

Economic Benefits of Expanding Broadband in Missouri **Atchison, Gentry and Worth Counties**



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Executive Summary

Gauging precisely how broadband impacts the economy — in terms of jobs, gross domestic product and other economic measures — is difficult because broadband technology's benefits intertwine with benefits that stem from computing advances and improved digital literacy. Other gains made possible by broadband, such as quality-of-life improvements, are easy to recognize but harder to quantify. Finally, broadband installation and adoption occur over a long period, so the economic benefits take time to unfold.

Despite these measurement challenges, recent research provides a practical approach to 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 generate construction-related economic activity for several years.
- **Telemedicine:** Virtual health care saves households money by reducing visits to the emergency room and doctor's office. It also reduces lost 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 that can raise household and farm incomes.
- **Employment:** Community job growth, especially in knowledge-intensive service industries, leads to entrepreneurial, investment and productivity gains.

Although necessary, broadband access 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 use drives long-term economic gains.**

About this study

This study estimated the 10-year economic benefits that would result from expanding fixed broadband adoption in three Missouri counties that vary in their existing adoption levels and population size: Atchison, Gentry and Worth. Fixed broadband includes fiberoptic, cable or DSL (digital subscriber line) technologies considered more reliable than 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 three counties. In the maximum scenario, household fixed broadband adoption increases by 20 percentage points.

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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, all counties see substantial employment growth in the 10-year period. Exhibit 1 shows these county's job gains by year 10 when assuming the minimum adoption scenario: Atchison (35), Gentry (89) and Worth (22). Job gains double in the maximum scenario.
- For context, Exhibit 1 shows annual average number of new jobs per year as a percent of 2019 employment and compares these rates to county job growth trends from 2014 to 2019. The minimum scenario shows annual job growth between 1.6% and 2.4% of 2019 employment for the three counties. Under the maximum scenario, the growth increases to roughly 3% or more per year. These gains substantially benefit all three counties, which experienced annual job declines from 2014 to 2019.
- Labor income would also increase as broadband use expands; see Exhibit 1. From \$4 million in total labor gains for Worth County in the minimum scenario to \$38 million for Gentry County in the maximum scenario, these income 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 projected that GDP would increase significantly under both minimum and maximum scenarios; see Exhibit 1. For example, Worth County gains \$6 million in total GDP over 10 years in the minimum scenario and

How Significant is GDP Growth?

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

For the three counties, the minimum growth scenario shows annual, inflation-adjusted GDP would increase by less than 2%.

Those gains, which may seem modest, are significant because they would allow the three counties to grow their economies more than they have in recent years.

For example, Atchison County had a 0.3% annual GDP growth rate from 2014 to 2019. The minimum scenario provides an annual boost of 1.4% in new GDP over 10 years. For context, Missouri's annual GDP growth rate from 2014 to 2019 averaged 1%.

Adding 1.4% to Atchison County's annual GDP over ten years, all else equal, would make the county's economy

12% larger than in 2019.

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\$9.7 million in the maximum scenario. The more populated Atchison and Gentry counties have greater GDP increases ranging from \$23 million to \$54 million, depending on the scenario.

- With modest 10 percentage point broadband adoption gains, all counties would increase their annual GDP by 1.3% to 1.6% relative to their 2019 GDP levels.
- Annual GDP growth would total between 2.1% and 2.6% assuming 20 percentage point broadband adoption gains in these counties.

Exhibit 1 shows how the three 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

	Atchison	Gentry	Worth
Minimum Scenario - 10 Percentage Point Increase in Household Fixed Broadband Adoption			
10-Year Total Economic Benefits of Broadband Expansion			
Employment Gain in Year 10	35	89	22
Total Labor Income (<i>in Millions</i>)	\$15.1	\$21.8	\$4.1
Total Gross Domestic Product (<i>in Millions</i>)	\$23.2	\$31.0	\$6.0
Average Annual Gains of Broadband Expansion Compared to 2019 Figures and Prior 5-Year Trends			
Annual Avg. Employment as % of 2019 Emp.	2.2%	1.6%	2.4%
<i>For Reference: Annual Employment % Change, 2014-19*</i>	-0.7%	-0.4%	-1.9%
Annual Avg. GDP as % of 2019 GDP	1.4%	1.3%	1.6%
<i>For Reference: Annual GDP % Change, 2014-19*</i>	0.3%	-3.2%	-3.8%
Maximum Scenario - 20 Percentage Point Increase in Household Fixed Broadband Adoption			
10-Year Total Economic Benefits of Broadband Expansion			
Employment Gain in Year 10	72	178	43
Total Labor Income (<i>in Millions</i>)	\$23.4	\$37.7	\$6.7
Total Gross Domestic Product (<i>in Millions</i>)	\$36.1	\$54.1	\$9.7
Average Annual Gains of Broadband Expansion Compared to 2019 Figures and Prior 5-Year Trends			
Annual Avg. Employment as % of 2019 Emp.	3.0%	2.9%	3.6%
<i>For Reference: Annual Employment % Change, 2014-19*</i>	-0.7%	-0.4%	-1.9%
Annual Avg. GDP as % of 2019 GDP	2.1%	2.3%	2.6%
<i>For Reference: Annual GDP % Change, 2014-19*</i>	0.3%	-3.2%	-3.8%

Notes: Reference source is U.S. Bureau of Economic Analysis, 2014-19. Average annual employment and GDP are divided by 2019 county figures to show the percentage of that figure to compare against 2014-2019 growth trends. 2014-2019 annual GDP % change is the compound annual growth rate in real dollars. 2020 data excluded to avoid COVID-19 economic influences. Income and GDP figures reported in 2022 dollars.

Economic Benefits of Broadband Expansion

This analysis will document the economic benefits arising from expanded broadband availability and the ensuing adoption. We begin by defining important terms in the context of 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 reliable.

Moderate-to-high speed “broadband services” is defined by the Federal Communications Commission (FCC) as broadband speed of at least 25 Mbps (transfer of “megabits per second”) of download speed and at least 3 Mbps of upload speed, which is often referred to as 25/3. The 25/3 speed is currently assumed to be sufficient for communities to benefit economically. However, what counts as “sufficient” will change as applications and technologies used by households demand more information and faster broadband service, so this assumption must be revisited periodically.

“Broadband availability” refers the presence of broadband infrastructure so that a household or business can request and receive that service. The FCC provides information on broadband availability, but the quality of those data has been criticized for overstating coverage and speed.¹ Due to FCC data issues, we use U.S. Census data to estimate households in a county needing broadband infrastructure.

“Broadband adoption” refers to the number of households in a county that subscribe to fixed broadband services. This figure comes from the U.S. Census Bureau’s American Community Survey (ACS) 5-Year estimates.² 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.

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. Causal research findings, however, statistically isolate those relationships, to suggest cause-and-effect. These studies are particularly useful in an economic benefit analysis.

Telemedicine

Telemedicine creates a range of benefits to health care providers and the patients they serve. Health care providers benefit from rural hospital cost savings due to outsourcing services and increased lab and pharmacy work that can be performed locally.³ Telemedicine allows patients to reduce travel

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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.^{4,5}

Telemedicine gains to patients, enabled by broadband adoption, are easy to understand from a cost perspective. However, the benefits to health care 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 has disadvantaged students, especially those from lower-income families, perhaps diminishing their lifetime of earnings.⁶ While broadband service is a basic requirement for remote learning, many rural school districts in 2020 struggled to help students that lacked home broadband access.⁷ COVID-19 has created a large experiment on the benefits and costs of remote learning that is still in progress. Prior to the pandemic, research on causal educational benefits from broadband expansion largely focused on cost savings to schools to provide education or in teacher's time to find information.⁸

Research has also demonstrated that having broadband access to the learning resources positively correlates with better school outcomes for students.⁹ But quantifying the benefits in a causal manner can prove difficult. However, new information surrounding student learning during the COVID-19 pandemic, and increased interest in broadband access, may result in new causal research into educational benefits in the years ahead.

Household Income

The potential to raise incomes with broadband adoption makes intuitive sense as people can bolster their pay with greater access to online educational resources, productivity tools, and the ability to find more job opportunities. Given that it is so strongly linked with other factors such as educational and skill attainment and job selection, isolating income gains from broadband adoption can prove challenging.

One often-cited study estimated household income gains from increased broadband adoption that can be interpreted as causal.¹⁰ 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 ten 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 that estimating separate gains from these factors

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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 remote work, that 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 the real-time information on weather, pricing, and management practices.¹¹ 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 smart phones, so many of these benefits are already integrated into the farm economy.

However, a more recent study of farming gains confirmed the on-going benefit of broadband to crop production.¹² 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 county. Increased broadband adoption, however, creates lasting employment gains to 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.¹³ Another study found that the number of knowledge-intensive professional and business service firms grew as the number of broadband providers increased.¹⁴ Similar findings from 2012 research confirmed that benefits of broadband expansion can be seen in service industries that rely most heavily on information technology.¹⁵ The research indicated that even though broadband expansion is associated with employment growth, it does not increase average pay. One possible explanation is that the draw of employment opportunity increased the population, and therefore the labor supply, which suppressed wage increases.

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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.¹⁶ 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.¹⁷

Broadband productivity benefits in knowledge-intensive industries have also been documented, along with a dilemma for rural areas with less educated or skilled workers.¹⁸ A 2013 study found that broadband produces positive productivity impacts when used by a highly-educated or skilled workforce. Rises in productivity also impacts 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 was influenced by factors such as distance to metropolitan areas and educational attainment.¹⁹ 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, TN highlights a number of important benefits found in the metro community over ten years.²⁰ 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 the 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 the COVID-19 pandemic. 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 the COVID-19 pandemic illustrate how quickly technologies, like

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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. But 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

Exhibit 4 provides baseline 2019 characteristics and model inputs for the three counties in this study. While 2020 baseline data is available, the economic effects of the pandemic make it a problematic year to compare with this study's results.

With populations under 7,000, all three counties are small by comparison to other Missouri counties - the median Missouri county population is 18,302. Gentry and Worth have similar household fixed broadband adoption levels as 48.6% and 46.9% respectively, according to 2015-19 U.S. Census data. Atchison County households have a higher adoption level of 62.8%. The minimum scenarios assume a household fixed broadband adoption gain of 10 percentage points over ten years. The maximum scenarios assume an adoption gain of 20 percentage points over ten years.

Exhibit 4. 2019 County Characteristics and 10-Year Model Inputs

	Atchison	Gentry	Worth
2019 County Characteristics			
Population	5,143	6,571	2,013
Employment	2,728	4,107	985
Labor Income (<i>in Millions</i>)	\$91.2	\$135.9	\$21.7
GDP (<i>in Millions</i>)	\$189	\$264	\$42
Households	2,562	2,555	859
Household Broadband Adoption	62.8%	48.6%	46.9%
Minimum Scenario - 10 Percentage Point Increase in Household Fixed Broadband Adoption			
10-Year Direct Model Inputs			
10-Year Broadband Adoption Gain (<i>in pp</i>)	10.0%	10.0%	10.0%
Broadband Investment (<i>in Millions</i>)	\$24.4	\$13.2	\$7.1
Total Direct Income Gains (<i>in Millions</i>)	\$14.2	\$5.6	\$2.1
Direct Employment Gain by Year 10	23	70	17
Maximum Scenario - 20 Percentage Point Increase in Household Fixed Broadband Adoption			
10-Year Direct Model Inputs			
10-Year Broadband Adoption Gain (<i>in pp</i>)	20.0%	20.0%	20.0%
Broadband Investment (<i>in Millions</i>)	\$24.4	\$13.2	\$7.1
Total Direct Income Gains (<i>in Millions</i>)	\$28.6	\$11.4	\$4.3
Direct Employment Gain by Year 10	46	140	33

Notes: Input dollar values represent 10-year total benefit in nominal figures.

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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 generate further economic benefits.

Broadband investment costs are customized to each county based on a \$30,000 cost per mile to install buried fiber optic cable and rural area household densities. Buried fiber optic cable is the most weather-proof option for broadband delivery and typical range in costs from \$25,000 to \$35,000 per mile so an average of \$30,000 was used in this study. Rural area household densities were calculated using U.S. Census data and resulted in increased investment costs in less densely populated rural areas.

Direct income gains are derived from the telemedicine, education productivity, household and farm income benefits. The number of new households adopting fixed broadband generate these benefits. Income gains will therefore be greater in counties where more households adopt fixed broadband.

Direct employment gains represent an annual employment increase that scales up over ten years for minimum (1.7%) and maximum (3.4%) gains from the base year depending on the scenario. The employment gains, however, are sensitive to the base household broadband adoption level. Atchison County, with a base household adoption level above 60%, is assumed to see smaller direct employment gains as a percent of total employment than Gentry and Worth counties as it is assumed some job gains are already integrated into the economy of higher-adopting counties.

The appendix provides additional details on how the investment cost and direct gain assumptions were developed.

Economic Benefits Summary

Four measures show the total gains to each county in: employment, county taxes, labor income, and gross domestic product (see Exhibit 5). The average annual gain in jobs, income, and gross domestic product (GDP) is compared to 2019 figures for context. The annual average increase in GDP is also compared to the 2014 to 2019 annual average growth rate.

Employment gains

Under the minimum scenario, by the tenth year employment increases by 35, 89 and 22 jobs in Atchison, Gentry and Worth counties, respectively. The annual average increase in jobs during the ten years represent a 2.2%, 1.6% and 2.4% gain in employment over 2019 levels in Atchison, Gentry and Worth counties, respectively. While the job increases may seem modest, these gains would represent a positive trend for the counties given that, between 2014 to 2019, they experienced employment declines.

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Employment gains are more significant in the maximum scenario. Jobs increase in the tenth year by 72, 178 and 43, in Atchison, Gentry and Worth counties, respectively. In Atchison and Gentry counties these gains represent an annual average increase of 3.0% and 2.9%, respectively, from 2019 employment levels. Worth County annual average jobs gains represent a 3.6% increase from 2019 job levels.

Exhibit 5. 10-Year Total Economic Benefits Summary by County

	Atchison	Gentry	Worth
Minimum Scenario - 10 Percentage Point Increase in Household Broadband Adoption			
10-Year Total Economic Benefits of Broadband Expansion			
Employment Gain in Year 10	35	89	22
Total County Taxes <i>(in Millions) *</i>	\$1.4	\$1.3	\$0.4
Total Labor Income <i>(in Millions)</i>	\$15.1	\$21.8	\$4.1
Total Gross Domestic Product <i>(in Millions)</i>	\$23.2	\$31.0	\$6.0
Average Annual Gains of Broadband Expansion Compared to 2019 Figures and Prior 5-Year Trends			
Annual Avg. Employment as % of 2019 Emp.	2.2%	1.6%	2.4%
Annual Avg. Labor Income as % of 2019 Income	1.8%	1.8%	2.1%
Annual Avg. GDP as % of 2019 GDP	1.4%	1.3%	1.6%
<i>For Reference: Annual GDP % Change, 2014-2019**</i>	0.3%	-3.2%	-3.8%
Maximum Scenario - 20 Percentage Point Increase in Household Broadband Adoption			
10-Year Total Economic Benefits of Broadband Expansion			
Employment Gain in Year 10	72	178	43
Total County Taxes <i>(in Millions) *</i>	\$2.1	\$2.2	\$0.6
Total Labor Income <i>(in Millions)</i>	\$23.4	\$37.7	\$6.7
Total Gross Domestic Product <i>(in Millions)</i>	\$36.1	\$54.1	\$9.7
Average Annual Gains of Broadband Expansion Compared to 2019 Figures and Prior 5-Year Trends			
Annual Avg. Employment as % of 2019 Emp.	3.0%	2.9%	3.6%
Annual Avg. Labor Income as % of 2019 Income	2.9%	3.1%	3.4%
Annual Avg. GDP as % of 2019 GDP	2.1%	2.3%	2.6%
<i>For Reference: Annual GDP % Change, 2014-2019**</i>	0.3%	-3.2%	-3.8%

*Notes: All income and GDP totals are in 2021 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, 2014-2019. GDP is compound annual growth rate in real dollars.*

County tax gains

The model estimates that county-level sales and property tax gains, under the minimum scenario, provides Worth County with an additional \$0.4 million in tax collections over the ten years. Gentry County would see \$1.3 million more in tax collections while Atchison's gain is estimated at \$1.4 million. Under the maximum scenario, tax collections increase to \$0.6 million for Worth, \$2.2 million for Gentry, and \$2.1 million for Atchison. Tax figures are based on U.S. Census Bureau state-level data that is allocated by the economic model to counties using a variety of factors, so should be considered a broad estimate.

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Labor income gains

Labor income gains over the ten years includes all employee compensation and proprietor income. Income gains are estimated to be approximately \$15 million in Atchison and nearly \$22 million in Gentry, under the minimum broadband adoption scenario. Worth's income gain is \$4 million, but it is a much smaller economy than the other two counties. For Atchison and Gentry, the annual increase in labor income was about 1.8% of their 2019 levels. Worth's average labor income increase was 2.1% higher than 2019 levels. In the maximum scenario, labor income gains totaled \$23 million for Atchison, \$38 million for Gentry, and \$6.7 million for Worth over the ten-year period. Annual income increases represented gains between 2.9% and 3.4% of 2019 county levels.

Gross domestic product gains

Gross domestic product (GDP) is a key indicator used to capture the total economic gains a community is expected to see from fixed broadband adoption. The minimum scenario shows expected GDP gains of \$23 and \$31 million over ten years, for Atchison and Gentry counties, respectively. Smaller Worth County gains \$6 million in GDP in this scenario.

Under the maximum scenario, total GDP increases by \$36 to \$54 million, for Atchison and Gentry counties, respectively. Worth County gains nearly \$10 million in new GDP over the ten years.

The annual average GDP growth rate puts the GDP gains in context. In the minimum scenario the annual average GDP growth rate is expected to be between 1.3% and 1.6% higher than 2019 GDP levels. For the maximum scenario, the growth rates increase from 2.1% to 2.6% of 2019 GDP levels.

Annual increases to GDP growth are especially significant over time. For example, Gentry and Worth counties have seen GDP decline annually over the 2014 to 2019 time-period. Under the maximum scenarios the expected 2.3% to 2.6% annual increases in GDP, for Gentry and Worth counties respectively, would offset much of these declines, all else equal. For Atchison County, with a 0.3% annual average GDP growth rate from 2014 to 2019, the expected annual GDP gains of 2.1% would greatly accelerate economic growth.

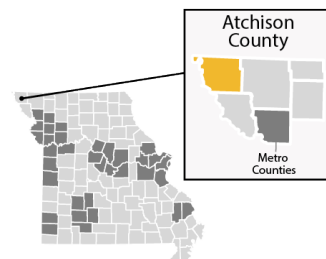
Individual County Summaries

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

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Atchison County, Missouri, Broadband Expansion Economic Benefit Analysis

Atchison County borders Nebraska and Iowa in the northwest corner of Missouri. It has a relatively higher percent of households with fixed broadband service (62.8%) compared with the Missouri county median value (49.7%). Atchison County's 2019 population totaled 5,143, ranking it 108th in Missouri for population size.



Two 10-year expansion scenarios estimate the benefits to Atchison County if it increased household broadband adoption by 10 (minimum) and 20 (maximum) percentage points. Exhibit A1 shows the number and percent of households assumed to have fixed broadband by year ten. Exhibit A2 shows the total benefit model inputs for each scenario.

Exhibit A1. 10-Year Fixed Broadband Household Adoption Scenarios

Characteristic	Base Value	Minimum Scenario	Maximum Scenario
Households without Fixed Broadband Service	953	697	441
Households with Fixed Broadband Service	1,609	1,865	2,121
Percent of Households with Fixed Broadband Service	62.8%	72.8%	82.8%

Sources: Demographics from U.S. Census Bureau, ACS, 2019 5-Year summary data.

Exhibit A2. 10-Year Economic Benefit Direct Model Inputs

Basic Assumptions	Minimum Scenario	Maximum Scenario
Percent of Households that Adopted Broadband by Year 10	72.8%	82.8%
Broadband Installation Investment to Serve Remaining Households	\$24,406,615	\$24,406,615
Telemedicine Benefits		
Patient Savings from Reduced Use of Emergency Departments	\$878,365	\$1,756,731
Patient Savings from Initial Health Consultation via Internet	\$482,512	\$965,023
Patient Transportation Savings due to Telemedicine	\$11,698	\$23,397
Missed Work Income Savings to Patient	\$10,708	\$21,417
Education Productivity Benefits		
K12 Teacher Productivity Savings	\$552,736	\$552,736
Income and Employment Benefits		
Household Income Increases	\$359,356	\$1,439,650
Farm Income Changes	\$11,924,508	\$23,849,016
Annual Average Direct Employment Increases by Year 10	23	46

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

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Atchison County 10-Year Broadband Expansion Benefit Results

Benefits arise from both fixed broadband infrastructure construction and household broadband adoption. In year two, the construction investments and household adoption expansion benefits begin. The temporary construction activity, and associated jobs, concludes in year five. In each scenario, new jobs, labor income and GDP include the total impact of direct inputs (from Exhibit A2) 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 35 jobs is realized in year 10. On average, annual employment is 2.2% higher than 2019 county employment. Annually, this scenario adds 1.8% and 1.4%, respectively, to county labor income and GDP on average compared with 2019 levels.

Exhibit A3. 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	N/A	93	98	103	107	22	26	29	32	35	35	2.2%
New Labor Income (in Millions)	N/A	\$1.9	\$2.1	\$2.3	\$2.5	\$0.9	\$1.1	\$1.2	\$1.4	\$1.5	\$15.1	1.8%
New GDP (in Millions)	N/A	\$2.8	\$3.2	\$3.6	\$3.8	\$1.5	\$1.8	\$2.0	\$2.2	\$2.4	\$23.2	1.4%

Notes: All income and GDP figures in 2022 dollars. *Total employment is for year 10 as jobs are not cumulative, and other figures are cumulative totals. **Average annual change compared to 2019 county employment, income and GDP totals.

Maximum Scenario: 20 Percentage Point Gain in Fixed Broadband Adoption over 10 Years

In the maximum scenario, the annual average increase of 72 jobs is seen in year 10. On average, annual employment is 3.0% higher than 2019 county employment. This scenario adds an annual average of 2.9% and 2.1%, respectively, to labor income and GDP compared with 2019 levels.

Exhibit A4. Maximum Scenario – Total Economic Benefits by Year

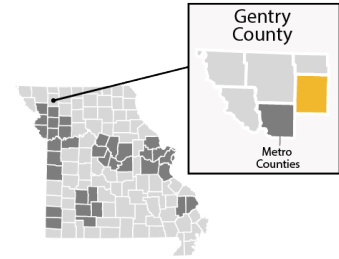
Characteristic	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8	Year 9	Year 10	10-Year Total*	Avg. Annual Change**
New Annual Average Employment	N/A	98	108	119	126	44	51	58	65	72	72	3.0%
New Labor Income (in Millions)	N/A	\$2.1	\$2.5	\$3.0	\$3.3	\$1.9	\$2.2	\$2.5	\$2.8	\$3.1	\$23.4	2.9%
New GDP (in Millions)	N/A	\$3.2	\$3.9	\$4.6	\$5.0	\$3.0	\$3.5	\$3.9	\$4.3	\$4.8	\$36.1	2.1%

Notes: All income and GDP figures in 2022 dollars. *Total employment is for year 10 as jobs are not cumulative, and other figures are cumulative totals. **Average annual change compared to 2019 county employment, income and GDP totals.

ECONOMIC BENEFITS OF EXPANDING BROADBAND

Gentry County, Missouri, Broadband Expansion Economic Benefit Analysis

Located in northwest Missouri, Gentry County has 48.6% of households with fixed broadband services, just below the Missouri county median value (49.7%). Gentry County's 2019 population totaled 6,571 people, ranking it 103rd in Missouri for population size.



Two 10-year expansion scenarios estimate the benefits to Gentry County if it increased household broadband adoption by 10 (minimum) and 20 (maximum) percentage points. Exhibit G1 shows the number and percent of households assumed to have broadband by year ten. Exhibit G2 shows the total benefit model inputs for each scenario.

Exhibit G1. 10-Year Fixed Broadband Household Adoption Scenarios

Characteristic	Base Value	Minimum Scenario	Maximum Scenario
Households without Fixed Broadband Service	1,314	1,059	803
Households with Fixed Broadband Service	1,241	1,497	1,752
Percent of Households with Fixed Broadband Service	48.6%	58.6%	68.6%

Sources: Demographics from U.S. Census Bureau, ACS, 2019 5-Year summary data.

Exhibit G2. 10-Year Economic Benefit Direct Model Inputs

Basic Assumptions	Minimum Scenario	Maximum Scenario
Percent of Households that Adopted Broadband by Year 10	58.6%	68.6%
Broadband Installation Investment to Serve Remaining Households	\$13,168,148	\$13,168,148
Telemedicine Benefits		
Patient Savings from Reduced Use of Emergency Departments	\$1,094,957	\$2,189,914
Patient Savings from Initial Health Consultation via Internet	\$481,193	\$962,386
Patient Transportation Savings due to Telemedicine	\$14,583	\$29,166
Missed Work Income Savings to Patient	\$11,592	\$23,183
Education Productivity Benefits		
K12 Teacher Productivity Savings	\$583,285	\$583,285
Income and Employment Benefits		
Household Income Increases	\$340,925	\$1,365,811
Farm Income Changes	\$3,121,057	\$6,242,115
Annual Average Direct Employment Increases by Year 10	70	140

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

ECONOMIC BENEFITS OF EXPANDING BROADBAND

Gentry County 10-Year Broadband Expansion Benefit Results

Benefits arise from both fixed broadband infrastructure construction and household broadband adoption. In year two, benefits from construction investments and household adoption expansion begin. Temporary construction activity, and associated jobs, concludes in year five. In each scenario, new jobs, labor income and GDP include the total impact of direct inputs (from Exhibit G2) 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 89 jobs is realized in year 10. On average, annual employment is 1.6% higher than 2019 county employment. This scenario annually adds 1.8% and 1.3%, respectively, on average to county labor income and GDP compared with 2019 levels.

Exhibit G3. 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	N/A	48	59	69	78	50	60	70	79	89	89	1.6%
New Labor Income (in Millions)	N/A	\$1.9	\$2.2	\$2.6	\$2.9	\$1.8	\$2.1	\$2.4	\$2.8	\$3.1	\$21.8	1.8%
New GDP (in Millions)	N/A	\$2.4	\$3.0	\$3.5	\$4.0	\$2.6	\$3.1	\$3.6	\$4.1	\$4.6	\$31.0	1.3%

Notes: All income and GDP figures in 2022 dollars. *Total employment is for year 10 as jobs are not cumulative, and other figures are cumulative totals. **Average annual change compared to 2019 county employment, income and GDP totals.

Maximum Scenario: 20 Percentage Point Gain in Fixed Broadband Adoption over 10 Years

In the maximum scenario, the annual average increase of 178 jobs is seen in year 10. On average, annual employment is 2.9% higher than 2019 county employment. Annually, this scenario adds 3.1% and 2.3%, respectively, on average to county labor income and GDP compared with 2019 levels.

Exhibit G4. Maximum Scenario – Total Economic Benefits by Year

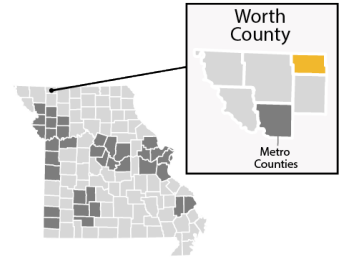
Characteristic	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8	Year 9	Year 10	10-Year Total*	Avg. Annual Change**
New Annual Average Employment	N/A	59	79	100	120	101	120	140	159	178	178	2.9%
New Labor Income (in Millions)	N/A	\$2.2	\$3.0	\$3.7	\$4.4	\$3.5	\$4.2	\$4.9	\$5.6	\$6.2	\$37.7	3.1%
New GDP (in Millions)	N/A	\$2.9	\$4.0	\$5.1	\$6.1	\$5.2	\$6.2	\$7.2	\$8.2	\$9.1	\$54.1	2.3%

Notes: All income and GDP figures in 2022 dollars. *Total employment is for year 10 as jobs are not cumulative, and other figures are cumulative totals. **Average annual change compared to 2019 county employment, income and GDP totals.

ECONOMIC BENEFITS OF EXPANDING BROADBAND

Worth County, Missouri, Broadband Expansion Economic Benefit Analysis

Worth County borders Iowa in the northwest corner of Missouri. Worth County's 46.9% rate of households with fixed broadband service is just below the Missouri county median value (49.7%). The county's 2019 population totaled 2,013, making it the smallest county in Missouri for population size.



Two 10-year expansion scenarios estimate the benefits to Worth County if it increased household broadband adoption by 10 (minimum) and 20 (maximum) percentage points. Exhibit W1 shows the number and percent of households assumed to have fixed broadband by year ten. Exhibit W2 shows the total benefit model inputs for each scenario.

Exhibit W1. 10-Year Fixed Broadband Household Adoption Scenarios

Characteristic	Base Value	Minimum Scenario	Maximum Scenario
Households without Fixed Broadband Service	456	370	284
Households with Fixed Broadband Service	403	489	575
Percent of Households with Fixed Broadband Service	46.9%	56.9%	66.9%

Sources: Demographics from U.S. Census Bureau, ACS, 2019 5-Year summary data.

Exhibit W2. 10-Year Economic Benefit Direct Model Inputs

Basic Assumptions	Minimum Scenario	Maximum Scenario
Percent of Households that Adopted Broadband by Year 10	56.9%	66.9%
Broadband Installation Investment to Serve Remaining Households	\$7,108,528	\$7,108,528
Telemedicine Benefits		
Patient Savings from Reduced Use of Emergency Departments	\$340,151	\$680,301
Patient Savings from Initial Health Consultation via Internet	\$161,779	\$323,558
Patient Transportation Savings due to Telemedicine	\$9,060	\$18,121
Missed Work Income Savings to Patient	\$7,918	\$15,837
Education Productivity Benefits		
K12 Teacher Productivity Savings	\$142,674	\$142,674
Income and Employment Benefits		
Household Income Increases	\$128,507	\$514,824
Farm Income Changes	\$1,317,695	\$2,635,390
Annual Average Direct Employment Increases by Year 10	17	33

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

ECONOMIC BENEFITS OF EXPANDING BROADBAND

Worth County 10-Year Broadband Expansion Benefit Results

Benefits arise from both fixed broadband infrastructure construction and household broadband adoption. In year two, the construction investments and expanded household adoption benefits begin. The temporary construction activity, and associated jobs, concludes in year five. In each scenario, new jobs, labor income and GDP include the total impact of direct inputs (from Exhibit W2) 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 22 jobs is realized in year 10. On average, annual employment is 2.4% higher than 2019 county employment. This scenario adds an annual average of 2.1% and 1.6%, respectively, to county labor income and GDP relative to 2019.

Exhibit W3. 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	N/A	28	30	33	35	12	14	17	19	22	22	2.4%
New Labor Income (in Millions)	N/A	\$0.4	\$0.5	\$0.6	\$0.6	\$0.3	\$0.3	\$0.4	\$0.5	\$0.5	\$4.1	2.1%
New GDP (in Millions)	N/A	\$0.6	\$0.7	\$0.8	\$0.9	\$0.4	\$0.5	\$0.6	\$0.7	\$0.7	\$6.0	1.6%

Notes: All income and GDP figures in 2022 dollars. *Total employment is for year 10 as jobs are not cumulative, and other figures are cumulative totals. **Average annual change compared to 2019 county employment, income and GDP totals.

Maximum Scenario: 20 Percentage Point Gain in Fixed Broadband Adoption over 10 Years

In the maximum scenario, Worth County sees the annual average increase of 43 jobs in year 10. On average, annual employment is 3.6% higher than 2019 county employment. This scenario adds an annual average of 3.4% and 2.6%, respectively, to labor income and GDP relative to 2019.

Exhibit W4. 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	N/A	30	35	40	45	24	29	34	38	43	43	3.6%
New Labor Income (in Millions)	N/A	\$0.5	\$0.6	\$0.7	\$0.8	\$0.6	\$0.7	\$0.8	\$0.9	\$1.0	\$6.7	3.4%
New GDP (in Millions)	N/A	\$0.7	\$0.9	\$1.1	\$1.3	\$0.8	\$1.0	\$1.2	\$1.3	\$1.5	\$9.7	2.6%

Notes: All income and GDP figures in 2022 dollars. *Total employment is for year 10 as jobs are not cumulative, and other figures are cumulative totals. **Average annual change compared to 2019 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 health care. Federal and state efforts have rolled out programs to fund broadband expansion and adoption in 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. It can serve as a foundation for further research.

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 service, 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 three counties increased annual average GDP between 1.3% and 1.6% above 2019 levels. When adoption gains reached 20 percentage points, average annual GDP growth was 2.1% and 2.3% higher than base 2019 levels.

Annual employment increases were also significant in both scenarios. In the minimum broadband adoption scenario, Gentry and Atchison counties had annual job increases averaging 1.3% and 1.4%, respectively, of their 2019 employment levels. Worth County's annual job increases averaged 1.6% above 2019 levels. With broadband adoption gains of 20 percentage points, annual employment increases averaged 2.9% to 3.0% above 2019 levels for the three counties.

This study provides a practical method for analyzing broadband expansion's economic benefits to a community. It assumes that gains are driven primarily from a population that adopts and uses the technology once it is accessible. Investing in broadband clearly benefits a community, but access alone will not spur 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.²¹ Economic modeling assumptions are divided into investment needs and household broadband adoption gains followed by assumptions that cover 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 the Internet Service Provider (ISP) to pay for materials and labor. The ISP investments create community-level economic benefits as workers are paid, supplies purchased, etc. for the duration of the investment. These temporary construction activities add new income to the county through local spending which in turn spurs indirect benefits as some part of that spending circulates throughout the local economy. The first part of this analysis therefore requires the estimation of broadband investment needs for each county.

Exhibit A shows the number of households in each county that had not yet adopted fixed broadband services in the 2015-19 U.S. Census survey period (highlighted in yellow). While this figure is an overestimate of homes that need fixed broadband installation – as some households will choose not to pay for the service even if broadband is available – it is currently the best estimate available of households without fixed broadband in the county. This household figure is multiplied by the average cost per rural household to install fixed broadband to derive a total investment need.

Exhibit A. Households That Have Not Adopted Fix Broadband Services

	Atchison	Gentry	Worth
Household Fixed Broadband Characteristics			
Total Households (HH)	2,562	2,555	859
Households that ADOPTED Fixed Broadband Service	1,609	1,241	403
Households that HAVE NOT ADOPTED Fixed Broadband Service	953	1,314	456

Source: U.S. Census Bureau, ACS, 2019 5-year summary data.

Buried fiber optic cable – a common broadband delivery method in these counties – is the most weather-proof option and typical costs between \$25,000 to \$35,000 per mile to install. Higher per mile costs can occur with rocky soils or mountainous terrain. The installation costs were informed by discussions with area internet service providers (ISPs), nearby [USDA ReConnect 50/50 program investment information](#), and [Missouri legislative testimony](#). Based on these above figures, an average installation cost of \$30,000 per mile was used in this study.

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The \$30,000 cost per mile was divided by the average rural household density (households per square mile) in each county to develop an average costs per household to provide broadband services. Household density estimates use 2010 census figures as the latest block group information.

Exhibit B shows the estimated fixed broadband investment needs by county in nominal dollars. Due to the likely overestimate in households needing broadband access, these investment totals should be considered an upper estimate to providing fixed broadband to all households within the county.

Exhibit B. Fixed Broadband Investment Needs

	Atchison	Gentry	Worth
Household Fixed Broadband Investment Needs			
Households that HAVE NOT ADOPTED Fixed Broadband Service	953	1,314	456
Average Per Mile Cost to Install Buried Fiber Optic Cable	\$30,000	\$30,000	\$30,000
Average Rural Household Density (Households per Square Mile)	1.3	3.3	2.1
Average Cost per Rural Household to Provide ACCESS to Fixed Broadband Service	\$23,000	\$9,000	\$14,000
Total Fixed Broadband Investment Need	\$21,919,000	\$11,826,000	\$6,384,000

Sources: U.S. Census Bureau, ACS 2019 5-year summary data for households without fixed broadband, average costs from ISPs and grant information, and density figures from U.S. Census Bureau 2010 rural block group households per square mile.

Broadband investment was assumed to occur over 6 years in our similar [2021 study](#), based on the FCC's Connect America requirements. Winning bidders had to have 40% of locations served by the end of year three, 20% each subsequent year, and 100% of locations served by the end of year six. This study will assume a faster investment timing due to the new availability of federal broadband funds. Many of these [federal programs](#) indicate that the funding must be spent by the end of 2026, so the implementation timing is accelerated to assume completion over a 5-year period.

Given that the first year in a long-term investment project usually involves upfront planning, often in a centralized headquarters, it was assumed that local construction activity would begin in year two. Exhibit D provides the cumulative broadband investment year timing assumptions.

Household broadband adoption rate increases and timing

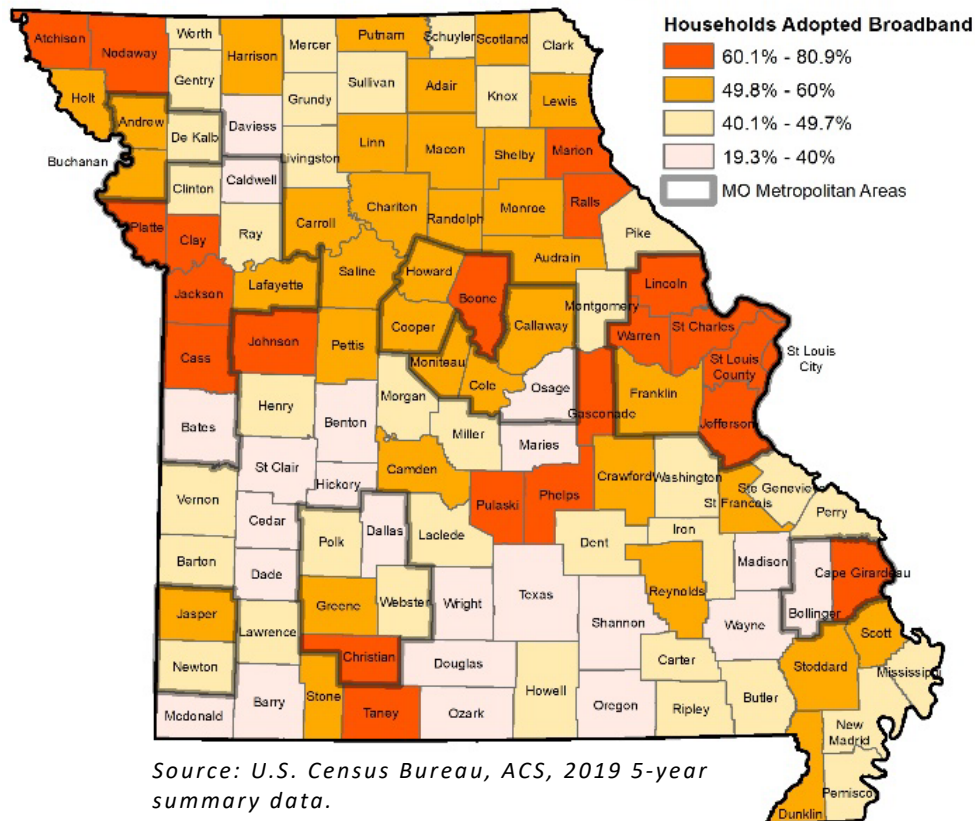
Household broadband adoption is the key causal factor in realizing the economic benefits of broadband investments. While this must follow the availability of broadband services, if households do not purchase those services, then the community will see limited economic benefits.

The U.S. Census Bureau ACS 2019 five-year summary is used to determine baseline county fixed broadband adoption levels – see Exhibit C. Counties in Missouri range from 19% (Bollinger County) to 81% (St. Charles County) in adoption levels. For context, the lowest U.S. county

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adoption level was 10% and the highest level 90% during the same time period. The median Missouri county adoption level was 49.7%.

Exhibit C. Missouri County Household Fixed Broadband Adoption, 2015-2019



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 2021, urban areas adoption levels increased by 5%, suburban by 8%, and rural by 11%.

These increases reflect the reality that urban and suburban areas, typically with 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 ten-year period in household adoption from the 2015-19 base level.

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- **Maximum scenario:** A gain of 20 percentage points over a ten-year period in household adoption from the 2015-19 base level. Gains are capped at an 85% adoption level.

The 2015-19 base adoption estimates may be lower than current levels but the analysis is driven mainly by the absolute increase in new households adopting broadband (10 or 20 percentage point gains) so generally a higher base would not substantially change the economic benefit estimates.

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 are realized in years 5 to 10. Exhibit E summarizes the adoption gains to households over 10 years.

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

Characteristic	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8	Year 9	Year 10
Year	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031
Cumulative broadband investment	0%	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%	3.0%	6.0%	9.0%	9.2%	9.4%	9.6%	9.8%	9.9%	10.0%
Maximum Scenario - Household Broadband Percentage Point Adoption Increases above Base Adoption Rate										
Household adoption gains	0%	6.0%	12.0%	18.0%	18.4%	18.8%	19.2%	19.6%	19.8%	20.0%

Exhibit E. County Broadband Adoption Gains over 10 Years

	Atchison	Gentry	Worth
Household Fixed Broadband Characteristics			
Total Households (HH)	2,562	2,555	859
Minimum Scenario			
Households that ADOPTED Fixed Broadband Service	1,609	1,241	403
Base HH Fixed Broadband Adoption Rate (Start Year)	62.8%	48.6%	46.9%
Households that ADOPTED Fixed Broadband Service After 10 Years	1,865	1,497	489
Final HH Fixed Broadband Adoption Rate (After 10 Years)	72.8%	58.6%	56.9%
Maximum Scenario			
Households that ADOPTED Fixed Broadband Service	1,609	1,241	403
Base HH Fixed Broadband Adoption Rate (Start Year)	62.8%	48.6%	46.9%
Households that ADOPTED Fixed Broadband Service After 10 Years	2,121	1,752	575
Final HH Fixed Broadband Adoption Rate (After 10 Years)	82.8%	68.6%	66.9%

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 health care 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 cost \$928 while a telehealth consultation averages \$45, so the net savings to a patient is \$883. The Center for Disease Control (CDC) 2017 data indicates that there were 43 visits to the ER per 100 people in that year.²² Missouri Department of Health and Senior Services 2015 data indicated 39 ER visits per 100 people.²³ 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 due to avoiding one ER visit during the year.
- *Patient savings from initial health consultation via internet*
Similar to ER savings, patients with access to telemedicine are assumed to make fewer in-person doctor visits. Estimated net savings are also based on Nord et al. that show average costs of urgent care (\$131) and physician office (\$108) visits, compared to the \$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 households with broadband service.
- *Patient transportation savings due to telemedicine*
The reduction in ER visits also saves transportation costs for patients who would travel to the nearest hospital for treatment. There is likely travel savings from urgent care and physician office visits that are avoided but these services are more numerous and distance data is a limiting factor. Transportation savings is derived from the reduced ER visits per new household with broadband services that is 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.²⁴ If a county does not have a hospital, then the roundtrip miles are doubled to assume travel to an adjoining county for services.
- *Missed work income savings to patient*
The income from missed work, due to the 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, from the Pew study, plus an hour visit for

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health care services. If a county does not have a hospital, then 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 a week with an additional 20% indicated they saved up to two hours a week. This time savings works out to an average of 0.6 hours saved a week due to online resources. That 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's salaries in the county based on data from the Missouri Department of Elementary and Secondary Education.²⁵ These productivity benefits will modestly accrue to the school district that can, over time, save money 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 ($\geq 60\%$) compared to counties at moderate levels (40%-60%). These findings underpin the income growth assumption in this analysis with the consideration, from this and other research, that economic benefits do not scale up uniformly across all geographies, as influences like the proximity to metros and labor supply can impact income gains (Kim & Orazem (2016),¹³ Kolko (2012)¹⁵). Whitacre et al. notes that any number of factors can drive income gains, but could include increased worker productivity.

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

- MHHI is assumed to increase by 1.3% over ten 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 ten years if broadband adoption increases are less than 20 percentage points over ten years.

Median household income growth was applied to the number of new households with broadband service each year. This income growth is cumulative, so that a household adopting broadband in year two will accumulate more income over the ten 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 LoPiccolo

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(2020)¹²). LoPiccolo's 2020 research into crop yield gains are 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, presumably 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 ten years, for nonmetro counties with household adoption rates below 40% when 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 suggests 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 ten years knowledge-intensive employment will increase by 3.4%, if there is a significant expansion of broadband adoption from the base county level in 2019. But that rate of increase is adjusted based on a couple of underlying factors:

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

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 and that would miss important beneficial impacts. Economic models consider typical spending patterns, such as what types of goods or services are purchased locally, to follow the flow of income

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that stays within a county and spurs additional gains in income, employment, taxes, and gross domestic product.

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

- **Employment** estimates that describe 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** are an estimate of county sales and property taxes. It is based on U.S. Census state-level data that is allocated to counties using a variety of factors. Due to the tax allocation process, IMPLAN tax figures should be considered a broad estimate that may not be suitable for fiscal cost-benefit analysis without further refinement.
- **Labor Income** describes wages and benefits, such as healthcare and retirement, along with the income to sole proprietors.
- **Gross Domestic Product (GDP) or Value Added.** Gross domestic product 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—that leaves money to pay for labor income, rents, interests and taxes.

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