

The COVID-19 pandemic made the need for broadband expansion more apparent and urgent as residents shifted to remote work, learning, shopping and healthcare. Federal and state funding for broadband expansion and adoption followed the pandemic with hopes of closing the gap between communities that benefit from broadband and those that feel left behind. Given these changes, estimating future broadband benefits is a challenge. However, causal research provides a reasonable approach to understanding broadband expansion's economic benefits.

In this study, broadband expansion's economic gains resulted from the temporary boost in broadband infrastructure spending within the community and the longer-term economic impacts resulting from higher broadband adoption levels among area households. Adoption benefits stemmed from more telemedicine services, elevated education productivity, greater household and farm incomes and employment growth.

This analysis found that large increases in broadband adoption can spur significant economic gains over time, especially for counties with lower base levels of broadband adoption. Modest 10-year adoption gains of 10 percentage points for the two counties increased annual average GDP between 1.0% and 2.0% above 2022 levels. When adoption gains reached 30 percentage points, average annual GDP growth was 1.7% and 3.1% higher than base 2022 levels.

Annual employment increases were also significant in both scenarios. In the minimum broadband adoption scenario, Shannon and Carter counties had annual job increases averaging 2.1% and 2.3%, respectively, of their 2022 employment levels. With broadband adoption gains of 30 percentage points, annual employment increases averaged 3.2% to 3.6% above 2022 levels for the two counties.

This study provides a practical method for analyzing broadband expansion's economic benefits to a community. It assumes that gains are driven primarily by a population that adopts and uses the technology once it is accessible. Investing in broadband benefits a community, but access alone will not spur long-term economic gains. Building out broadband to communities represents a first step. However, arguably more important are successful efforts to increase adoption and digital literacy skills needed to harness these economic benefits.

Appendix: Methodology

A 2018 Purdue University study informs the methodological approach used in this analysis, while several causal research papers underpin the assumptions for economic benefit inputs.[20] Economic modeling assumptions are divided into investment needs and household broadband adoption gains followed by assumptions covering the long-term benefits of telemedicine, education productivity, income and employment spurred by broadband adoption.

Investment and Adoption Assumptions

Broadband investment needs

Broadband investments represent a direct cost to internet service providers (ISP) for materials and labor. These ISP investments create community-level economic benefits as workers are paid and supplies are purchased. During the investment period, temporary construction activities add new income to the county through local spending, which in turn impacts indirect benefits as some of that spending circulates throughout the local economy. Therefore, the first part of this analysis requires estimating broadband investment needs for each county.

In 2024, a Finley USA engineering study provided cost estimates to deploy buried fiber to locations in Carter and Shannon counties where there was a gap in access to 100/20 broadband services. Exhibit A shows fixed broadband costs provided by the study. Broadband installation occurs over five years, so expected inflation costs were included in the model inputs. Exhibit D provides the cumulative broadband investment year timing assumptions.

Exhibit A. Fixed Broadband Investment Estimates

Fixed Broadband Investment Needs	Carter	Shannon
Underground Fiber Deployment	$23,693,633	$21,819,721

Source: Finley USA, 2024 engineering study. Figures do not include inflation expectations.

Household broadband adoption rate increases and timing

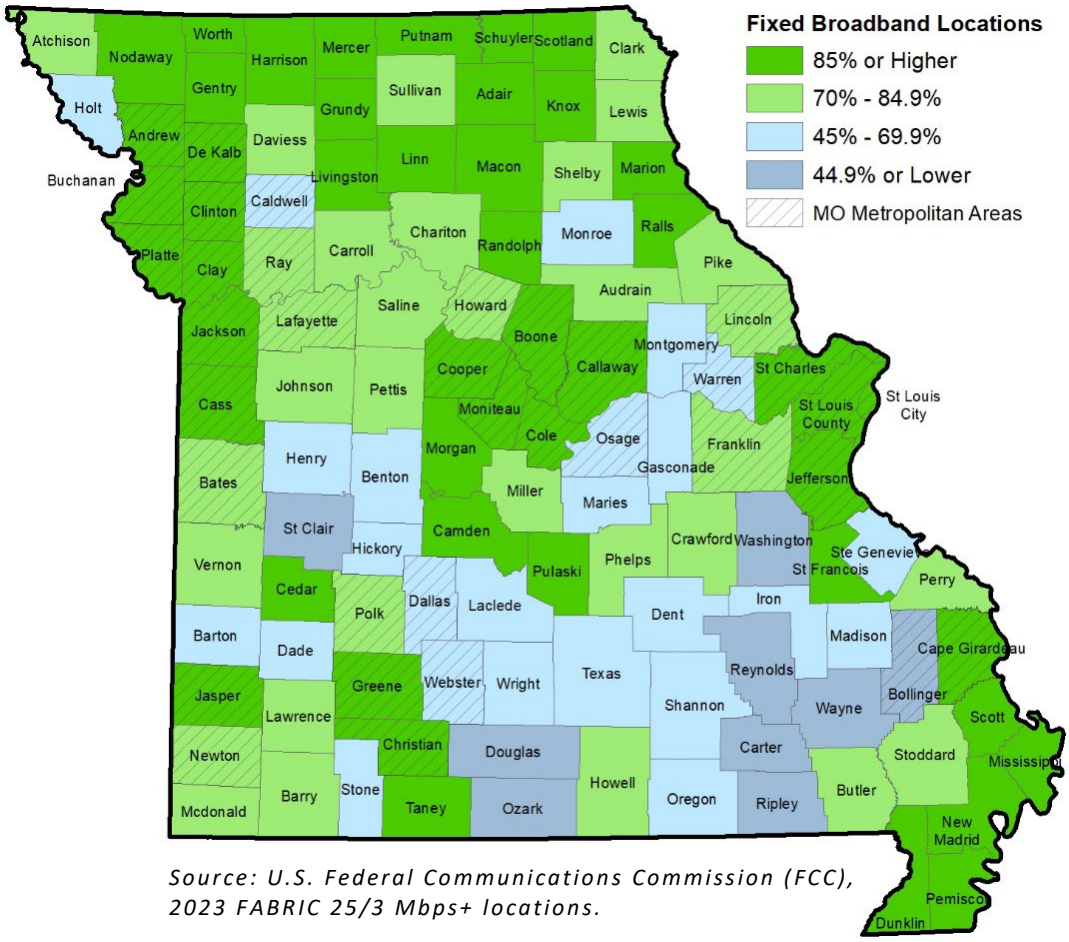
Household broadband adoption is the key causal factor in realizing the economic benefits of broadband investments. Although broadband services must be available first, if households do not purchase these services, the community will see limited economic benefits.

The U.S. Census Bureau provides fixed broadband household adoption estimates, but these figures represent a five-year period (2018-22), which is less ideal given the renewed interest in internet access during and after the COVID-19 pandemic. More recent FCC broadband data is now available and, with quality improvements made in the past two years, it represents a better source for determining a base level of broadband access. While broadband access is not the same as internet adoption—adoption levels are typically lower than access levels—the FCC data can serve as a

reasonable starting point to analyze potential economic gains. The increase in adoption levels, from any baseline, is what generates the community benefits highlighted in this study.

Exhibit B shows the percentage of serviceable county locations that have at least 25/3 Mbps speed. While current internet usage often requires broadband speeds greater than 100 Mbps, even the lower levels are sufficient for communities to see economic gains.

Exhibit B. Percent of Locations with Fixed Broadband Access



Source: U.S. Federal Communications Commission (FCC), 2023 FABRIC 25/3 Mbps+ locations.

This FCC data is for 2023; however, estimates for Carter and Shannon counties have been updated to March 2024 based on information from the Missouri Office of Broadband Development. Broadband access levels in Missouri counties range from 15.6% in Carter County to 99% in six counties. The median 2023 access level for Missouri counties was 81.6%.

Discussions with area ISPs, other subject-matter experts and a Pew Research Center survey that tracks U.S. broadband adoption growth trends informed the scenarios for assumed gains in broadband adoption rates. The Pew survey broke down responses by urban, suburban and rural

communities. Over a five-year period ending in February 2023, internet usage levels increased by 5% in urban areas, 7% in suburban areas and 15% in rural areas.

These increases reflect that urban and suburban areas, which typically have higher adoption levels than rural communities, are slowing in relative gains as more remote populations catch up with broadband infrastructure. The pandemic has accelerated broadband demand, so these adoption increases are likely on the lower end of future growth trends.

This analysis assumes two broadband household adoption level increases:

- **Minimum scenario:** A gain of 10 percentage points over a 10-year period in household adoption from the 2024 base level.
- **Maximum scenario:** A gain of 30 percentage points over a 10-year period in household adoption from the 2024 base level.

The 2018-22 U.S. Census adoption estimates will differ from FCC 2024 access levels, but the analysis is driven by the absolute increase in new households adopting broadband (10 or 30 percentage point gains).

Exhibit D indicates the assumed timing of broadband investments and broadband adoption gains. As broadband investments occur, households are expected to rapidly increase adoption during the first four years to equal 90% of total gains. The remaining 10% of gains occur in years five to 10.

Exhibit D. Broadband Investment and Household Adoption Gains over 10 Years

Characteristic *Year*	**Year 1** *2024*	**Year 2** *2025*	**Year 3** *2026*	**Year 4** *2027*	**Year 5** *2028*	**Year 6** *2029*	**Year 7** *2030*	**Year 8** *2031*	**Year 9** *2032*	**Year 10** *2033*
Broadband investment	5%	25%	50%	75%	100%	100%	100%	100%	100%	**100%**
Minimum Scenario - Household Broadband Percentage Point Adoption Increases above Base Adoption Rate										
Household adoption gains	0%	3%	6%	9%	9%	9%	10%	10%	10%	**10.0%**
Maximum Scenario - Household Broadband Percentage Point Adoption Increases above Base Adoption Rate										
Household adoption gains	0%	9%	18%	27%	28%	28%	29%	29%	30%	**30.0%**

Broadband Benefit Assumptions

Broadband investment and household adoption timing inform the speed at which these technologies benefit communities economically. However, the economic gains come from different components that, when combined, form the basis for describing the potential benefits over time to a community.

Telemedicine

Telemedicine benefits were informed primarily by research from Whitacre (2011)[3], Gordon et al. (2017)[4], and Nord et al. (2019).[5] While healthcare providers benefit, Whitacre's research notes there are questions about where the gains would accrue. This study focuses on the telemedicine benefits to patients, which alone are significant.

This analysis used four subcategories of telemedicine benefits:

- **Patient savings from reduced use of emergency departments:** Patients with broadband access to telemedicine are assumed to have fewer emergency room (ER) visits per year. Nord et al. show that the average ER visit costs $928, while a telehealth consultation averages $45, resulting in net savings of $883 per patient. Center for Disease Control (CDC) data from 2017 indicates that were 43 ER visits per 100 people that year.[21] Missouri Department of Health and Senior Services data from 2015 indicated 39 ER visits per 100 people.[22] This analysis uses the 2017 CDC figures and assumes that of the 43% of the population in new households with broadband service, half receive savings from avoiding one ER visit during the year.
- **Patient savings from initial health consultation via internet:** Like ER savings, patients with access to telemedicine are assumed to make fewer in-person doctor visits. Estimated net savings are based on Nord et al., showing average costs of urgent care ($131) and physician office ($108) visits, compared to $45 for telehealth consultations. It is assumed that one urgent care and two physician office visits are replaced with initial telehealth consultations, saving $211 a year per new household with broadband service.
- **Patient transportation savings due to telemedicine:** The reduction in ER visits also saves transportation costs for patients traveling to the nearest hospital. Travel savings from avoided urgent care and physician office visits are included, but distance data is limited. Transportation savings are derived from the reduced ER visits per new household with broadband services, multiplied by the 2021 IRS rate of 56 cents per mile and average roundtrip miles to a hospital for rural (21) and urban (9) travelers, based on a Pew study.[23] If a county does not have a hospital, the roundtrip miles are doubled to assume travel to an adjoining county for services.
- **Missed work income savings to patient:** The income lost from missed work due to travel and time spent at a hospital visit is calculated as an additional patient benefit. Lost time is estimated as the average roundtrip time to a hospital for rural (0.57 hours) and urban (0.35 hours) patients, plus an hour visit for healthcare services, from the Pew study. If a county does not have a hospital, the roundtrip times are doubled to assume travel to an adjoining county for services. The lost work time is multiplied by the county's median hourly earnings for visits saved by new households with broadband service.

Education Productivity

Kindergarten to 12th grade (K-12) teacher productivity gains were estimated using research from Smith et al. (2008).[8] This research included a teacher survey where 20% of respondents indicated that online resources saved them up to one hour per week, with an additional 20% indicating they saved up to two hours per week. This time savings works out to an average of 0.6 hours saved per week due to online resources. Time savings scales up with broadband investment timing, as it is assumed that public schools would have these services as soon as available. The scaled-up time savings are then multiplied by the total costs of K-12 teacher salaries in the county based on data from the Missouri Department of Elementary and Secondary Education.[24] These productivity

benefits will modestly accrue to the school district, which can save money over time by reducing labor needs through increased productivity.

Income

Household incomes are expected to rise in homes that adopt broadband. Research from Whitacre et al. (2014)[10] estimates that for nonmetro counties, the increase in household income is 1.3% over 10 years for counties with higher levels of adoption (60% or more) compared to counties with moderate levels (40%-60%). These findings underpin the income growth assumption in this analysis, with the consideration that economic benefits do not scale uniformly across all geographies, as influences like proximity to metros and labor supply can impact income gains (Kim & Orazem (2016),[13] Kolko (2012)[15]). Whitacre et al. notes that various factors can drive income gains, including increased worker productivity.

The median household income (MHHI) rate of increase is adjusted by the final level of broadband adoption at the end of 10 years:

- MHHI is assumed to increase by 1.3% over 10 years if a county significantly gains in broadband adoption levels by 20 percentage points or more.
- MHHI is assumed to increase by 0.65%, or half of 1.3%, over 10 years if broadband adoption increases are less than 20 percentage points over 10 years.

Median household income growth was applied to the number of new households with broadband service each year. Income growth is cumulative, so a household adopting broadband in year two will accumulate more income over the 10 years than a household gaining broadband service in year four.

Farm income can also be expected to increase in certain situations, and as a result, it was analyzed separately from household income. Two studies point to gains in crop farming from expanded broadband access, but gains to livestock production are less clear (Kandilov et al. (2011),[11] LoPiccalo (2020)[12]). LoPiccalo's 2020 crop yield research is used as the basis for assuming farm income growth.

This analysis assumes that for every 1% increase in new households adopting broadband, a 0.1% increase in crop sales can be expected due to advances in precision agriculture and crop marketing. Crop sales base data comes from the U.S. Department of Agriculture.

Employment

Employment from new and expanding firms is expected to rise as a county increases household broadband adoption. A study shows that employment growth was 3.4% less over 10 years for nonmetro counties with household adoption rates below 40% compared to counties with higher adoption levels (Whitacre et al. (2014)[10]). The study did not find a meaningful relationship between jobs and broadband adoption in metro counties. This suggest that metro counties, typically with higher adoption levels, have already seen the gains of broadband expansion or that those gains are too intertwined with other factors to distinguish a causal relationship. This analysis uses the 2014 study findings as the foundation for employment growth assumptions. Based on other research

findings (Kolko (2012),[15] Mack & Faggian (2013)[18]), it is assumed that direct employment increases are concentrated in knowledge-intensive industries, such as professional and business services.

It is assumed that over 10 years, knowledge-intensive employment will increase by 3.4% if there is a significant expansion of broadband adoption from the base county level. However, that rate of increase is adjusted based on a couple of underlying factors:

- Employment increases by 3.4% over 10 years if a county significantly gains in broadband adoption levels by 15 percentage points or more and the county is below a base adoption rate of 60%. If a county's base adoption rate is 60% or higher, the employment growth rate is half, or 1.7%, over 10 years under the assumption that much of the economic gains from broadband have already been realized.
- Employment increases by 1.7% over 10 years if broadband adoption gains are less than 15 percentage points over 10 years and the county is below a base adoption rate of 60%. If a county base adoption rate is 60% or higher the employment growth rate is half, or 0.85%, over 10 years assuming that much of the economic gains from broadband have already occurred.

In addition to the direct economic benefits from broadband expansion detailed in this section, there will be spillover effects from the new investments, savings, income and jobs that provide further gains. An economic model is used to estimate these additional spending impacts within each county.

Economic Model

An economic input-output model is used to understand the total benefits derived from broadband adoption. Without an economic model, only direct spending or savings activities could be described, missing important beneficial impacts. Economic models consider typical spending patterns, such as the types of goods or services purchased locally, to follow the flow of income that stays within a county and spurs additional gains in income, employment, taxes and GDP.

IMPLAN, provided by the IMPLAN Group LLC, is a common economic input-output model and is used in this study. Key outputs from IMPLAN analysis include:

- **Employment:** This describes the annual average full- or part-time jobs in a county. The jobs can be held by county residents or workers commuting into the area for employment.
- **County taxes:** These are estimates of county sales and property taxes, based on U.S. Census state-level data allocated to counties using various factors. Due to the tax allocation process, IMPLAN tax figures should be considered broad estimates that may not be suitable for fiscal cost-benefit analysis without further refinement.
- **Labor income:** This includes wages and benefits, such as healthcare and retirement, along with the income to sole proprietors.
- **Gross Domestic Product (GDP) or value added**: GDP represents the value of all final goods and services produced in the county. It is also equal to total sales minus the input cost of those goods and services, called value added, which leaves money to pay for labor income, rents, interests and taxes.

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