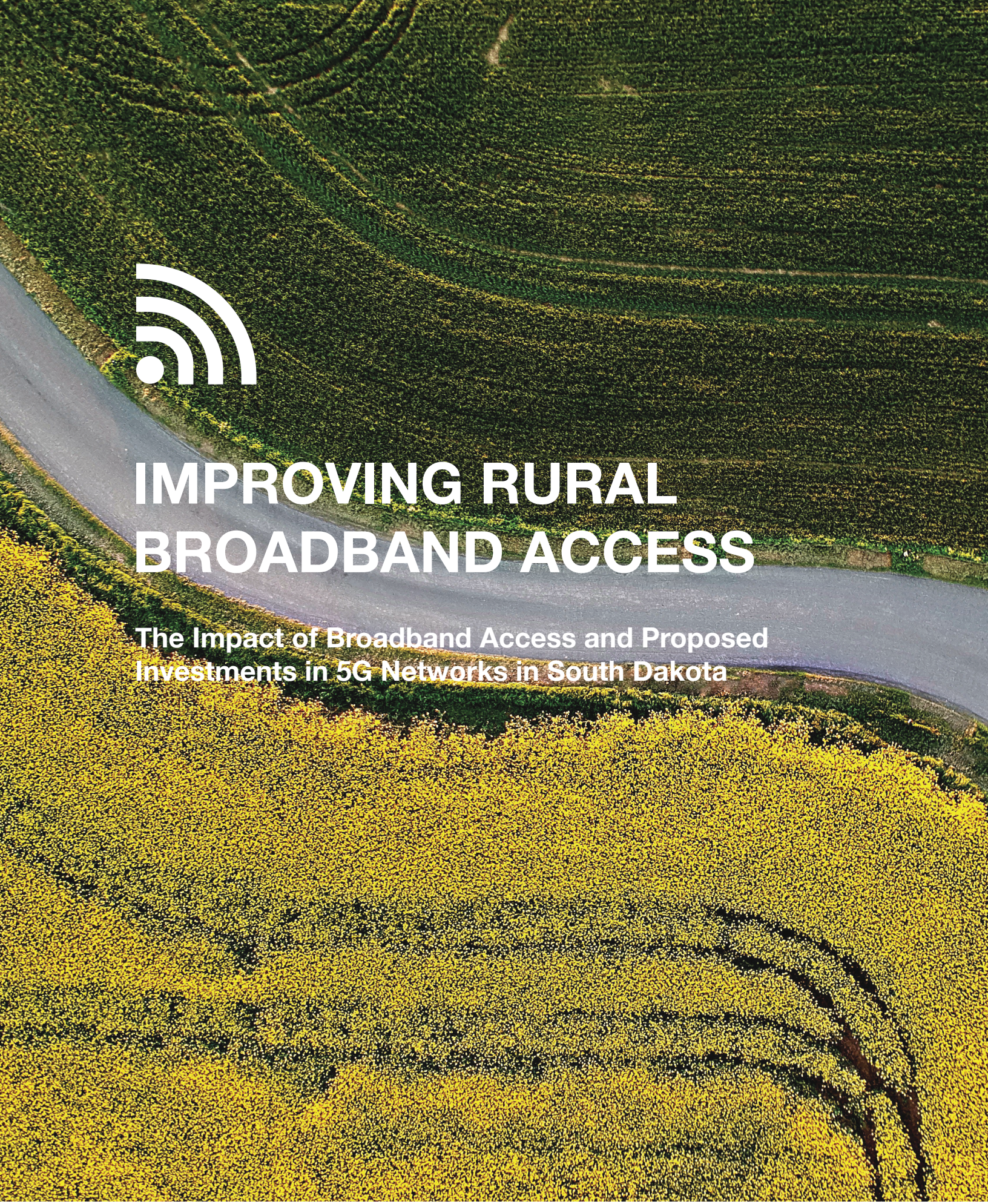

IMPROVING RURAL BROADBAND ACCESS

The Impact of Broadband Access and Proposed Investments in 5G Networks in South Dakota

Old Dominion University | January 2019 | University of South Dakota

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ACKNOWLEDGEMENTS

This report was underwritten by T-Mobile. The views and opinions expressed in this report are those of the authors alone and do not represent the official positions of T-Mobile, Old Dominion University, the University of South Dakota, or the Old Dominion University Research Foundation.

The authors gratefully acknowledge reviewers, colleagues, and the sponsor of this report. Review and support, however, do not imply affiliation or endorsement of the contents and opinions expressed in this report.

The authors also gratefully acknowledge the assistance with data collection, data analytics, and project support provided by Hannah Booth, Amber Hulse, Dominique Johnson, Brianna Monk, Elisha Nez, Steve Parker, Jacob Selgestad, Hannah White, Shania Williams, and Wendi Wilson-John.

EXECUTIVE SUMMARY

The Internet has transformed how Americans learn, interact, and conduct business. As Internet services and applications have risen in importance, so has the ability to access high quality voice and data services. While the United States Congress broadly defined "high quality" telecommunications capability as allowing users to "originate and receive high-quality voice, data, graphics, and video services," the Federal Communications Commission (FCC) established the benchmark as speeds equivalent to 25 Megabits per Second (Mbps) download and 3 Mbps upload for fixed broadband networks.[1] The FCC also recently noted that both fixed and mobile networks are capable of meeting the statutory definition of advanced telecommunications capability, although mobile networks are not yet full substitutes for fixed broadband networks.[2]

Access to faster Internet services is increasingly defined by where Americans live, with rural areas trailing urban areas in broadband access. For rural areas, mobile broadband is likely to be more cost-efficient than fixed broadband because mobile networks do not require the expenditure of capital to install cable or fiber directly to customers.[3] The introduction of fifth-generation mobile networks (5G), which bring improved coverage and speeds comparable to many fixed broadband networks, can reduce the persistent urban-rural digital divide.

The objective of this report is to assess the state of rural mobile broadband and whether the coverage, capacity, and speed of mobile networks influence the quality of life in rural America. To achieve this objective, we examined the state of South Dakota. A majority of South Dakota's population resided

[1] In this report, fixed broadband refers to broadband delivered by fixed wired technologies, including cable modem, DSL, and fiber. This contrasts with mobile broadband which is delivered through mobile networks. *See,* e.g., 2018 Broadband Deployment Report, FCC, February 2, 2018, available at: https://docs.fcc.gov/public/attachments/FCC-18-10A1.pdf. We note that fixed wireless is starting to be used in rural areas for broadband access. While fixed wireless broadband may have some of the same cost efficiencies as mobile wireless broadband, consumer preferences are trending towards mobile usage. Accordingly, our primary research question concerned access to mobile broadband, and mobile broadband is the focus of this report (see Appendix B).

[2] The FCC has declined to set a benchmark for mobile networks noting "...that adoption of a single mobile benchmark is currently unworkable given the inherent variability of actual mobile speeds and our available data." We use the 25 Mbps/3 Mbps standard as the threshold of broadband throughout this report. *See* 2018 Broadband Deployment Report, FCC, February 2, 2018, available at: https://docs.fcc.gov/public/attachments/FCC-18-10A1.pdf.

[3] This is commonly known as the "last mile problem," and refers to the last link in a supply chain network. The last link delivers goods or services to the final customer and is, on average, the most expensive link in the supply chain.

outside the metropolitan areas of Rapid City and Sioux Falls in 2017. The South Dakota economy has also diversified over the last two decades, shifting towards public and private services; services that require consistent access to the Internet. While agriculture has declined in relative importance, it increasingly relies on dependable access to mobile networks. South Dakota also has significant variations in topography, economic opportunities, public and private services, and amenities. Understanding how mobile networks affect and are affected by these variations is one facet of this report.

Over the last two decades, South Dakota has outperformed the United States in terms of average economic growth. In 2017, the finance and insurance, education, health, and public sectors each contributed more value added to the economy of South Dakota than the agricultural sector. The agriculture sector, however, remains the economic foundation of many rural counties in the state. Information is the key to improving productivity; information that, in many cases, is only readily available if one has consistent access to the Internet. Whether one is in financial services, sales, or agriculture, mobile coverage, capacity, and speed are critical elements of business operations.

As an economically vibrant state, South Dakota continues to attract individuals from other states and countries. While South Dakota continues to grow as a whole, these gains, however, have not been equally distributed across the state. A number of rural counties have lost population over the last decade. Rural areas of the state are growing older, on average, especially when compared to the metropolitan area of Sioux Falls. A lack of economic opportunities and amenities has led many to 'vote with their feet' and leave rural areas of the state.

To assess the effect of mobile networks on the quality of life in South Dakota, we conducted face-to-face interviews as well as a web-based survey. We employed a snowball sampling technique whereby key informants from rural communities recruited additional subjects from their personal and professional networks.[4] We started our

[4] Key informants are individuals with intimate knowledge of a community, including community leaders, professionals, and long-time residents. The use of qualitative key informant interviews has a long history in social sciences and is particularly useful for quality of life issues in rural communities.

interviews with key informants in Vermillion and Yankton and then expanded our sample to include respondents from Springfield, Elk Point, Tyndell, Tabor, and Wakonda. We also conducted a series of convenience interviews with students of the University of South Dakota and others in their social networks. Finally, we deployed a web-based survey to supplement the data gathered from face-to-face and telephone interviews.

In our discussions with residents of South Dakota, we found that more populated areas may have mobile coverage, but struggle with congestion, even though the population density is significantly less than many urban areas in the United States. More rural areas appear to suffer from a lack of widespread coverage, network congestion, and slower speeds, as compared to urban areas. We found that many respondents engaged in satisficing[5] behavior, accepting mobile service limitations as a fact of life.

Our interviews with key informants confirmed the presence of an urban-rural divide in mobile coverage, capacity, and speed. This divide not only created problems for everyday discourse, but also inhibited the ability of Emergency Management Services (EMS) to perform routine tasks. Network congestion prevented key informants from communicating with members of EMS during popular events. Medical EMS respondents noted that the lack of consistent, high-quality mobile service constrained their ability to transmit patient information to hospitals. Rural respondents also responded that they incurred greater costs due to gaps in mobile coverage because, as discussed below, compromises like traveling further to find service negatively impacted productivity, for example.[6] These gaps also presented challenges to health and safety, with one respondent noting that they had to drive their car on the rim of a flat tire due to a lack of mobile signal. Finally, our interviews highlighted that coverage was location dependent. In some instances, respondents had coverage in only one corner of their residence or workplace. Mobile coverage at home did not mean that an individual would have mobile coverage at work, school, or while traveling. The lack of ubiquitous mobile coverage meant that respondents had to choose where to have coverage or invest in multiple mobile devices from different providers. While no mobile network is perfect, the perception was that mobile networks in South Dakota provide lesser quality service than in relatively more urban states.

In this context, based upon our review of economic and social conditions in South Dakota, we argue that investments in mobile networks are necessary to sustain economic growth and improve the quality of life of residents. Mobile networks are not only increasingly preferred by customers, these networks are also relatively cost-efficient.[7] Further, while fourth-generation (4G) mobile networks are certainly a step in the right direction, the FCC recently noted that 4G networks cannot fully compete with fixed broadband networks in terms of capacity and speed.

5G networks, on the other hand, can compete with fixed broadband networks and offer multiple channels for different types of mobile traffic. 5G networks present an opportunity for rural America to close the digital divide. The challenge before decision-makers is to foster an environment conducive to the development of 5G networks in rural areas of the United States. As one respondent aptly observed: “If the Taliban can upload videos in Afghanistan, how can I not get Netflix to play in America?... just don’t know. It is 2018…and we are smart people. We should be able to watch a movie without it buffering.”

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[5] “Satisficing” means “to choose or adopt the first satisfactory option that one comes across: the tendency of decision-makers to satisfice rather than look for the optimal solution.” *See* Definition of Satisfice, Dictionary.com, available at: https://www.dictionary.com/browse/satisfice.

[6] The FCC is planning to spend over $6 billion over the next decade and ease regulatory requirements to close the digital divide. *See* Bridging the Digital Divide for All Americans, FCC, https://www.fcc.gov/about-fcc/fcc-initiatives/bridging-digital-divide-all-americans.

[7] The installation cost of fiber to a single home may be between $700 and $1,000, but the cost of a small cell delivering wireless to the same residence would be $100 to $200 a home. *See* The Dawn of 5G: Will Wireless Kill the Broadband Star, Forbes, September 22, 2017, available at: https://www.forbes.com/sites/washingtonbytes/2017/09/22/the-dawn-of-5g-will-wireless-kill-the-broadband-star/#385cf86fd7f2.

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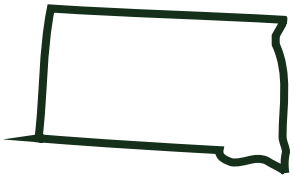


RURAL BROADBAND IN SOUTH DAKOTA

1. Introduction

In this report we examine the role of the Internet and, more specifically, mobile communications in rural and small-town America.[1] We discuss how rural household Internet access – measured by coverage, capacity, and speed – varies across states and specifically within rural areas in the United States. Americans living in rural areas spend a higher share of income for relatively constrained access to the Internet when compared to their urban counterparts, in part, due to the relatively high fixed costs of rural broadband (Carlson & Goss, 2016; Ryan, 2018). Rural households may be limited in their ability to access Internet services, and states with lower broadband penetration cannot expand public services as readily to disadvantaged populations. Improving rural Internet access and, specifically, broadband access, not only improves rural productivity but also access to health services. Lastly, improving rural Internet access spurs rural entrepreneurship and economic development. As the Chairman of the Federal Communications Commission, Ajit Pai, noted in a recent interview,

> “Broadband is a game changer for rural America…I see it is as an echo of the rural electrification efforts we saw in the 1930s, almost 100 years ago.”
>
> **- Ajit Pai** | Chairman, Federal Communications Commission

“Broadband is a game changer for rural America…I see it is as an echo of the rural electrification efforts we saw in the 1930s, almost 100 years ago (M. Reardon, 2018).”

Rural internet access is, on average, lower in the United States due, in part, to lower population density that inhibits telecommunications providers

[1] In 2015, the Federal Communications Commission (FCC) defined fixed broadband as speeds equivalent to 25 Megabits per Second (Mbps) download and 3 Mbps upload. *Inquiry Concerning the Deployment of Advanced Telecommunications Capability to All Americans in a Reasonable and Timely Fashion, and Possible Steps to Accelerate Such Deployment Pursuant to Section 706 of the Telecommunications Act of 1996, as Amended by the Broadband Data Improvement Act,* 2015 Broadband Progress Report and Notice of Inquiry on Immediate Action to Accelerate Deployment, 30 FCC Rcd 1375, 1377 (2015). We refer to Cable, DSL, Fiber, and Satellite as fixed line broadband throughout this report.

from reaping economies of scale. While the absolute cost of fixed broadband may be higher in urban areas (due to higher real estate costs, for example), unit costs are lower as providers are able to spread infrastructure costs across a larger number of customers.

Rural customers are not only separated by distance, but also, in many cases, by variations in topography. In these cases, fixed broadband providers have higher unit costs per customer than mobile broadband providers. Why? Fixed broadband, whether cable, DSL, fixed wireless, or fiber, typically requires the installation of infrastructure to each customer while mobile broadband providers reach multiple customers through each tower. With the advent of 5G networks, mobile coverage, capacity, and speed will rival many fixed broadband networks, albeit at lower unit cost, and consumer preferences are trending towards mobile usage.

Indeed, not only are mobile devices portable, consumption of Internet services is shifting towards mobile services. Simply put, mobile networks will gain in importance relative to fixed networks over the coming decade and are a key element of the FCC's strategy to bridge the urban-rural digital divide. To provide context for our discussion, we focus our analysis on the state of South Dakota and the voices of residents on the coverage, capacity, and speed of mobile networks in the state. South Dakota, even though it has experienced robust economic growth over the previous two decades, has also observed an outmigration of citizens from rural areas. In part, these outflows can be attributed to the lack of economic opportunities and amenities relative to the urban areas of the state. Building a robust economic development strategy will not only entail the continued diversification of the South Dakota economy but also a focus on improving the quality of life and economic opportunities for rural residents; residents that still comprise more than 50 percent of South Dakota's population.

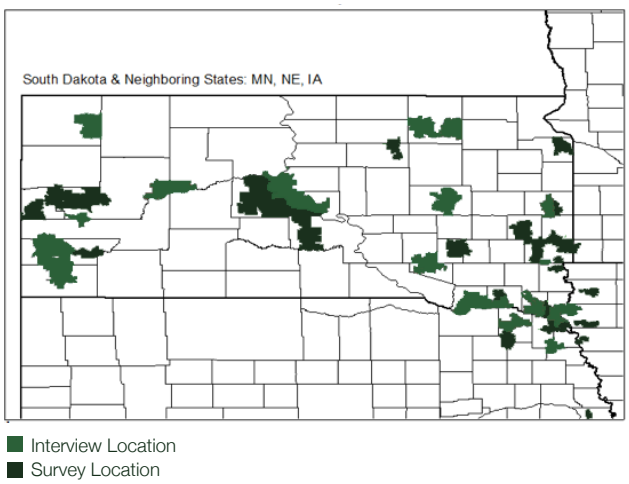
2. Perceptions of Mobile Service in South Dakota

Given the increasing importance of the Internet to daily life and business activities, and that more Americans are using mobile devices to access the Internet daily, the research team visited southeastern South Dakota in September 2018. Using a targeted snowball sampling technique, we gathered qualitative data from urban and rural residents on mobile coverage, capacity, and speed in South Dakota and, where possible, border areas of neighboring states.[2] We also conducted a series of in-depth interviews with key community informants to place the qualitative data in context and to explore the impact of mobile access on public services, to include education and emergency response services.[3] Lastly, we employed a convenience sampling technique to gather additional information about mobile services via a web-based survey for respondents in more remote areas of the state. In total, this effort resulted in 68 in-depth interviews, 29 of which were with key informants. We also obtained 80 useable web-based surveys. Since the web-based survey was anonymous, we cannot rule out that an individual who participated in a face-to-face interview may have also completed a web-based survey. Figure 1 illustrates the interview and survey locations of the study.

[2] Snowball sampling is a non-statistical sampling technique where current study subjects identify and assist in the recruiting of additional research subjects. Subjects recruit new subjects from professional and-or personal networks. The use of snowball or referral sampling is commonly used in sociology and related fields and is valued for its ability to allow researchers to identify informal relationships among study participants. For example, a member of the police department in one location recruits a member of a neighboring police or fire department. This approach reduces the cost of acquiring new subjects as current subjects "introduce" new subjects to the interviewer.

[3] The use of key informants has a long history in the social sciences for collecting qualitative and quantitative data across a variety of social settings. Key informant interviews are qualitative interviews with individuals in a community that, by formal or informal position, understand the community.

Figure 1. Interview and Survey Locations



With the help of University of South Dakota (USD) student interviewers, we asked residents of South Dakota how mobile networks affected their quality of life. We also established primary connections with key informants in Vermillion—the home of USD. For context, the population of Vermillion was approximately 21,033 in 2017 (10,772 residents and 10,261 students at USD). The current interviewees recruited new subjects from their personal and professional networks following the snowball sampling process. Using the contacts in Vermillion as a starting point, the team quickly expanded to the nearby city of Yankton (population approximately 14,454). The research team's sample continued to grow and led to additional interviews in smaller towns and places in southeastern South Dakota, such as Springfield (population 1,950), Elk Point (population 1,828), Tyndell (population 1,049), Tabor (population 413), and Wakonda (population 321).

A general theme of the in-depth interviews was the existence of an urban-rural divide with respect to mobile coverage, capacity, and speed. While this was not entirely surprising, several respondents engaged in satisficing behavior, that is, accepting the best of the available alternatives, even if the alternatives were relatively poor when compared to other areas in the United States. In general, interviewees and survey respondents viewed mobile networks in more populated areas of the state as 'good enough' but simultaneously noted that these areas continued to suffer from issues of coverage, capacity, and speed. Network congestion was a specific concern, especially during relatively large events. A number of respondents and key informants noted that rural mobile networks provided incomplete coverage, insufficient capacity, and often lack adequate speed, especially compared to more urban areas of the state.

Many of the interviewees and respondents opined that location matters. While respondents perceived that urban areas had better mobile coverage, capacity, and speed than rural areas, the idea of location did not just apply to movement through the state but also within cities and, in some locations, within homes and office buildings. Some respondents gave examples of needing to go to certain areas within their home or workplace to have service (e.g., the porch, near the window, not in the basement, or not in areas with a lot of concrete). Other troublesome locations for mobile access included some airports, hospitals, and schools.

While reports indicate that schools and medical facilities appeared to have adequate wired Internet and Wi-Fi access, at least one respondent explained that the same is not true for mobile phone coverage and clarity. Another education key informant speculated that colony schools in some of the Hutterite religious communities had poor connectivity and issues even checking emails. Even on the campus of USD in Vermillion, location matters. One student explained that speed is better at home versus when at school and speed also depends on "congestion." In the dorms of USD, mobile connectivity was comparatively better than the main areas of campus where there were more students. This student reported that the FaceTime connection was always poor on campus.

Another community key informant described potential challenges if needing to call during an emergency situation:

> "…the cell reception and connectivity is what I probably find most challenging and you know, in the moment of an emergency is really what we're going to suffer – being able to make contact with emergency services and have them hear us clearly. If we're not near a landline, I think we're going to struggle to be able to get communication as quick as we need to."

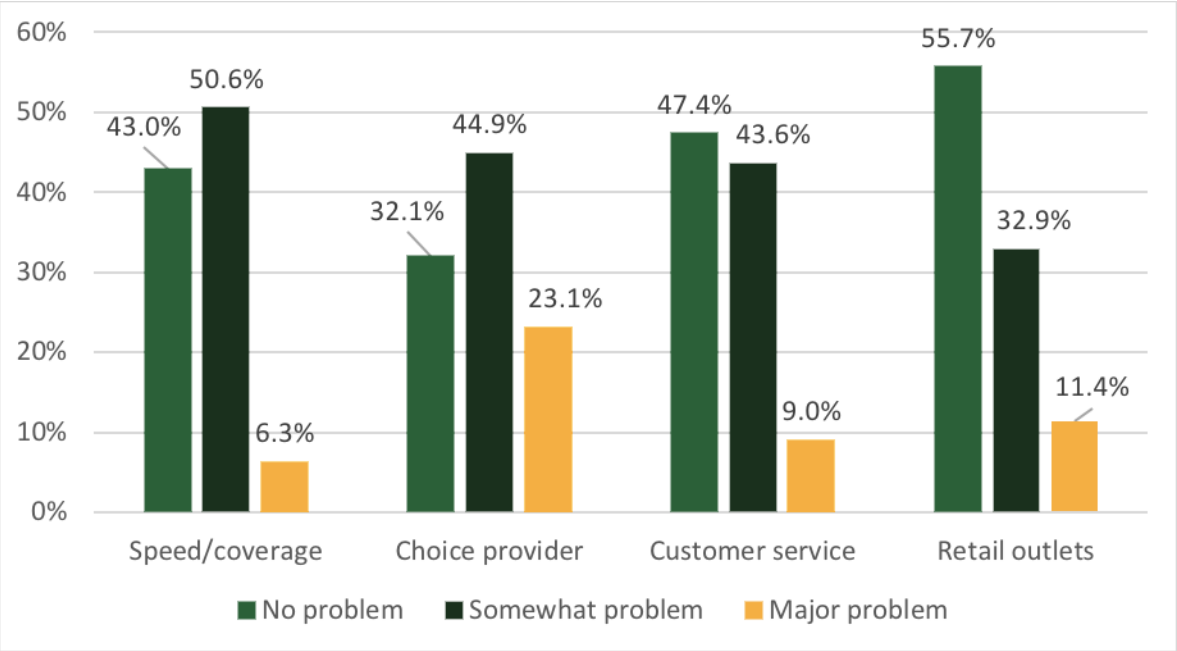
An Emergency Medical Service volunteer discussed the ability to transmit EKG information directly to the hospital, but also noted the service requires consistent mobile coverage: "…if we get down in some of those places [where there is no signal], it's not going to transmit because it relies on that coverage on the cellular providers…"

A community key informant from Verdigre, South Dakota expressed frustration with people not having equal access to connectivity. "The problem is not so much that the service is not here but the service is not provided equally. Nothing makes me more frustrated than looking at a cell phone tower and my phone does not work." Another key informant from a local library in South Dakota discussed how the library now loans out mobile hotspots as the need to connect to the Internet is increasing for citizens. The mobile hotspots allow limited access to the Internet for households that do not have a fixed broadband connection or a mobile data plan. As noted by the key informant, some library patrons, particularly those below the poverty level, cannot afford Internet access. The hotspot fills the gap, assuming the individual is in an area that has enough mobile coverage for the hotspot to work.

Even if access is available, concerns over the cost of data may limit access to the Internet. One respondent indicated that they do not use the Internet because it uses too much mobile data. Yet another respondent indicated that their Wi-Fi was bad at home and they had to use their mobile data if they wanted to access the Internet, and this practice was expensive. In some cases, the prevailing view was one of acceptance. One respondent aptly summarized this attitude by noting that the existing mobile service, even with its limitations, was as good as it was going to get. There was, from this perspective, no benefit in wanting something better because why would you want something you know that you could not have?

In addition to personal interviews, we conducted a web-based survey. The survey results should be considered informative rather than authoritative, but also lend credence to the detailed in-person interviews. Figure 2 illustrates responses regarding limitations of mobile service.

Figure 2. Extent of Problems with Current Smart/Mobile Phone Service



Source: Old Dominion University and University of South Dakota (2018).

Of those surveyed about problems associated with mobile phone service, half (50 percent) reported that quality of service (i.e., speed/coverage/stability) was somewhat of a problem and an additional 6.3 percent reported that is a major problem. A significant majority (68 percent) reported that a limited choice of providers that provided consistent and reliable service was either somewhat of a problem (44.9 percent) or a major problem (23.1 percent). Over half (52.6 percent) felt that customer service/technical support was either somewhat of a problem (43.6 percent) or a major problem (9 percent).

50%

REPORTED THAT QUALITY OF SERVICE WAS SOMEWHAT OF A PROBLEM

Access to retail outlets and cell phone stores was also a common concern with 32.9 percent reporting it to be somewhat of a problem and 11.4 percent reporting it to be a major problem (totaling 44.3 percent). Almost all the respondents identified at least one dimension of concern with regards to mobile phones and nearly half (47.5 percent) reported at least one dimension as a major concern.

Another significant theme that emerged from the interviews was the need for ubiquitous mobile service for personal safety. As one respondent said, "[it is] unsafe to be [in] an area without phone coverage at all and I think that should be handled if someone is going to implement new networks in the area – just to increase the safety of everybody." One respondent was concerned that the route they travel to Wyoming regularly to pick up and drop off their child has spotty coverage and that this would limit their ability to communicate delays or emergencies.

For those who rely on their phone's mapping applications to guide them through unfamiliar areas, when service drops, it can be disconcerting. As one respondent indicated "When I don't have good cell reception, I feel really unsafe because I share my location with all my friends when I am going out and I rely on my maps to get really anywhere outside of Vermillion or Sioux Falls. If I don't have cell service, I don't really know where I am going."

One respondent shared, "I literally have had vehicle breakdowns and issues and walked to the top of the nearest hill to get cell coverage to call for help." Another respondent shared a situation where they were driving with their infant and their animals and got a flat tire on a very hot day. There was no service, so they could not call for assistance and could not change the tire themselves. They ultimately ended up driving on the rim to get help. Another community key informant shared that a member of a search and rescue team lives on a lake nearby and has "zero reception" and even their pager is delayed.

"I think that is a pretty critical area. I don't think that is too much to ask. I don't expect everyone to have 100 percent access all the time. But at least a bar so I can at least make an emergency call."

"[it is] unsafe to be [in] an area without phone coverage at all and I think that should be handled if someone is going to implement new networks in the area – just to increase the safety of everybody."

3. The Urban-Rural Mobile Divide in South Dakota

While urban respondents were generally satisfied with service, they acknowledged capacity constraints, especially during popular events. One respondent shared their experiences while at a fair: "I am out here at the fair and it's really bad service and I can't get on things and it is really killing me…" Vermillion reportedly has good connectivity, but for large events, such as Dakota Days and the South Dakota State University versus USD football games, respondents shared a variety of complaints. During large events, some respondents were unable to access mobile networks and others, who could access mobile networks, found that phone quality was degraded, and mobile data speed was also limited.

To place this congestion into context, the population of the city of Vermillion was 10,772 in 2017 in 4.031 square miles, yielding an estimated population density of 2,623.3 people per square mile. Even if we included the 10,261 students in 2017 at USD, Vermillion's population density would have been approximately 5,217.8 people per square mile. For context, the Upper East Side of New York City had a population of 214,219 in approximately 2 square miles for a population density of 107,750.5 people per square mile (United States Census Bureau, 2018b).

VERMILLION

- Population: 10,772 in 4.031 square miles.
- Estimated Population Density:2,623.3 people per square mile

NYC-UPPER EAST SIDE

- Population: 214,219 in approximately 2 square miles.
- Estimated Population Density: 107,750.5 people per square mile.

Even if the population of Vermillion increased ten-fold, the demand for mobile voice and data would be significantly less than that of most metropolitan areas in the United States.

Rural respondents also noted that service cost of fixed broadband was a significant concern. Even if fiber networks are relatively close, the last mile problem prevents many from accessing these networks.[4] A key informant with an agricultural support business noted that it was cheaper to accept a lower quality mobile data service than to spend between $50,000 and $100,000 to provide fiber access to their building. According to the informant, while there were three fiber optic lines near the building, the nearest node was in a neighboring city. The last mile for the fixed broadband network would entail significant costs that would be borne by the informant.

A number of respondents also emphasized that while there may be multiple mobile providers in a locality, the number of providers does not necessarily equate to the number of high-quality providers. These respondents emphasized that importance of having a good quality mobile experience at home, work, school, while traveling, and other important locations. The challenge for many respondents was that one provider might provide sufficient coverage in one geographical location but poor coverage in other locations. Some respondents were thus faced with an unenviable quandary: choose between poor service at work or home or have multiple mobile devices with different providers, increasing the cost of mobile services. As noted by one respondent when asked about the cost of mobile voice and data, "I think cost for the average person in Vermillion, the average wage earner, is an issue. My wife and I both have smartphones and my mother-in-law has a dumb phone and, with the three phones, it is about $200 month. That is kind of steep if you are making $12 an hour."

In general, rural respondents noted similar concerns regarding access, connectivity, and capacity. A respondent from a more rural area of Vermillion

[4] The last mile problem is that, in general, the last leg of a supply chain is often the least efficient leg. Whether the supply chain pertains to telecommunications or goods, the "last mile" of the supply chain requires delivering information or goods to individual customers. For telecommunications, this requires the installation of cable, fiber, or wire to the residential of business customer, a relatively costlier endeavor when population density is low and-or geographical distances are more significant.

shared the difference just a few miles can make: “My husband and I use a Verizon hotspot. It is awful. A quarter-mile down the road my neighbor doesn’t have any issues with their Verizon hotspot. We always have dropped calls. We can no longer use the Internet on our computer in the house. Can’t do anything on it. If I drive three or four miles, I have four bars. We could get better service at our home, but it would cost us a lot. We have DISH for cable and DISH told us getting service from them would be so expensive.”

“We always have dropped calls. We can no longer use the Internet on our computer in the house. Can’t do anything on it. If I drive three or four miles, I have four bars. We could get better service at our home, but it would cost us a lot.”

A representative from Custer, South Dakota, shared their experiences with mobile connectivity in their part of the state. The city of Custer is about 1,800 people but serves as a tourist community for both Custer State Park and Mt. Rushmore resulting in millions of visitors each year. While the connectivity for western South Dakota has improved over the last 10 years, there reportedly remain issues and pockets where connectivity is problematic. Once leaving Custer and heading north and west, there is a 40-mile stretch to Newcastle, Wyoming with no service. Similarly, there is a 40 to 50 mile stretch with intermittent access on the highway between Newcastle and Sundance, Wyoming. Traveling south from Custer to Edgemont, SD and southwest to Lusk, WY, there is also no coverage, according to key informants.

A community key informant from higher education described some of the challenges for students taking classes from a distance or living in more rural areas given the unique topography:

“I know that nationally many students want to do their coursework on their smartphone. I know that many use their smartphone as a wireless modem to the cellular network and use their PC to do their coursework so they are basically using their phone to use the hotspot…This prehistorically was an inland ocean and we have geographic features called buttes, which are areas that did not sink when the water left the area so they are 100-plus feet tall rocky formations and they interrupt cell phone coverage. With the population so sparsely distributed, people sometimes set up a tent near the butte and do their coursework and typing from there. When wireless started to become available and telephone calls were free, they would go to the top of the butte to make their calls.”

In addition to impacts on work or school, respondents also discussed impacts of poor connectivity on their ability to use their phones for entertainment. A few students and others reported issues with speed and connectivity in terms of being able to watch movies or other streaming content on applications like Netflix. One respondent indicated it would take 30 minutes to load content from Netflix or music streaming sources. One respondent thought that if service was faster then they could probably stream higher quality videos. Another respondent reported needing to use their PC to download audio books because it is too slow to do so on their phone. Another limitation is that some respondents observed that they did not know what was possible due to the limitations of mobile service. As aptly observed by one interviewee regarding mobile service speed, “I might be able to use technologies I didn’t know existed if I had the option.”

For economic development and quality of life, key informants appear to agree that communities need access to broadband that is easy, affordable and readily accessible. When working with potential new businesses, a community leader felt that businesses will often evaluate access to high speed Internet along with other quality of life considerations. Potential new businesses, according to this key informant, want to know about access to Internet in their buildings. After ensuring that Internet access is available, businesses will consider other aspects of quality of life like affordable housing, schools, and healthcare. Potential new businesses and residents will only consider an equal or better transition from their current geographical location, and, if connectivity is perceived as slower or worse than other areas, this would be "substandard" and could slow down growth. Businesses increasingly rely on mobile voice and data to communicate and exchange information with remote employees. Mobile voice and, increasingly, mobile broadband are now critical for these core business functions.

4. The Changing Landscape of Internet Access

Perception is often reality, and mobile coverage, capacity, and speed in South Dakota will likely influence economic and social development in the coming decade. The use of Internet-connected devices is now a feature of everyday life, a rapid change from only three decades ago. In 1984, only 8 percent of households owned a computer, and the Internet was not yet available to retail users. By 2015, the percentage of households with a computer had increased to 78.2 percent. However, the number of Americans using a computer fell slightly to 77.4 percent in 2016 (Ryan, 2018). A 2018 survey by the Pew Research Center echoed these findings, with the percentage of respondents having a desktop or laptop computer in the house falling from 78 percent in 2016 to 73 percent in 2018 (Hitlin, 2018).

IN 2016, AN ESTIMATED 95 % OF AMERICANS OWNED OR USED A CELL PHONE

In 2016, an estimated 95 percent of Americans owned or used a cell phone and 89 percent reported using the Internet (Ryan, 2018). Age, income, and whether an individual lived in a metropolitan area were among the primary determinants of whether a household owned a smartphone. While 92.6 percent of householders 15 to 34 years old reported owning a smartphone in 2016, only 48.5 of householders 65 years or older owned a smartphone. Only 55.4 percent of households earning less than $25,000 owned a smartphone, compared with 92.6 percent of households earning $150,000 or more. Lastly, while 78.2 percent of metropolitan area residents owned a smartphone, only 66.4 percent of individuals residing outside a metropolitan area owned a smartphone (Ryan, 2018; United States Census Bureau, 2018b). The "digital divide" may manifest in multiple dimensions, but, in general, access to smartphones and the Internet are, on average, lower in rural areas.

Why are mobile networks important from the perspective of broadband access? In general, without any form of access to high-quality broadband service, many rural cities and towns are at a competitive disadvantage given the importance of the Internet, and, more specifically, the increasing importance of mobile services. If these rural localities are poorly served by existing fixed and mobile networks, the advent of 5G networks provides a generational opportunity for these communities to leapfrog existing fixed and mobile voice and data technology.

In general, rural areas are more likely to have lower rates of broadband coverage than urban areas, given that the unit costs of broadband investments are negatively correlated with population density. As noted previously, the last mile is the crux of this problem. Fixed broadband typically requires the installation of a line to each customer. If a node or pole is not near the customer's location, the installation costs can increase significantly. Mobile networks, on the other hand, require the installation of towers. Given the greater number of permanent and transient customers served by a tower, the unit costs of mobile networks should be less, on average, than fixed networks in rural areas. We argue that the FCC's efforts to expand broadband access, including, for example, its investment of up to $453 million in annual universal service support for a period of ten years through the FCC's Mobility Fund Phase II is, in part, acknowledgement of the increasing role of mobile broadband in closing the urban-rural digital divide.[5]

To place the challenge in context, we provide estimates of fixed broadband coverage for South Dakota and selected neighboring states in 2017 in Table 1.[6] We also provide New Jersey, which is ranked first in terms of broadband connectivity, as a comparison state. While no estimates are perfect, we argue that any biases should be common among all the states, that is, if the data overestimate coverage, the data should be biased upward for each of the states. Thus, we concentrate less on the absolute magnitude of the characteristics and more on the relative differences between the measures of coverage.

Table 1. Internet Access Characteristics, 2018

	South Dakota	Iowa	North Dakota	Nebraska	New Jersey
Estimated Broadband Coverage	87.1%	87%	93%	84%	99%
Estimated Fiber-Optic Coverage	28.1%	25.1%	41.8%	18.7%	65.4%
Estimated Average Mbps	28.1	28.2	31.7	29.5	56.1
Connectivity Ranking Among States	34	35	17	40	1
Lowest 25/3 Coverage	Dewey County (0%)	Ida County (33.8%)	Golden Valley County (2.4%)	Banner County (0.0%)	Cumberland County (94.4%)
Highest 25/3 Coverage	Harding County (100%)	Winnebago County (98.6%)	Emmons County (100%)	Hamilton County (99.3%)	Several counties at 100%

Source: Internet service providers: availability & coverage. 25 Mbps/3 Mbps coverage is an estimate of the percent of the population that has accesses to 25 Mbps download and 3 Mbps upload speed. Retrieved from https://broadbandnow.com/South-Dakota on December 18, 2018.

[5] *See* FCC Adopts Mobility Fund Order, FCC, February 23, 2017, available at: https://www.fcc.gov/document/fcc-adopts-mobility-fund-order. The FCC also provided $1.488 billion in support of the next decade to expand any broadband technology to "meet the FCC's buildout and performance standards for fixed service." *See* Connect America Auction to Expand Broadband to 713,176 Rural Locations, FCC, August 28, 2018, available at: https://www.fcc.gov/document/connect-america-auction-expand-broadband-713176-rural-locations.

[6] While fixed satellite services are able to provide 25 Mbps/3 Mbps coverage across the continental United States, these services suffer from high latency and cost issues.

A common characteristic of South Dakota and its selected neighbors is the relatively low population density outside of urban areas (United States Census Bureau, 2017). Higher-ranking states in terms of connectivity tend to be more geographically concentrated and thus offer lower unit-costs per broadband customer. Second, even within urban areas in South Dakota and its neighboring states, access to speeds higher than 25 Mbps down and 3 Mbps up is relatively limited compared with Mid-Atlantic and Pacific urban areas. For example, while 18.8 percent of South Dakotans lack access to 100 Mbps down and 10 Mbps up broadband speeds, 87.6 percent do not have access to 250 Mbps down and 25 Mbps up speeds (Federal Communications Commission, 2018).[7] Being in an urban area in a rural state may not afford the same access to the Internet as rural area in a relatively urban state.

A recent estimate by the South Dakota Telecommunications Association (SDTA) highlights the challenge of fixed broadband investments in less populated areas of the state. The estimated average per-mile cost of installing backbone fiber was $16,000 for rural areas of South Dakota but was $60,000 per mile in the metropolitan Sioux Falls area. However, while the SDTA estimated the population density of the Sioux Falls metropolitan area was 2,490 residents per square mile, it estimated that the population density of its rural customers was only 4.5 residents per square mile. The low population density of rural areas meant that the average cost per resident of installing backbone fiber was $3,571 per resident, compared to $25.54 in the Sioux Falls metro area (South Dakota Telecommunications Association, 2018).

THE LOW POPULATION DENSITY OF RURAL AREAS MEANT THAT THE AVERAGE COST PER RESIDENT OF INSTALLING BACKBONE FIBER WAS $3,571 PER RESIDENT, COMPARED TO $25.54 IN THE SIOUX FALLS METRO AREA.

While higher income households tend to access the Internet through multiple devices (desktop, laptop, and smartphone), lower-income households have fewer computing devices and are more likely to only use a smartphone to access the Internet. Businesses also continue to incentivize customers to interact online, in particular through the use of mobile applications (apps). Engaging customers through mobile apps not only appears to strengthen customer relationships but also significantly increases annual sales revenues (Gill, Sridhar, & Grewal, 2017). Automation and the emergence of algorithm-based services are only likely to exacerbate the trend towards mobile devices over the coming decade (Arntz, Gregory, & Zierahn, 2016).

The question of broadband access is not only one of improving the consumption of video and associated consumer and business services, it is directly and positively related to questions of employment and productivity. For the United States, the available empirical evidence suggests that broadband availability lowers the unemployment rate at the county level and these effects are concentrated in technology-concentrated and high-end service industries such as finance and insurance, education, and heath care (Bai, 2017; Crandall, Lehr, & Litan, 2007; Forman, Goldfarb, & Greenstein, 2012; Kolko, 2012). The empirical evidence also lends credence to the argument

[7] The FCC fixed broadband deployment data are current as of December 12, 2018 and the most recent estimates can be viewed at https://broadbandmap.fcc.gov.

that increased mobile network capacity and speed reduces information asymmetries between rural and urban areas, improves the acquisition of human capital and agricultural productivity, and improves connections between governments and the citizens that they serve (Baumüller, 2018; Beratarrechea et al., 2014; Haftu, 2018; Mittal, Gandhi, & Tripathi, 2012). Improving access to mobile networks also appears to reduce the incentives for rural-to-urban migration by improving economic opportunities in rural communities.

For South Dakota and other rural states, fixed broadband investments will likely remain important to providing the backbone for Internet services in the near term. While property and other costs may be lower in rural areas, relatively low population density and distance between customers yield significantly higher per-customer costs for rural customers relative to urban customers. Fixed wireless may present a bridge in the short-term between fixed and mobile broadband, however, the issue remains that consumption of the Internet is shifting towards mobile devices.

The emergence of 5G mobile networks over the coming decade will not only improve services for consumers and businesses. The emerging demands of the Internet of Things (IoT) will increase the demand for mobile connectivity, capacity, and speed. Given the available empirical evidence of the impact of broadband availability on employment, productivity, and incomes, and the higher per-unit costs of fixed broadband in rural areas, improving mobile broadband is likely to be more economically efficient over the coming decade. Unlike fixed line investments to residential customers that are not portable, mobile broadband can adjust to the consumer's geographical location, reducing "broadband lock."[8]

5. A Brief Overview of the Economy of South Dakota

A common perception of the South Dakota economy is one dominated by agriculture and, to a lesser extent, tourism. As recently noted by Dr. Dustin Oedekoven, Interim Secretary of the South Dakota Department of Agriculture, "Agriculture is the life-blood of South Dakota… South Dakota always has been and will continue to be an agricultural state."[9] While a significant proportion of economic activity and employment may continue in the agricultural sector, its relative importance to other sectors of the South Dakota economy has declined over the last two decades.

In 2017, a slight majority of the South Dakotan population resided outside the two Metropolitan Statistical Areas (MSAs) of Rapid City and Sioux Falls. It is highly likely, however, given current trends that sometime in the next two decades, more than 50 percent of the population will reside in these metropolitan areas of South Dakota. People follow jobs, and jobs have continued to migrate from rural to urban communities as South Dakota evolves from an agriculture-based economy to a more diversified economy based on financial services, health care, education, and tourism. The growth in these sectors is, in part, dependent upon the availability of access to the Internet, access which appears to be constrained in rural areas of the state.

People tend to vote about economic conditions with their feet and South Dakota is no exception.[10] In 2017, almost 47 percent of the population of South Dakota resided in the Sioux Falls (29.8 percent)

[8] Much like "job lock" refers to the reluctance to switch employers due to the availability of health insurance, "broadband lock" may occur as individuals are less willing to move from areas where broadband services are readily available to areas where these services are degraded or absent.
[9] Dr. Dustin Oedekoven, South Dakota Department of Agriculture, available at: https://www.nasda.org/organizations/south-dakota-department-of-agriculture.
[10] The Tiebout hypothesis states that individuals will sort themselves across local jurisdictions according to the preferences for taxes and the provision of public goods.

and Rapid City (16.9 percent) MSAs, up from approximately 38 percent in 1990. As illustrated in Table 2, relative to the United States, South Dakota is younger on average, with a median age of 36.9 years compared to 38.1 years for the United States in 2017. At 37.6 years, however, the median age in the Rapid City MSA is not only higher than the South Dakota median, it is over 2 years higher than the Sioux Falls' MSA median age. While the median age in both urban areas has risen since 2005, the increase has been markedly greater in Rapid City. The simple explanation is that Sioux Falls, through rapid growth, has attracted younger individuals from rural areas in South Dakota, other states, and other countries.

The rapid growth of the Sioux Falls MSA is also reflected in three measures: the sex ratio (the ratio of males to females), the old-age dependency ratio (the ratio of individuals older than 64 to the working age (15-64) population), and the child dependency ratio (the ratio of children to the working age population). Sioux Falls, on average, is younger, and has more children than the Rapid City MSA or South Dakota. Given that smartphone and Internet usage is, in part, determined by income, age, and employment, one would reasonably expect that mobile demand is higher in the Sioux Falls MSA than other parts of the state. In essence, economic and social conditions drive migration to Sioux Falls, which leads to increased incomes and amenities, which, in turn, drive further migration to Sioux Falls.

In Figure 3, we compare the real (inflation-adjusted) Gross Domestic Product (GDP) of South Dakota, Rapid City MSA, and Sioux Falls MSA. After accounting for the effects of price inflation, the size of the South Dakota economy increased at an average annual rate of 2.6 percent between 2001 and 2017, rising from $27.5 billion in 2001 to $41.8 billion in 2017. During this period, the South Dakotan economy outperformed the United States economy. While its neighbor, North Dakota, has posted, at times, higher rates of economic growth, the same state has endured significant contractions. Unlike its resource-dependent neighbors, the South Dakota economy has grown at a steady pace over the decade, reflecting the diversification of the economy.

In 2001, non-metropolitan areas of South Dakota produced approximately 48.4 percent of all economic activity, a share that declined slightly to 47.7 percent by 2017. On the other hand, the

Table 2. Demographic Characteristics, 2017

	United States	South Dakota	Rapid City MSA	Sioux Falls MSA
Total Population	325,719,178	869,666	147,087	259,650
Median Age	38.1	36.9	37.6	35.2
Sex Ratio	97.0	101.7	105.3	99.7
Old-Age Dependency Ratio	25.2	27.6	29.0	21.6
Child Dependency Ratio	36.6	41.4	38.7	42.8

Source: United States Census Bureau (2018), 2017 American Community Survey 1-Year Estimates.

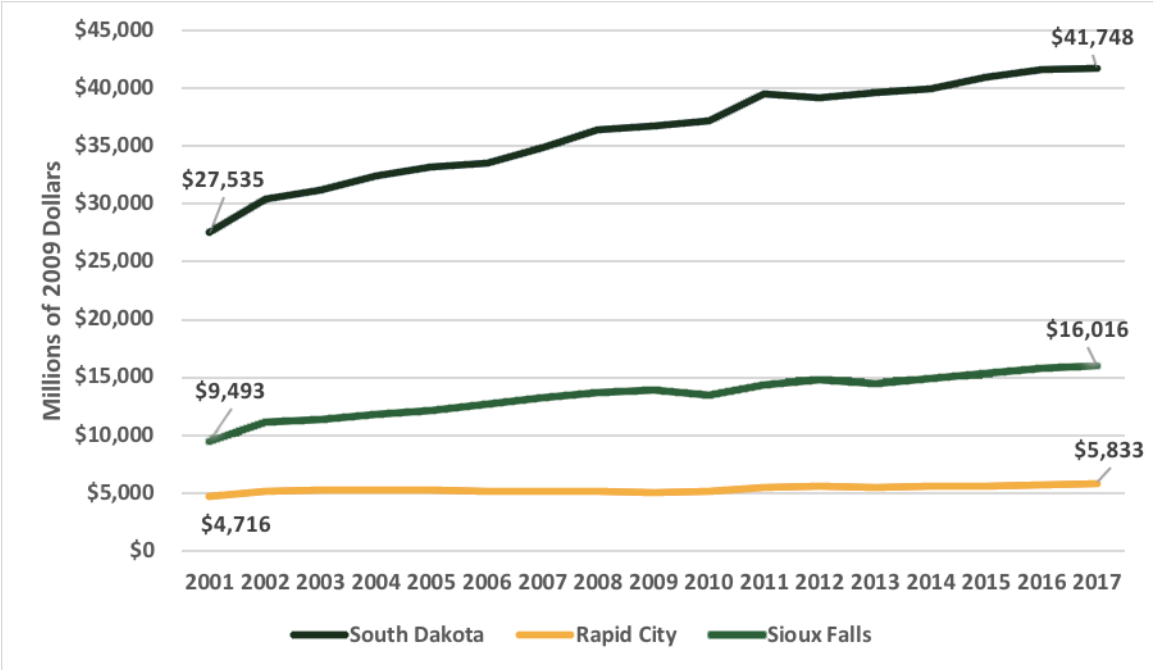
[10] The Tiebout hypothesis states that individuals will sort themselves across local jurisdictions according to the preferences for taxes and the provision of public goods.

Sioux Falls MSA's share of South Dakota's real GDP increased from 34.5 percent in 2001 to 38.4 percent in 2017. While the absolute level of economic activity in Rapid City MSA has increased this decade, its proportional contribution to South Dakota's economy has fallen. In 2001, the Rapid City MSA produced about 17.1 percent of real GDP, a share that had fallen to 14.0 percent in 2017.

Focusing on the contributions of each economic sector to the South Dakotan economy further illustrates that agriculture is no longer the dominant economic force. As Table 3 reveals,[11] fully one-quarter of the value of South Dakota's economic activity is generated by finance, insurance, real estate, rental, and leasing, dwarfing that sector's approximate 10.7 percent share of the state's employment. The finance, insurance, real estate, rental, and leasing sector generated about $12.5 billion dollars of economic output in 2017. Why has the share of this industry risen over time? In part, this can be explained by South Dakota's legal environment, which is designed to be more favorable to firms in this sector.

Within this industry, the finance and insurance sub-industry generated more than 50 percent of total sectoral output, accounting for $7.6 billion dollars of sectoral economic activity. In other words, the finance and insurance sector generated more than 15 percent of South Dakota's GDP in 2017. Real estate, rental, and leasing generated almost $5.0 billion dollars of output in the same year, accounting for almost 10 percent of South Dakota's GDP. The state's traditional economic base, agriculture, accounted for 5.3 percent of total employment and 6.6 percent of economic output.

Figure 3. Real Gross Domestic Product, 2001-2017 South Dakota, Rapid City MSA, Sioux Falls MSA



Sources: Bureau of Economic Analysis. Data for 2017 are advance estimates. Real GDP is in 2009 Chained Dollars.

[11] We note that Table 3 is in nominal dollars and thus contains different values for GDP than Figure 1. Figure 1 accounts for the effects of inflation as we are comparing GDP across time. Table 3 examines the composition of GDP for 2017 and thus there is no need to account for the impact of annual inflation.

Table 3. Gross Domestic Product, South Dakota, 2017, Millions of Current Dollars

Industry	2017 Contribution to State GDP	Percentage Contribution to State GDP
Finance, insurance, real estate, rental, and leasing	$12,554	25.1%
Government and government enterprises	$5,837	11.7%
Educational services, health care, and social assistance	$4,930	9.9%
Manufacturing	$4,789	9.6%
Wholesale trade	$3,684	7.4%
Retail trade	$3,645	7.3%
Agriculture, forestry, fishing, and hunting	$3,307	6.6%
Professional and business services	$2,864	5.7%
Construction	$2,061	4.1%
Arts, entertainment, recreation, accommodation, and food	$1,833	3.7%
Transportation and warehousing	$1,179	2.4%
Information	$1,130	2.3%
Other services	$1,109	2.2%
Utilities	$839	1.7%
Mining, quarrying, and oil and gas extraction	$168	0.3%
Total	**$49,929**	

Source: U.S. Bureau of Economic Analysis, Gross Domestic Product by State. 2017 Annual data. Other services exclude government and government enterprises.

Changes in population and economic activity are also reflected in the data on covered employment.[12] While 53.5 percent of jobs were in non-metropolitan areas in 2000, by 2017 the share of non-metropolitan jobs had fallen to 48.4 percent. Employment in the Rapid City MSA increased as a share of all jobs, but only slightly, from 15.3 percent in 2000 to 15.8 percent in 2017. The relatively rapid growth of the Sioux Falls economy is reflected in the jobs data, with the share of jobs in the Sioux Falls MSA rising from 31.2 percent of all jobs in South Dakota in 2000 to 35.8 percent of all jobs in 2017. If we examine employment at the county level, 43 percent of all jobs in South Dakota were in Minnehaha County (part of the Sioux Falls MSA) and Pennington County (part of the Rapid City MSA) in 2017. It should be no surprise that employment and migration are closely correlated.

The challenge for South Dakota over the coming decade is how to sustain economic growth and simultaneously spur development in the non-metropolitan regions of the state. While South Dakota is an attractive destination for domestic and international migrants, intrastate migration flows are

[12] The Quarterly Census of Employment and Wages (QCEW) is a federal-state program that produces employment and wage information for workers covered by state unemployment insurance (UI) laws and federal workers covered by the Unemployment Compensation for Federal Employees (UCFE) program. The QCEW program serves as a near census of monthly employment and quarterly wage information. Data are collected on the number of establishments, monthly employment, and quarterly wages by NAICS industry, county, and ownership sector for the entire United States. *See* Quarterly Census of Employment and Wages, United States Department of Labor Bureau of Labor Statistics, available at: https://www.bls.gov/cew/.

characterized by outflows from relatively poorer, rural counties to relatively wealthier, urban counties. Disparities in opportunities and incomes have exacerbated the urban-rural gap in South Dakota and its neighboring states. It should be no surprise that many of the areas that were identified as having poor quality mobile service were rural, poorer, and had suffered outmigration over the previous decade.

Unlike some of its neighbors, South Dakota's economic growth over the past decade can be attributed to a welcoming business climate and relatively skilled urban workforce. While South Dakota has not suffered from the 'boom-bust' cycle of the natural resource dominated economies of its neighbors, its economic fortunes have been closely tied to financial and related services, which now account for about one-quarter of the value of South Dakota's output. The financial value-added per employee in the financial sector is substantially higher than health care (which employs more people) or agriculture (which has been a mainstay of the South Dakota economy) (Bureau of Economic Analysis, 2018). Access to broadband is a key component in maintaining South Dakota's comparative advantage in these sectors.

A significant challenge for South Dakota is that it fares relatively poorly in perceptions of infrastructure and technology (CNBC, 2018). Wise investments in both are required for South Dakota to maintain its competitiveness and to improve economic development opportunities in rural areas of the state. Mobile coverage does not necessarily equate to network capacity, nor does capacity equate to speed. While many concluded that mobile data speeds are sufficient in urban areas, the same individuals complained about the lack of coverage, capacity, and speed in certain rural areas. In other words, the qualitative evidence suggests that residents view mobile networks as 'good enough,' a relatively low standard. Furthermore, there appears to be wide agreement regarding the lack of connectivity, capacity, and speed for rural communities. Coupled with the relatively high unit cost of providing fixed broadband to rural customers,[13] this suggests that an appropriate course of action to promote economic development is to increase the connectivity, capacity, and speed of mobile networks in South Dakota.

6. Final Thoughts

Internet access has changed over the last two decades from a luxury to a necessity. Not only does the evidence suggest that improved Internet access and speed is positively associated with employment, it corroborates the argument that Internet access improves the acquisition of human capital, agricultural productivity, and a host of other positive outcomes. The important policy question now is whether South Dakota, and by extension, other rural states, can access these outcomes. Investments in mobile coverage, capacity, and speed are likely to be a fundamental component of any future growth strategy.

For South Dakota, the relatively low population density in rural areas means that public services may be infrequent or require significant travel. Improving mobile coverage and speeds offers local and state governments the opportunity to provide more services remotely. Online education is difficult, farmers cannot reliably utilize and take advantage of market data, and remote medicine is fraught with peril without high-quality Internet connectivity. The challenge, however, is a persistent urban-rural divide in access to the Internet. This divide not only manifests itself in fixed broadband networks, but, more importantly, in mobile access, capacity, and speed. The transition to 5G networks presents a

[13] In a review of fixed, mobile, and satellite broadband, the European Commission found that mobile avoids the costs associated with the last mile. *See* Broadband Technologies Policy, European Commission, April 13, 2018, available at: https://ec.europa.eu/digital-single-market/en/broadband-technologies.

unique opportunity to bridge the digital divide and improve the quality of life of rural residents.

South Dakota's economy has recently grown faster than that of the United States. In retrospect, South Dakota wisely placed its economic bets on the financial services industry. Changes in the legal climate brought about by new court decisions and populist laws, however, could potentially injure South Dakota. Technological advances could render it unnecessary for financial firms to have employees' feet on the ground in South Dakota. We cannot predict either, but prudent public policy makers in South Dakota should not ignore these possibilities. The time is not for South Dakota to rest upon its laurels.

If South Dakota wishes to broaden its economic base and participate in the scientific and engineering developments that propel many other states, it must consciously promote investments in technology. In the short-term, South Dakota should examine how to foster a climate to promote private investments in infrastructure that would be a complementary (and relatively low-cost) effort to investments in public research and development. South Dakota should seek to lower artificial barriers to entry, continue to promote a favorable tax and business climate, and adapt its education system to produce a technologically-proficient workforce. Without a regulatory climate at the federal and state level that favors investments in, and access to, the Internet and, specifically, mobile broadband deployment, the future prospects of South Dakota may become more uncertain in the coming decade.

Interviews with South Dakotan residents highlight two key features of mobile networks in the state: residents have satisficed with regards to mobile networks, and there is wide agreement that rural networks have insufficient coverage, capacity, and speed for basic health and safety. Residents, even those located at or near institutions of higher education, found mobile networks to struggle during large events and that mobile network coverage degraded quickly upon leaving more populated areas of the state. Rural residents appear to be more resigned than their urban counterparts, accepting poor or non-existent coverage and adjusting their lives to cope with gaps in coverage, capacity, or speed.

We argue that decision-makers should also not satisfice with regards to the quality of mobile broadband. Internet services and applications evolve quickly with the advent of new technology. While older generations of mobile networks may have been 'good enough' for voice and text, the primary drivers of Internet traffic in the next decade will be video and IoT data. 5G networks not only utilize multiple channels, these networks offer greater capacity, reliability, and speed. Investments in fourth-generation networks (4G) will undoubtedly be beneficial for rural areas, however, the danger is that rural areas could become 'locked in' to older technology. Policy and networks must evolve with new technology, otherwise rural areas will not be able to access the benefits associated with the introduction of 5G networks.

Mobile coverage, capacity, and speed are not an economic luxury. We argue that, especially for lower population areas of the state, mobile networks can not only provide residents with improved amenities but also can promote economic opportunities and productivity in rural areas of the state. Improving mobile networks, including the deployment of 5G networks, is important to reducing the economic and social incentives for individuals to 'vote with their feet' and migrate from rural communities to urban areas. The alternative is to abandon these communities, an outcome that will likely harm lower-income residents who are not able to readily move in search of economic opportunities and an improved quality of life.

Appendix A: Understanding the South Dakota Economy

A.1 Introduction

While South Dakota may be best known for its agricultural sector that consisted of 31,000 operating farms on over 43 million acres in 2017 (National Agricultural Statistics Service, 2018), it is also the host for the processing centers of several major banks. According to the Bureau of Economic Analysis (BEA), the finance and insurance industry employed 38,967 individuals in 2016, with 17,124 in credit intermediation and related activities and another 12,056 individuals working for the insurance and related activities sector (Bureau of Economic Analysis, 2018). Most of this financial and insurance activity is in South Dakota's largest city, Sioux Falls.

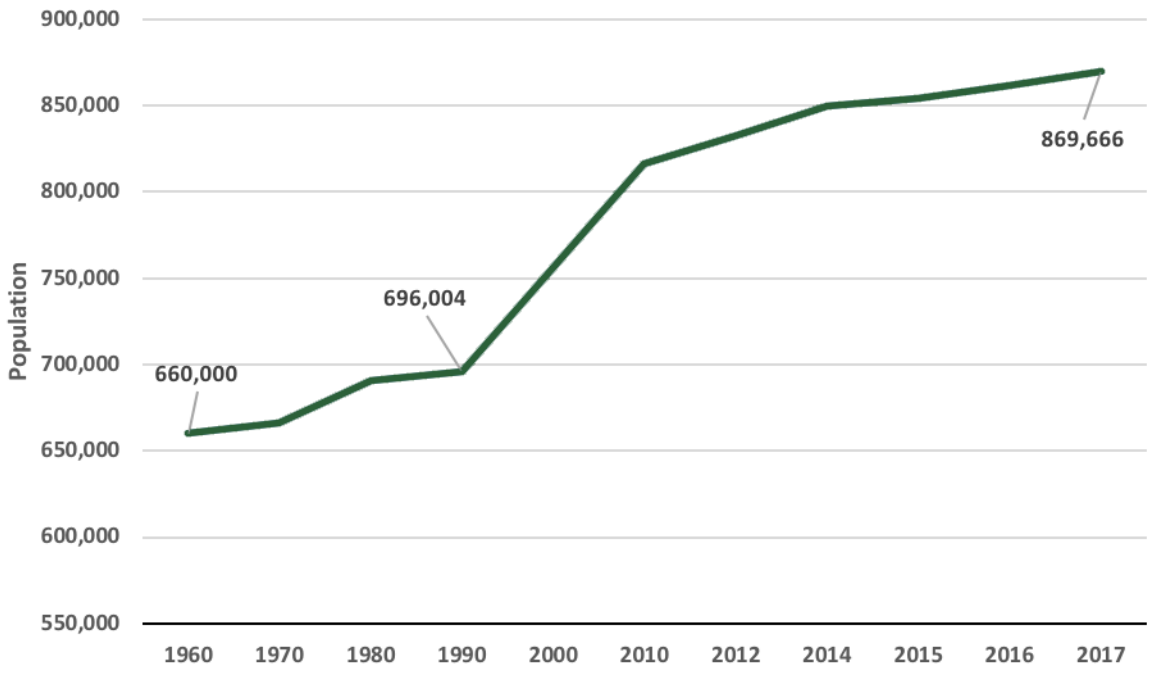
Understanding the South Dakota economy is important for estimating the impact of improved broadband access. While the finance and insurance industries are in relatively densely populated urban areas with somewhat higher quality Internet access,[1] farmers and others engaged in agricultural industries face varying densities of broadband access. Population changes over time can also be partly explained by the lack of services in rural areas, with a common refrain that younger generations are moving to urban areas in search of employment and amenities. South Dakota's economy has been growing more rapidly than that of the United States and its rate of unemployment consistently has been lower than that of the nation. Let's delve into the details.

A.2 Demographic Trends

Figure 1 reports the growth in South Dakota's population as estimated by the United States Census since 1960. It is immediately apparent that after 1990, population growth accelerated. Why? One of the main reasons relates to a 1978 decision rendered by the United States Supreme Court ("*Marquette National Bank of Minneapolis v. First of Omaha Service Corp.," 1978*). In *Marquette*, the Court ruled that national banks could charge the highest interest rate allowed in that bank's home-chartered state, regardless of where its headquarters was located, or its customers lived. This meant that states such as South Dakota could develop laws that would be attractive to banks whose presence heretofore had been minimal in South Dakota. *Marquette* meant that South Dakota's financial laws and regulations would apply to those banks' activities in Florida, California, or any other state.

[1] Interviews with residents in Sioux Falls suggest that mobile networks become congested and inconsistent during large events.

Figure 1. Total Population of South Dakota, 1960-2017



Source: United States Census Bureau, 1960-2010 Decennial Census and Population Estimates for 2011-2017.

South Dakota was the first-mover among the states to write credit-card favorable laws and regulations (Vanatta, 2016). At the time, decision-makers believed this would attract banks and financial institutions and stimulate economic development. In retrospect, they were correct. In 1981, Citibank relocated its credit card processing center to Sioux Falls as major banks relocated charters and operations to rate and regulation-favorable states.

After growing only 5.5 percent between 1960 and 1990, South Dakota's population grew 25 percent between 1990 and 2017 (United States Census Bureau, 2018b). On an annual basis, South Dakota's population grew 0.8 percent per year (Table 1). While economic growth seldom can be tracked to a single source, there is consensus that South Dakota's change in banking regulations is partly responsible for this upsurge. South Dakota's population growth rate was higher than the neighboring states of Iowa, Nebraska, and North Dakota but lagged that of Minnesota, Montana, Wyoming, and the United States as a whole.

Within South Dakota, the population of South Dakota has shifted over time from rural cities and counties to the Metropolitan Statistical Areas (MSAs) of Rapid City and Sioux Falls (Office of Management and Budget, 2017).

Table 1. Population Change Among Neighboring States July 1, 1990 to July 1, 2017

State	Population 1990	Population 2017	Percent Change in Population	Annual Percentage Change
Iowa	2,781,000	3,145,700	13.1%	0.5%
Minnesota	4,389,900	5,576,600	27.0%	0.9%
Montana	800,204	1,050,500	31.3%	1.0%
Nebraska	1,581,700	1,920,100	21.4%	0.7%
North Dakota	637,685	755,393	18.5%	0.6%
South Dakota	**697,101**	**869,666**	**24.8%**	**0.8%**
Wyoming	453,690	579,315	27.7%	0.9%
United States	249,622,800	325,719,200	30.5%	1.0%

Source: United States Census Bureau, 1990 Decennial Census and Population Estimates for 2017. The annual percentage change in the population is the Compound Average Growth Rate.

Table 2 presents the population in the Rapid City MSA, the Sioux Falls MSA, and areas in South Dakota outside these MSAs. Undoubtedly, the population of South Dakota has shifted towards the MSAs and Sioux Falls, in particular. In 1990, 62.1 percent of the population lived outside of the MSAs. By 2000, this share had fallen to 58.2 percent (Bureau of Economic Analysis, 2017). This downward trend continued this century. In 2010, 55.4 percent of the population lived in non-metropolitan areas and, by 2017, this share had declined to 53.3 percent (United States Census Bureau, 2018b).

Among the MSAs, Sioux Falls gained population more rapidly than Rapid City. In 1990, the Sioux Falls MSA accounted for 22.1 percent of South Dakota's population, rising to 24.9 percent by 2000. By 2017, the population of the Sioux Falls MSA was almost 30 percent (29.8 percent) of the entire population of South Dakota. Rapid City has also grown, albeit at a much slower pace relative to Sioux Falls. In 1990, for example, the Rapid City MSA was 15.8 percent of the South Dakotan population. In 2017, the share of the population residing in the Rapid City MSA had increased to 16.9 percent of the population.

Given that over 50 percent of South Dakota's population resides outside the metropolitan areas, we will focus our analysis at the county level. Figure 2 illustrates the total population of the state's 66 counties in 2017 using data from the U.S. Census Bureau. Two of the 66, Minnehaha County and Pennington County, stood out with populations of 188,616 and 110,141, respectively.

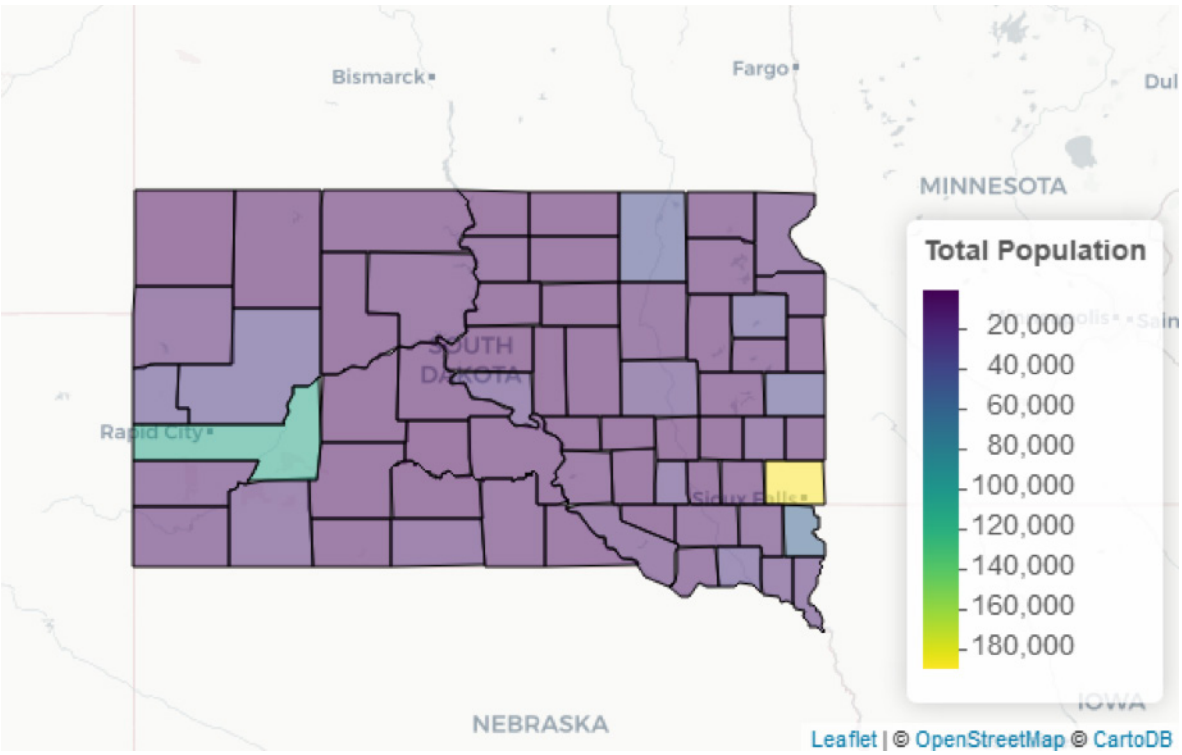
Table 2. Total Population in Metropolitan and Non-Metropolitan Areas South Dakota, 2010-2017

	2010	2011	2012	2013	2014	2015	2016	2017
Rapid City	135,004	136,229	138,334	140,755	142,713	143,357	144,879	146,850
Sioux Falls	229,123	232,305	236,948	242,227	246,657	250,469	254,372	259,094
Non-Metro	452,100	454,804	457,294	459,531	460,085	460,210	462,291	463,722
South Dakota	816,227	823,338	832,576	842,513	849,455	854,036	861,542	869,666

Source: United States Census Bureau, Population Estimates for 2017.

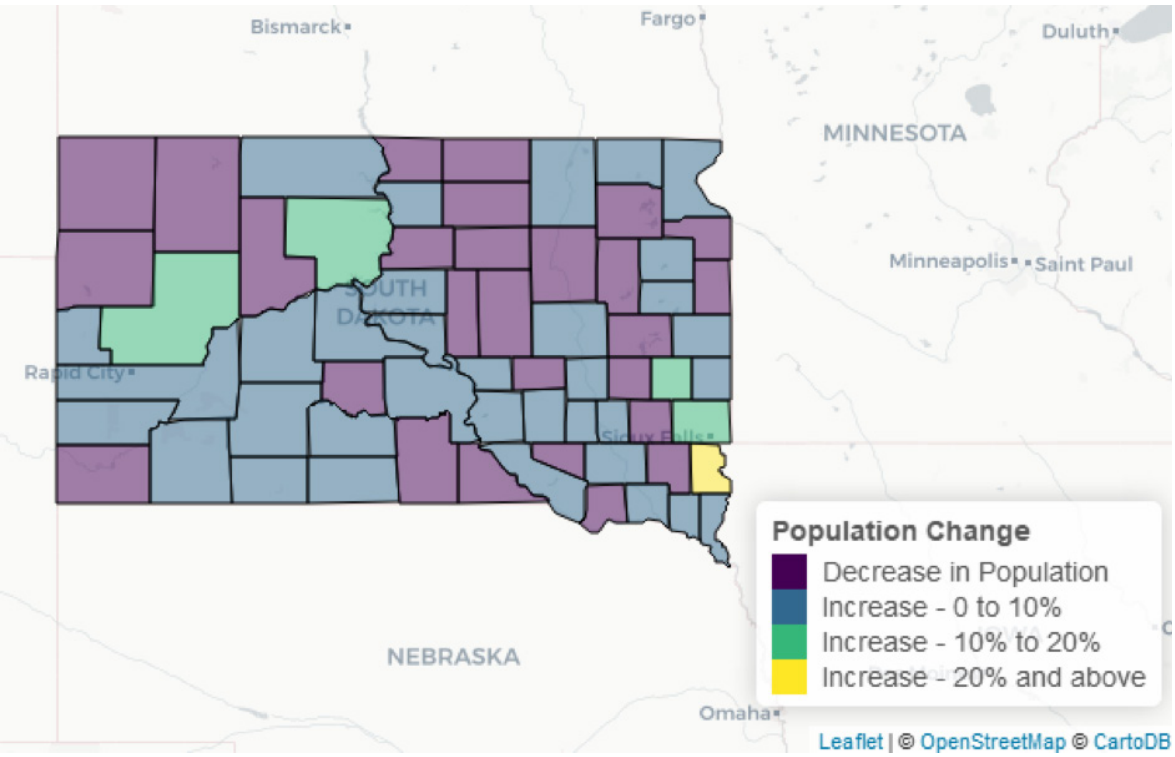
Many of the 66 counties are sparsely populated, with the median population of the state's 66 counties being 5,480 individuals. Minnehaha County, with a population density of 233 residents per square mile, was the only county in South Dakota with a population density greater than 100 residents per square mile. Harding County, with a population of 1,242 residents, had the lowest density with 0.46 residents per square mile.

Figure 2. South Dakota, Total Population by County, 2017



Source: U.S. Census Bureau, 2017 Vintage Population Estimates.

Figure 3. South Dakota, Population Change by County, 2010-2017



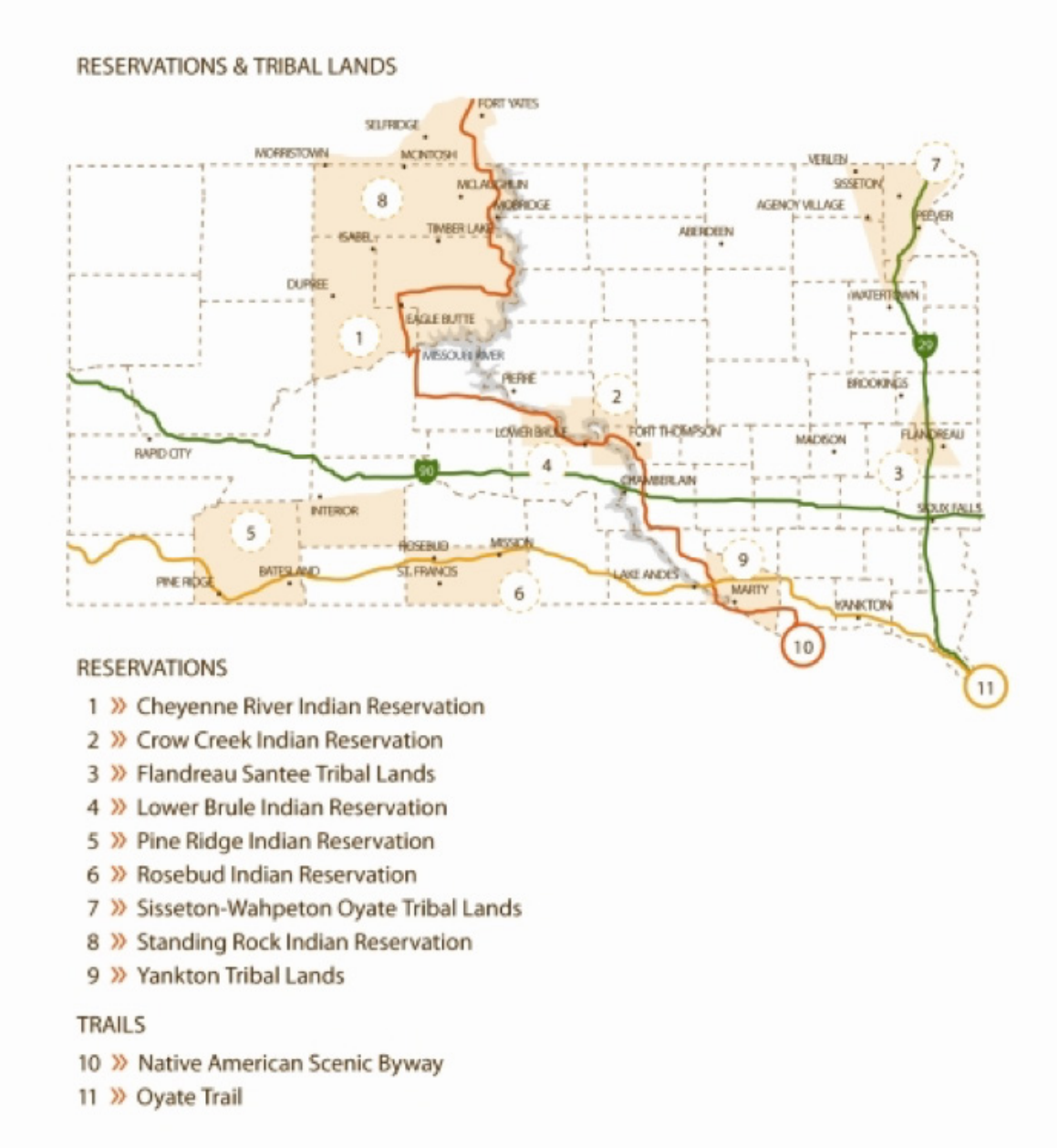
Source: U.S. Census Bureau, 2010 Decennial Census and 2017 Vintage Population Estimates.

Population growth has not been evenly distributed across South Dakota. Since the 2010 Decennial Census, 16 of 66 counties have lost population. Hyde County, for example, lost over 7 percent of its population from 2010 to 2017. On the other hand, the remaining 50 counties gained population over this period. The leaders in population growth were Lincoln County (26.4 percent), Lake County (14.4 percent), Minnehaha County (11.3), Meade County (10.2 percent), and Dewey County (10.1 percent). In general, rural areas tended to lose population as residents have moved either to metropolitan areas within the state or to other states. These changes in population reflect the shifts in economic opportunities.

When considering the population of South Dakota, one cannot ignore the distinctive presence of nine Native American tribal nations within the state. According to the U.S. Census, 8.7 percent of South Dakotans identify as Native American (American Indian) .[2] About 12 percent of the state's geographic area is devoted to the nine tribal reservations (United States Department of Justice, 2018). South Dakota has a greater percentage of its geographic area set aside for reservations and tribal lands than any other state. We focus our analysis at the state and county level but recognize the presence and contributions of these tribes to the tapestry that is South Dakota.

[2] We follow the U.S. Census Bureau's categories for race throughout this chapter. When surveyed, individuals may voluntarily choose to self-identify as belonging to one or more racial categories as delineated by the Office of Management and Budget in the 1997 Standard for the Classification of Federal Date on Race and Ethnicity. *See* Revisions to the Standards for the Classification of Federal Data on Race and Ethnicity, Office of Management and Budget, October 30, 1997, available at: https://www.govinfo.gov/content/pkg/FR-1997-10-30/pdf/97-28653.pdf.

Map 1. South Dakota Reservations and Designated Tribal Land Areas



Source: South Dakota Indian Business Alliance (2018).

A.3 Components of Population Change

Why do we observe differences in population growth within a state? First, the natural change in the population is determined by the number of births and deaths. Second, net domestic migration measures individuals moving into a state from other states and out of the state to other states. Lastly, net international migration is determined by individuals moving into the state from another country and out of the state to another country.

From 2010 to 2017, South Dakota's natural increase (births – deaths) in population was 34,405 (Table 3). The natural increase of the population was the primary factor in population growth during this period, trailed by a positive net domestic migration of 11,890 individuals. International migration also contributed a positive net of 8,969 individuals.

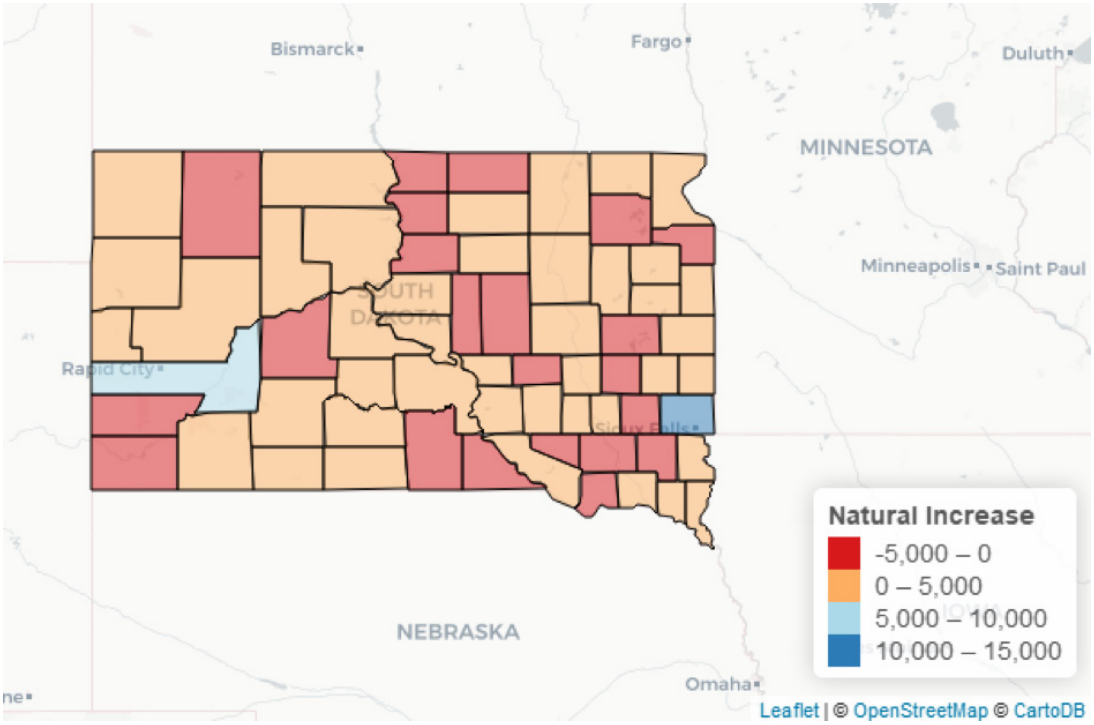
This decade, South Dakota has compared favorably to several of its neighbors. Iowa, Minnesota, Nebraska, and Wyoming all lost more residents than they gained to/from other states. Existing research suggests that positive net domestic migration is a sign of a dynamic, growing economy because the number one determinant of domestic migration is job availability and quality (Koch, 2015). South Dakota's economy is generating jobs, and people are moving to the state, especially to its two major metropolitan areas and idiosyncratic locales such as Brookings and Vermillion, home to South Dakota State University and the University of South Dakota, respectively.

Table 3. Components of Population Change Among Neighboring States
April 1, 2010 to July 1, 2017

State	Total Population Change	Natural Increase	Domestic Migration	International Migration
Iowa	98,843	74,839	-17,695	42,037
Minnesota	272,682	203,827	-32,518	103,720
Montana	61,079	21,073	37,304	2,503
Nebraska	93,749	76,500	-12,289	30,047
North Dakota	82,808	32,146	39,178	9,953
South Dakota	**55,469**	**34,405**	**11,890**	**8,969**
Wyoming	15,548	21,460	-8,838	2,563
United States	16,961,073	9,727,447	--	7,233,626

Source: United States Census Bureau, Population Estimates for 2017.

Figure 4. South Dakota, Natural Increase in the Population by County, 2010-2017

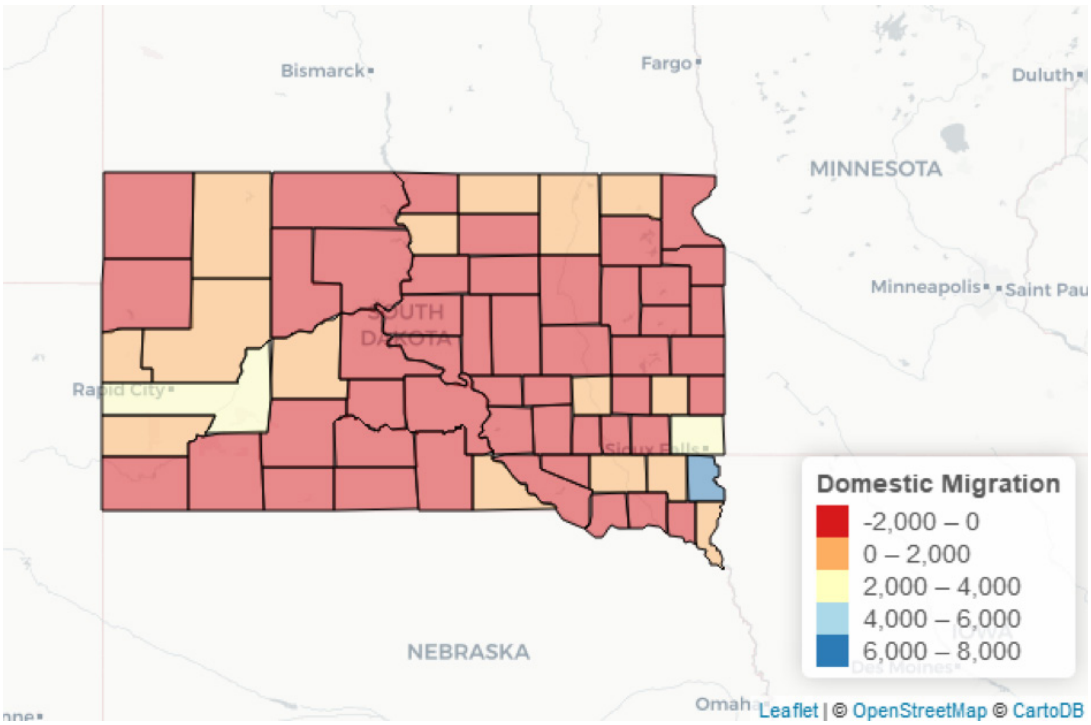


Source: U.S. Census Bureau, 2017 Population Estimates, Components of Population Change.

Figure 4 illustrates that the natural increases in population were not evenly distributed throughout the state from 2010 to 2017. 23 counties had more deaths than births. Fall River County, for example, had 816 deaths and 434 births, resulting in a natural decrease in the population of 382 individuals. Two counties, Minnehaha (11,398) and Pennington (5,059) saw the largest natural increases in population.

The next most significant contribution to population growth in South Dakota from 2010 to 2017 was net domestic migration, that is, arrivals from other states minus departures to other states. As with other factors, at the county level, some counties lost population as more residents on net left for other states, while others attracted residents from other states. The challenge for rural areas is how to retain and attract people as many counties had a net loss of population to other states from 2010 to 2017.

Figure 5. South Dakota, Net Domestic Migration by County, 2010-2017

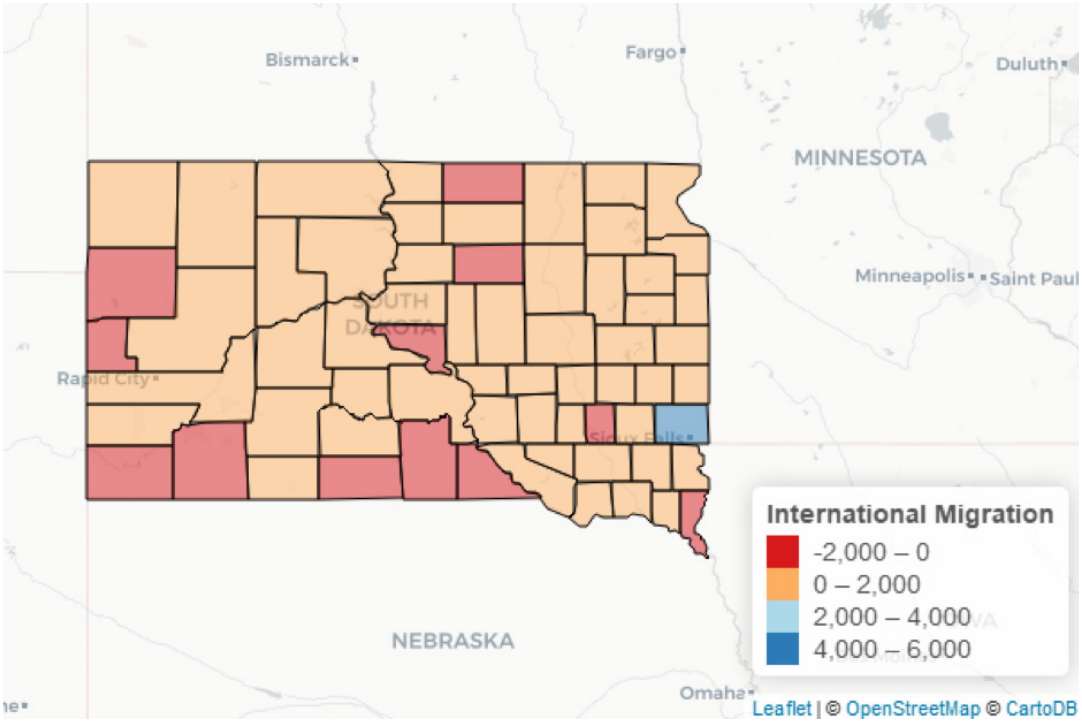


Source: U.S. Census Bureau, 2017 Population Estimates, Components of Population Change.

The last source of population growth is international migration. Attracting international migrants may be an important source of population growth if the natural increase in the population is low or if the state is not a destination for domestic migrants. In 2017, a record percentage of the national population was foreign-born, reflecting the changing demographics of the United States. For South Dakota, a higher percentage of foreign-born residents are employed in private industry than native-born residents, illustrating the potential contribution of immigrants to the overall economy (United States Census Bureau, 2017).

Overall, South Dakota experienced positive net international immigration from 2010 to 2017, with 8,969 more individuals arriving from other countries than South Dakotans departing for other countries. Figure 6 illustrates net international migration by county over this period.

Figure 6. South Dakota, Net International Migration by County, 2010-2017



Source: U.S. Census Bureau, 2017 Population Estimates, Components of Population Change.

Even with the arrival of migrants from other states and nations, South Dakota remains less diverse than the United States. In 2010, individuals who identified themselves as White to the U.S. Census accounted for 86 percent of the South Dakota population, while individuals who identified as American Indian accounted for 9 percent of the population and Black-African Americans represented 1.3 percent of the population. In comparison, for the U.S. in 2010, 74.2 percent of individuals identified as White, while 12.6 reported that they were Black-African American. Individuals who identified as American Indian accounted for less than 1 percent of the population of the United States (United States Census Bureau, 2011). Table 4 discloses the estimated racial diversity for 2017.

With gains in population this decade, however, South Dakota has become more diverse. In a relatively short period of time, for example, the percentage of the population identifying as Black-African American has increased from 1.3 percent in 2010 to 2.0 percent in 2017. Among its neighbors, only Minnesota's population is more diverse, with a higher percentage of African-Americans. South Dakota also had the highest reported percentage of the American Indians.

Table 4. Race 2017 American Community Survey

State	White	Black or African American	American Indian	Asian	Two or More Races
Iowa	90.0%	3.4%	0.3%	2.6%	2.2%
Minnesota	82.7%	6.5%	1.1%	4.9%	2.8%
Montana	88.6%	0.4%	6.2%	0.7%	3.2%
Nebraska	87.3%	4.6%	0.8%	2.5%	2.7%
North Dakota	86.6%	3.1%	5.5%	1.7%	2.0%
South Dakota	**84.7%**	**2.0%**	**8.7%**	**1.2%**	**2.6%**
Wyoming	91.2%	1.0%	2.4%	0.8%	2.8%
United States	72.3%	12.7%	0.8%	5.6%	3.3%

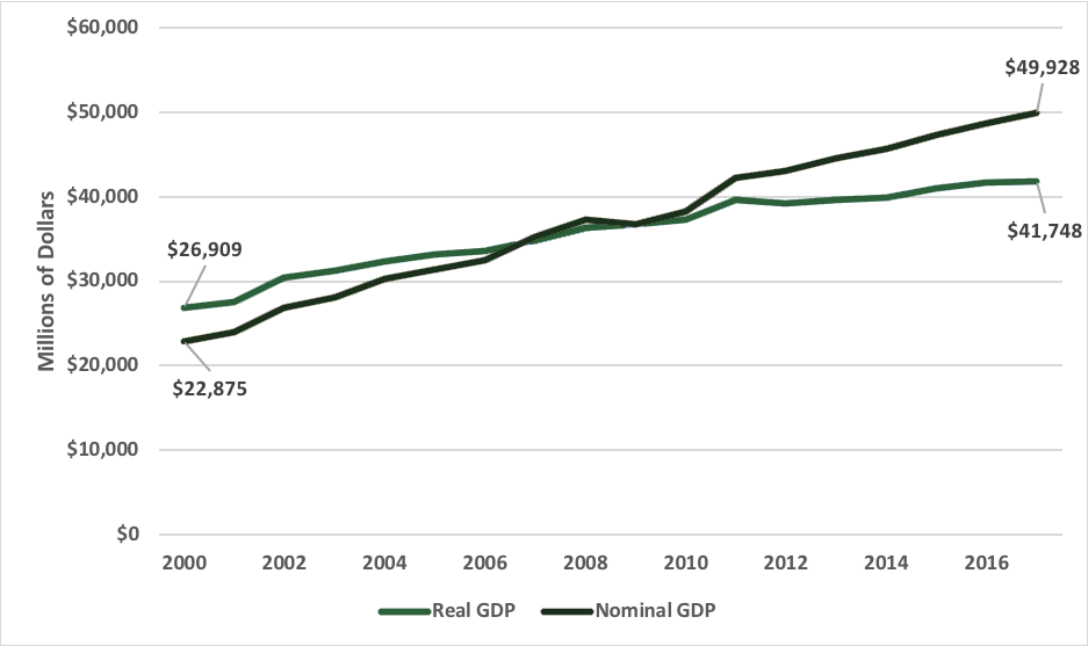
Source: United States Census Bureau, American Community Survey 2017, 1-Year Estimates. Native Hawaiian and Other Pacific Islander and Some Other Race categories are excluded from the table. Margin of errors are available upon request.

A.4 The Economic Performance of the South Dakota Economy

Between 2000 and 2017, real (inflation adjusted) economic activity in South Dakota, as measured by GDP, increased from $26.9 billion to $41.8 billion, an increase of 55 percent (Figure 7) or an annual rate of 2.6 percent. Over the same period, U.S. real GDP grew only 37.5 percent or at an annual rate of 1.8 percent. Simply put, South Dakota outgrew the U.S. from 2000 to 2017.

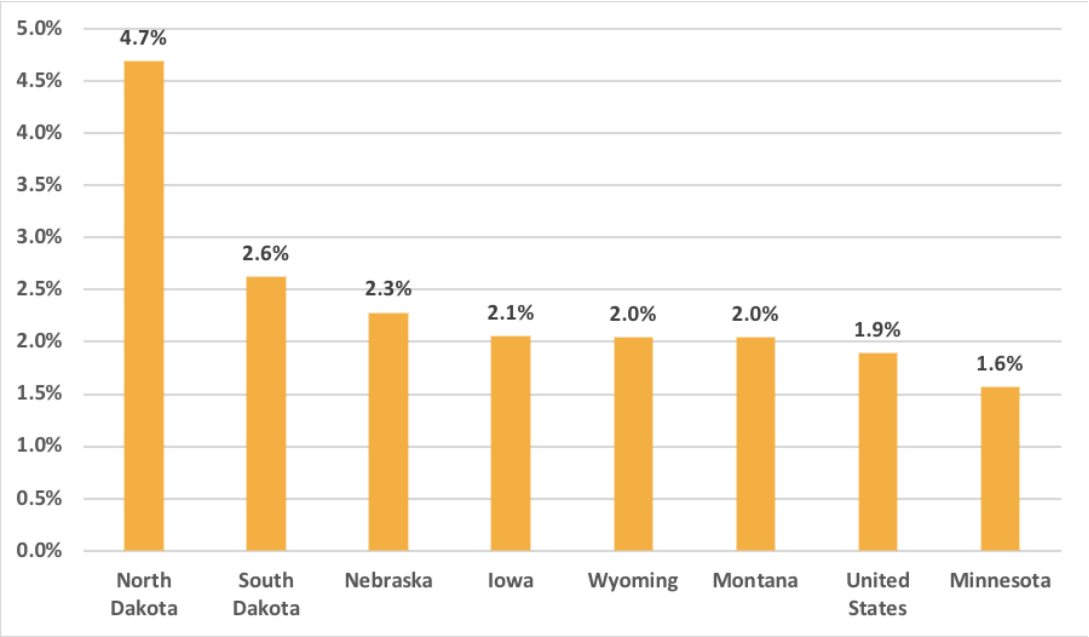
South Dakota's economic performance, however, has differed from that of some of its neighbors, whose economic expansions have been fueled by natural resources. South Dakota's good fortune coincided with not only growth in its financial sector but also robust growth in health care, real estate, and other services. While these sectors may be impacted by downturns in the overall economy, natural resource based economic activities tend to be more volatile over time. One only needs to witness the 'boom and bust' cycle of North Dakota's economic fortunes to understand how external forces may influence commodity and natural resource prices and, in turn, overall economic activity. As illustrated in Figure 8, South Dakota outperformed its neighbors (except for the aforementioned North Dakota) from 2000 to 2017.

Figure 7. South Dakota, Nominal and Real Gross Domestic Product, 2000 – 2017



Source: Bureau of Economic Analysis. Real GDP is millions of chained 2009 Dollars.

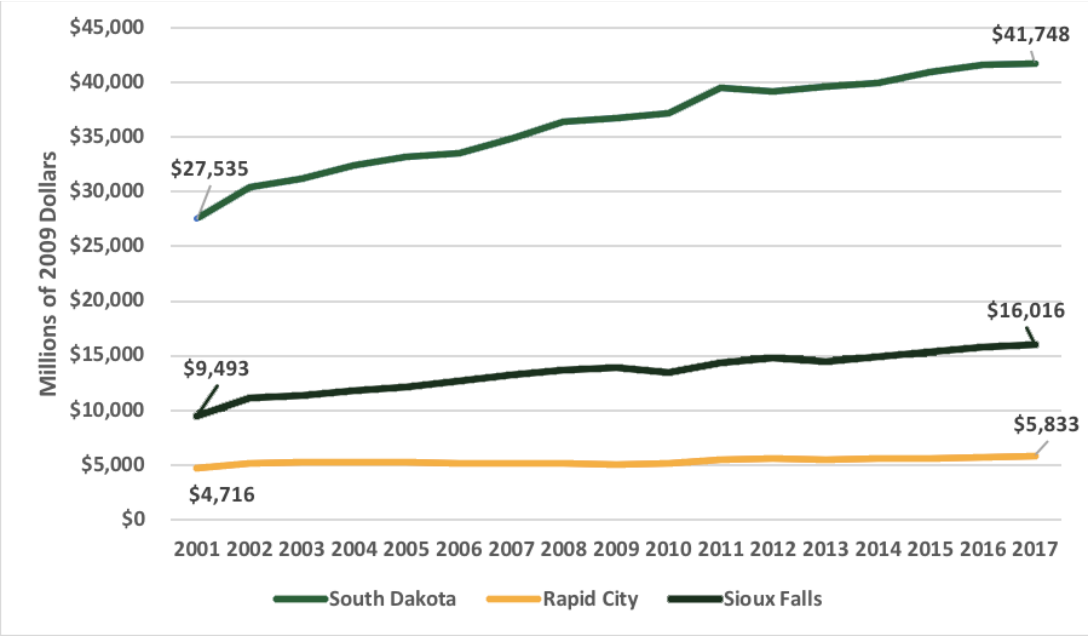
Figure 8. Compound Annual Growth Rate in Gross Domestic Product, 2000 – 2017



Source: Bureau of Economic Analysis, 2018. Real GDP for states is millions of chained 2009 Dollars while real GDP is 2012 chained Dollars for the United States.

In Figure 9 we compare the real GDP of South Dakota, Rapid City MSA, and Sioux Falls MSA. In 2000, non-metropolitan areas of South Dakota produced approximately 48.4 percent of all economic activity, a share that only declined slightly to 47.7 percent by 2017. Sioux Falls' share of South Dakota's real GDP increased from 34.5 percent in 2000 to 38.4 percent in 2017. On the other hand, while the absolute level of economic activity in Rapid City MSA has increased this decade, its contribution to South Dakota's has fallen. In 2001, the Rapid City MSA produced about 17.1 percent of real GDP, a share that had fallen to 14.0 percent in 2017. Even though rural areas may have lost population, these areas still account for almost 50 percent of economic activity in South Dakota.

Figure 9. Real Gross Domestic Product, 2001-2017 (South Dakota, Rapid City MSA, Sioux Falls MSA)



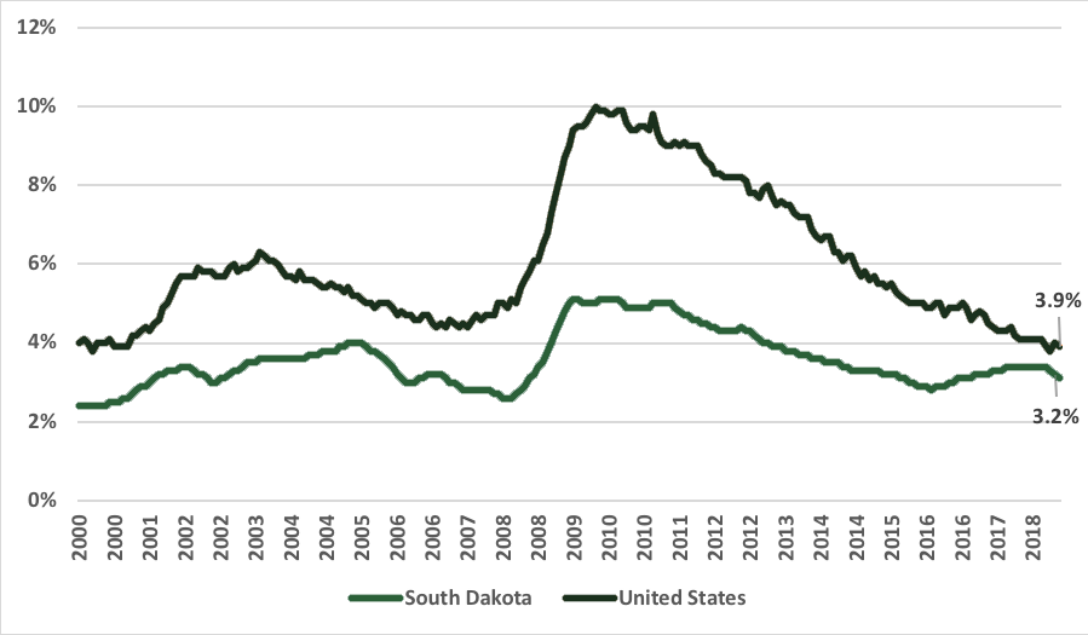
Sources: Bureau of Economic Analysis. Data for 2017 are advance estimates. Real GDP is in 2009 Chained Dollars.

A.4.1 Employment Trends in South Dakota

South Dakota's robust economic growth over time has fueled a demand for labor and, as such, South Dakota's rate of unemployment has always been several percentage points below the U.S. unemployment rate. As illustrated in Figure 10, in some years, the unemployment rate in South Dakota was more than four percent below the U.S. rate. Not only is this an impressive performance by itself, it is a sign of the relative strength of the South Dakotan economy.

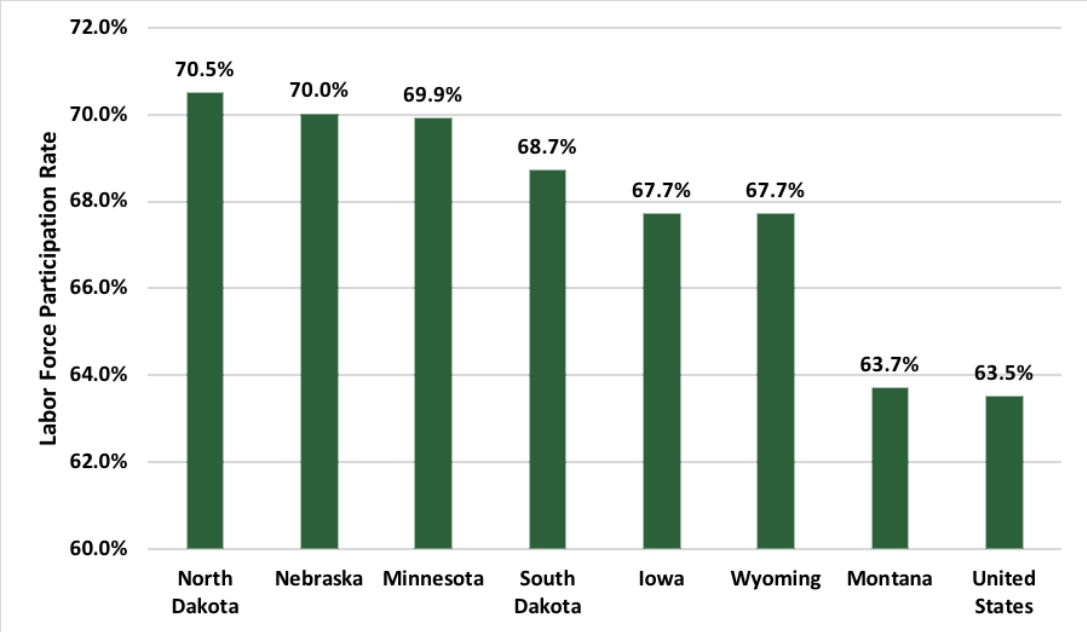
A low or declining unemployment rate can result from a variety of conditions. First, and most advantageous, more of the labor force is gainfully employed and the unemployment rate decreases. Another possibility is that individuals become discouraged, exit the labor force, and the unemployment rate also decreases. In the case of South Dakota, its relatively high labor force participation rate is the result of a larger number of residents being employed rather than individuals exiting the labor force. Figure 11 illustrates labor force participation in South Dakota, its neighbors, and the United States.

Figure 10. South Dakota and the United States, Headline Unemployment Rate (U3), January 2000 – July 2018



Source: Bureau of Labor Statistics, 2018.

Figure 11. Labor Force Participation Rate 2012 – 2016

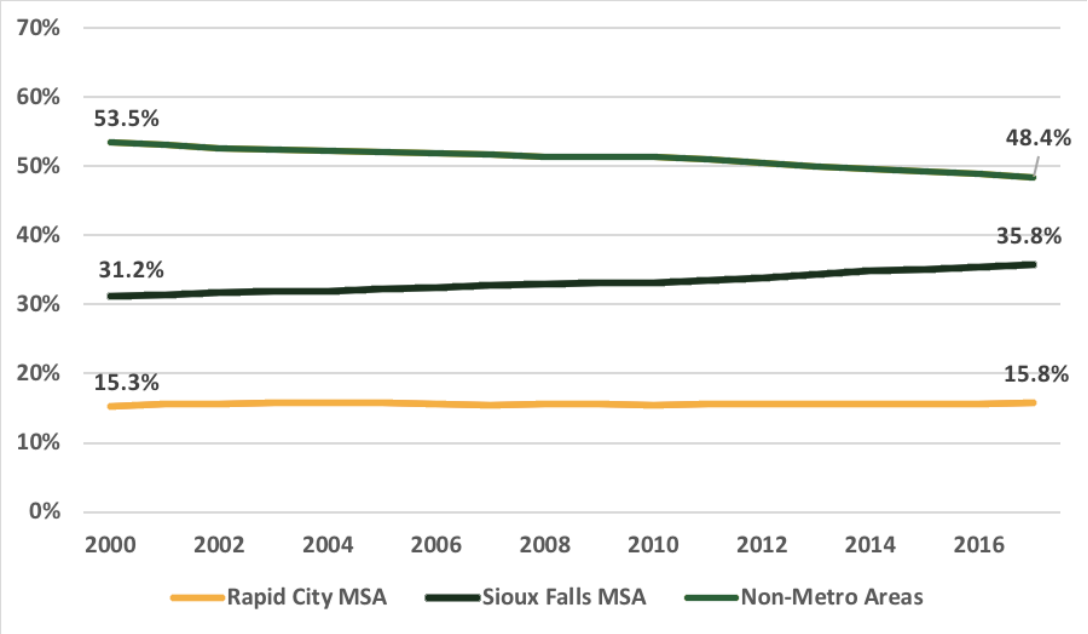


Source: United States Census, 2012-2016 American Community Survey 5-Year Estimates.

Labor force participation is higher in South Dakota and its neighbors than the United States. Why is labor force participation so high in South Dakota? The answer depends upon an intriguing combination of culture and economics. Societal attitudes count in South Dakota—work is valued and sloth is not.[3] Even so, the state's lofty labor force participation is also supported and stimulated by job creation. The South Dakota economy has been generating generous numbers of new jobs, and abundant opportunities for a variety of kinds of work exist. South Dakota's 3.2 percent rate of unemployment would be considered by many economists to be a full employment rate, implying that most individuals who want to work will find it possible to do so. In Figure 12, we compare data on jobs for the metropolitan and non-metropolitan areas of South Dakota.

[3] Wallethub.com, for example, ranked South Dakota as the 4th hardest working state in America. *See* Hardest-Working States in America, Wallet Hub, August 27, 2018, available at: https://wallethub.com/edu/hardest-working-states-in-america/52400/. Additionally, South Dakota's work ethic has been touted as attractive to businesses. *See* South Dakota Work Ethic Attractive to Businesses, The Daily Republic, February 13, 2010, available at: https://www.mitchellrepublic.com/news/1524503-south-dakota-work-ethic-attractive-businesses.

Figure 12. South Dakota Share of Total Covered Employment, 2000 – 2017

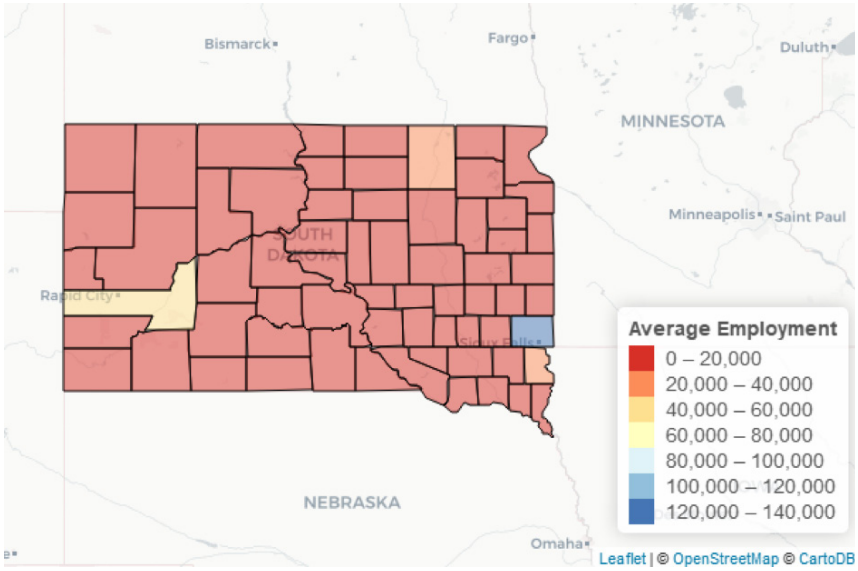


Source: Bureau of Labor Statistics, Quarterly Census of Employment and Wages, 2017.

Figure 12 illustrates data from the Quarterly Census of Employment and Wages (QCEW) from the Bureau of Economic Analysis (BEA). These data reflect jobs in South Dakota from 2000 to 2017. A story like that of real GDP emerges from the data. Non-metropolitan areas still account for the greater share of jobs in 2017, however, this share has declined over time. Almost 36 percent of all employees are now within the Sioux Falls MSA, while the Rapid City MSA now accounts for 15.8 percent of all employees, up slightly from 15.3 percent in 2000.

Figure 13 illustrates total covered employment by county for 2017. Almost 30 percent of covered employees in South Dakota were in Minnehaha County in 2017. If we add in the 13 percent of covered employees that work in Pennington County, this means jobs are increasingly concentrated in the two metropolitan areas of Sioux Falls and Rapid City. As employment grows in these cities, amenities increase, attracting more individuals in search of an improved quality of life.

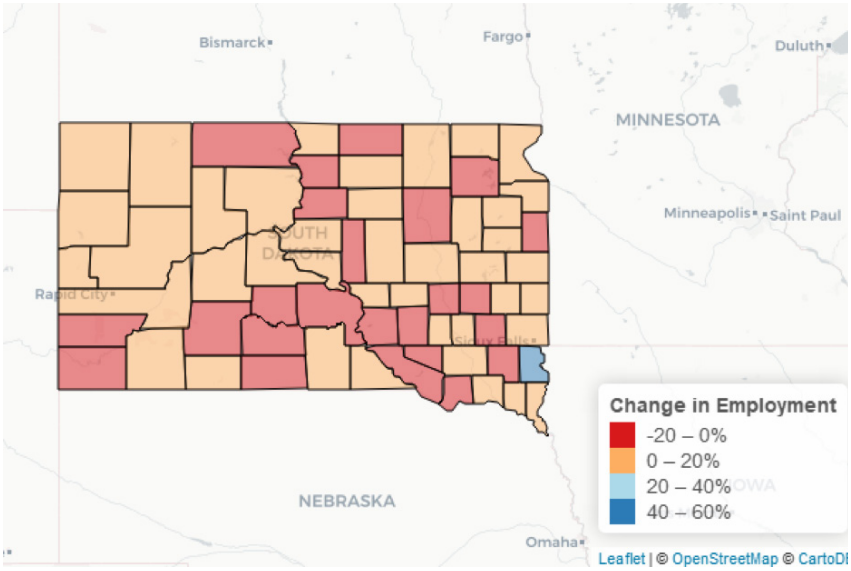
Figure 13. South Dakota, Total Covered Employment, 2017



Source: Bureau of Labor Statistics, Quarterly Census of Employment and Wages, 2017.

Figure 14 displays the percentage change in covered employment from 2010 to 2017. Again, it should be no surprise that the movement of jobs to metropolitan areas coincides with the declines in population in several rural counties. The rapid increase in employment of the Sioux Falls metropolitan area, for example, is highlighted in the southeastern part of the state. Lackluster employment growth (or outright decline) in many rural counties has led many to seek their fortunes elsewhere.

Figure 14. South Dakota, Percentage Change in Total Covered Employment 2010-2017



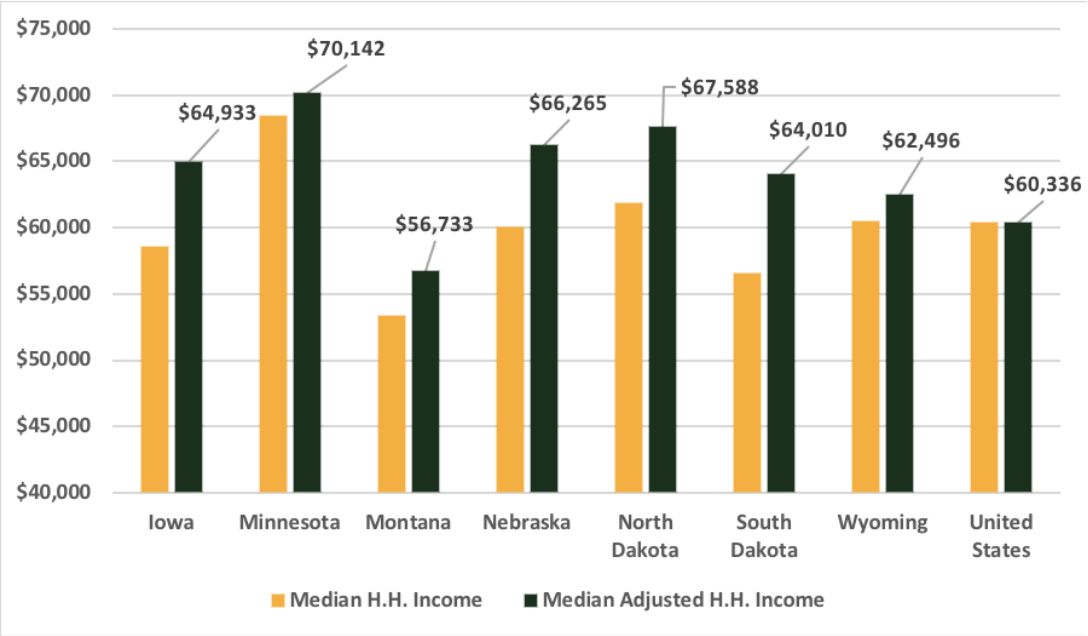
Source: Bureau of Labor Statistics, Quarterly Census of Employment and Wages, 2010 and 2017.

A.4.2 Household Income and Poverty

Median household income in South Dakota was $56,521 in 2017, almost $4,000 less than the national median. Out of 50 states, the District of Columbia, and Puerto Rico, South Dakota ranked 30th, between Arizona and Kansas. Among its neighbors, median household income in South Dakota was only greater than Montana. However, median household income may be misleading if we do not account for price variations among the states. It is cheaper to live in South Dakota than, say, California.

Figure 15 below illustrates median household income for South Dakota and neighboring states and median household income adjusted for regional price differences. Prices in South Dakota were 11.7 percent less than the national average in 2016. In fact, South Dakota had the lowest regional price parity index among its neighbors, reflecting the value in living in the state. While South Dakota's unadjusted household income is below that of the U.S., its price adjusted median household income was almost four thousand dollars greater than the median for the United States. Simply put, a dollar goes farther in South Dakota than in more populous states such as California or New York.

Figure 15. Median Household Income and Median Adjusted Household Income, 2017
2016 Inflation-Adjusted Dollars



Source: U.S. Census Bureau, 2017 American Community Survey and U.S. Bureau of Economic Analysis, 2016 Implicit Regional Price Parities Index.

In Table 5, we present inflation and price adjusted median household income by race. For South Dakota, an immediate economic challenge is apparent. Median household income for Black-African American and American Indian households was the lowest among the selected states. Given that approximately 8 percent of the population in South Dakota is American Indian, it is an economic imperative to create economic opportunities to reduce poverty. As we will discuss later, a lack of access to a high-quality broadband connection is one feature shared among many households in poverty.

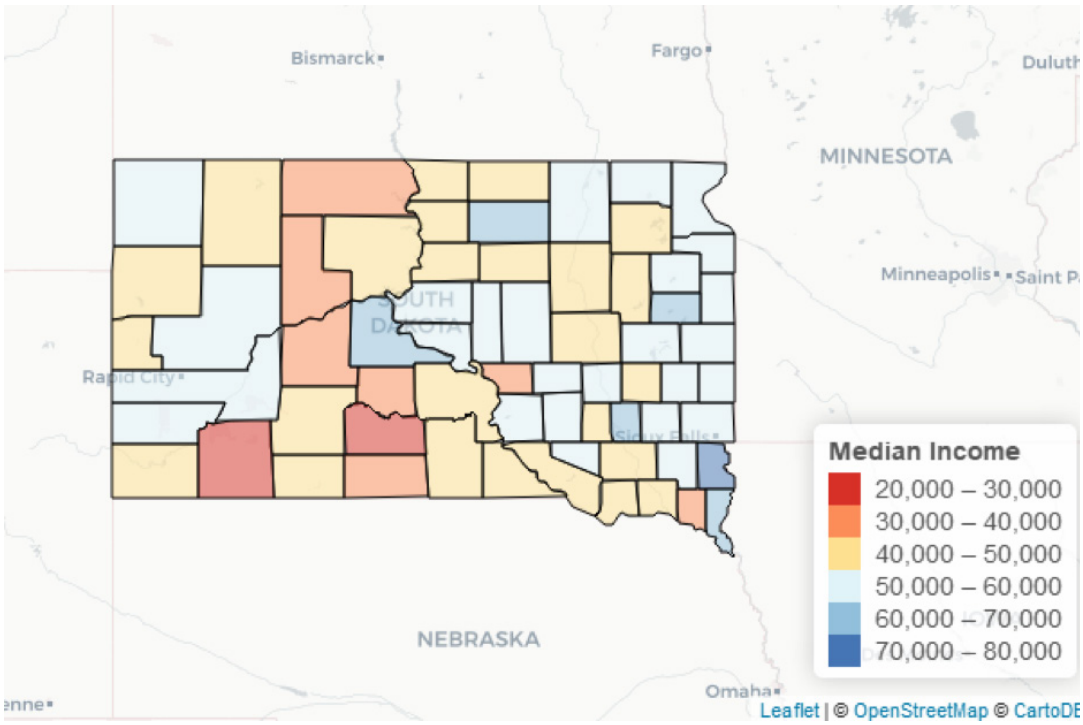
Household incomes are, as with jobs and population, not equally distributed throughout South Dakota (Figure 16). Oglala Lakota County and Mellette County, with median household incomes of $26,330 and $29,471, respectively, had the lowest reported values for the state in 2016. At the other end of the spectrum, Lincoln County's median income of $77,455 was almost three times that of Oglala Lakota County. The unequal distribution of incomes is closely correlated with economic opportunity and employment.

Table 5. Median Household Income by Race, 2016 Inflation and Regional Price Parity Adjusted Dollars, 2017 American Community Survey

State	All	White	Black or African American	American Indian	Asian	Two or More Races
Iowa	$64,933	$66,542	$34,191	$42,634	$73,775	$73,775
Minnesota	$70,142	$73,382	$39,125	$37,858	$76,683	$76,683
Montana	$56,733	$58,126	$44,676	$35,490	$68,262	$68,262
Nebraska	$66,265	$68,225	$39,418	$46,864	$66,804	$66,804
North Dakota	$67,588	$70,178	$41,760	$32,303	$53,734	$53,734
South Dakota	**$64,010**	**$67,781**	**$30,639**	**$27,616**	**$59,499**	**$59,499**
Wyoming	$62,496	$62,986	..	$45,802	$45,745	$45,745
United States	$60,336	$63,704	$40,232	$41,882	$83,456	$56,519

Source: United States Census Bureau, American Community Survey 2017, 1-Year Estimates. See notes for Table 3. Black or African-American median household income is not available for Wyoming due to data identification concerns.

Figure 16. South Dakota, Median Household Income by County, 2012-2016



Source: U.S. Census Bureau, 2012-2016 American Community Survey 5-Year Estimates.

The contrasts between Oglala Lakota County and Lincoln County serve to remind us that South Dakota's prosperity and economic growth have not been shared universally. South Dakota ranks 27th among the 50 states, District of Columbia, and Puerto Rico in terms of the percentage of population who are below the poverty level. Thirteen percent of South Dakota residents have incomes below the poverty level, slightly below the 13.4 percent poverty rate at the national level. A higher percentage of South Dakota residents, however, are below the poverty level when compared to neighboring states.

Table 6 breaks down poverty status by state and gender for 2017. Compared with neighboring states, South Dakota has the largest share of individuals below the poverty line. Women are more likely to be below the poverty line.

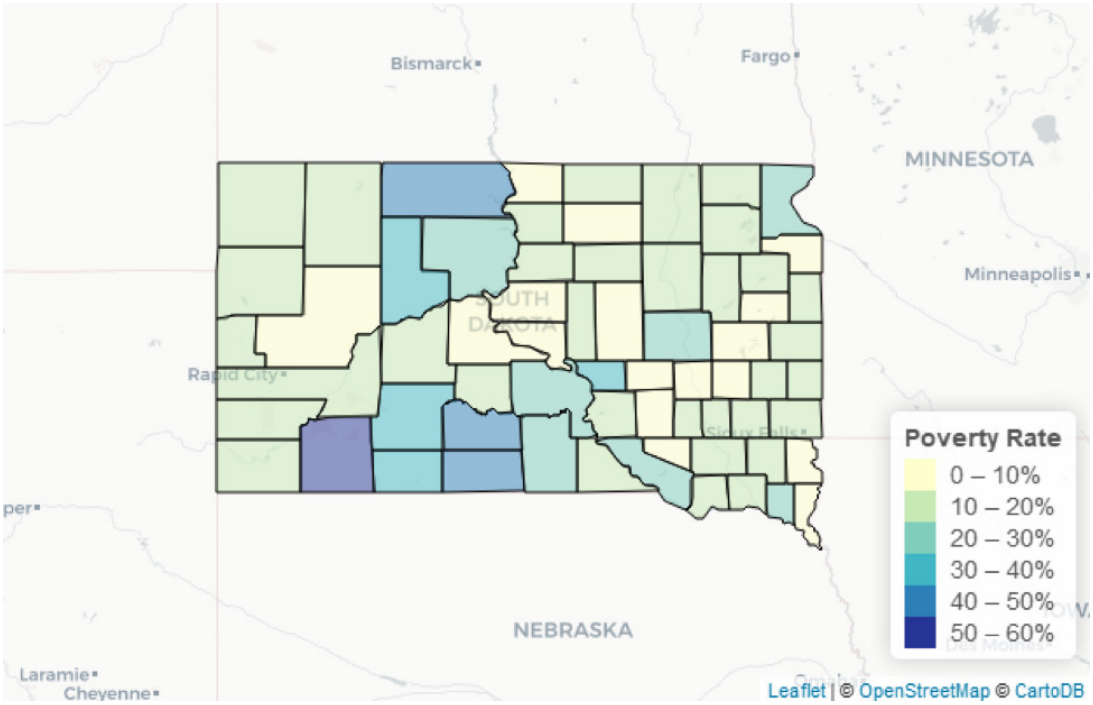
Table 6. Percent of Population Below Poverty Level, 2017 American Community Survey

State	All	Male	Female
Iowa	10.7%	9.8%	11.7%
Minnesota	9.5%	8.6%	10.4%
Montana	12.5%	11.4%	13.6%
Nebraska	10.8%	9.5%	12.0%
North Dakota	10.3%	8.9%	11.9%
South Dakota	**13.0%**	**12.0%**	**14.0%**
Wyoming	11.3%	10.5%	12.2%
United States	13.4%	12.2%	14.5%

Source: United States Census Bureau, American Community Survey 2017, 1-Year Estimates. Margin of errors are available upon request.

At the county level, poverty rates varied from a low of 3.7 percent in Lincoln County to 54.0 percent in Oglala Lakota County in 2016. Figure 17 illustrates the disparity in poverty rates among South Dakotan counties. Dewey County (population 5,835 in 2017) lies almost entirely within the Cheyenne River and Standing Rock Indian reservations. The U.S. Census Bureau reported that, for 2016, 76.6 percent of the residents of Dewey County were Native American and 20.8 percent were White. Median household income was $40,585, almost $19,000 lower than the state median and 27.6 percent of residents lived below the poverty line. While the labor force participation rate was 66.9 percent in 2016, the unemployment rate was 24.6 percent, almost 6 times that of the state. Dewey County compares favorably to Oglala Lakota County where the labor force participation rate was 46.6 percent and the unemployment rate was 28.1 percent in 2016.

Figure 17. Percent of Population Below Poverty Level, South Dakota, 2012-2016



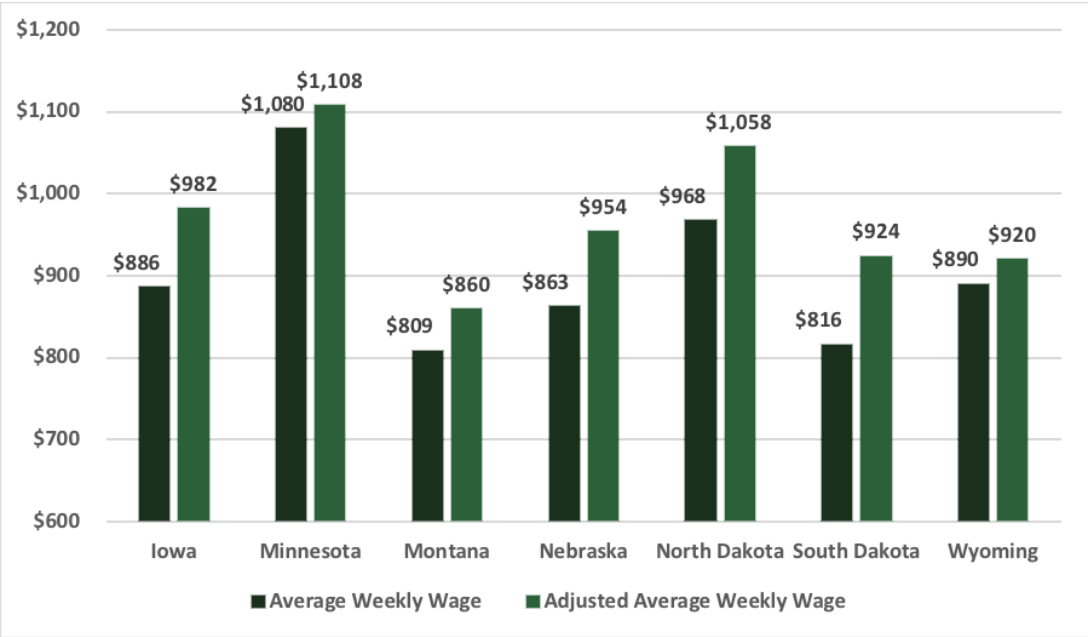
Source: U.S. Census Bureau, 2012-2016 American Community Survey 5-Year Estimates.

A.4.3 Wages

Poverty is, in part, a result of a lack of economic opportunity and, even when employment presents itself, relatively low wages. While wages reflect the demand and supply for labor, wages also reflect local conditions. A $15 an hour wage in Sioux City is likely to 'go farther' than the same wage in Los Angeles. California's regional price parity in 2016 was 114.4, indicating the cost of living there is more than 14 percent above the national average or about 27 percent higher than South Dakota. At the end of the day, South Dakota remains a low wage state, but after adjusting for living costs, workers in South Dakota earn only 11 to 12 percent per week less than the national average.

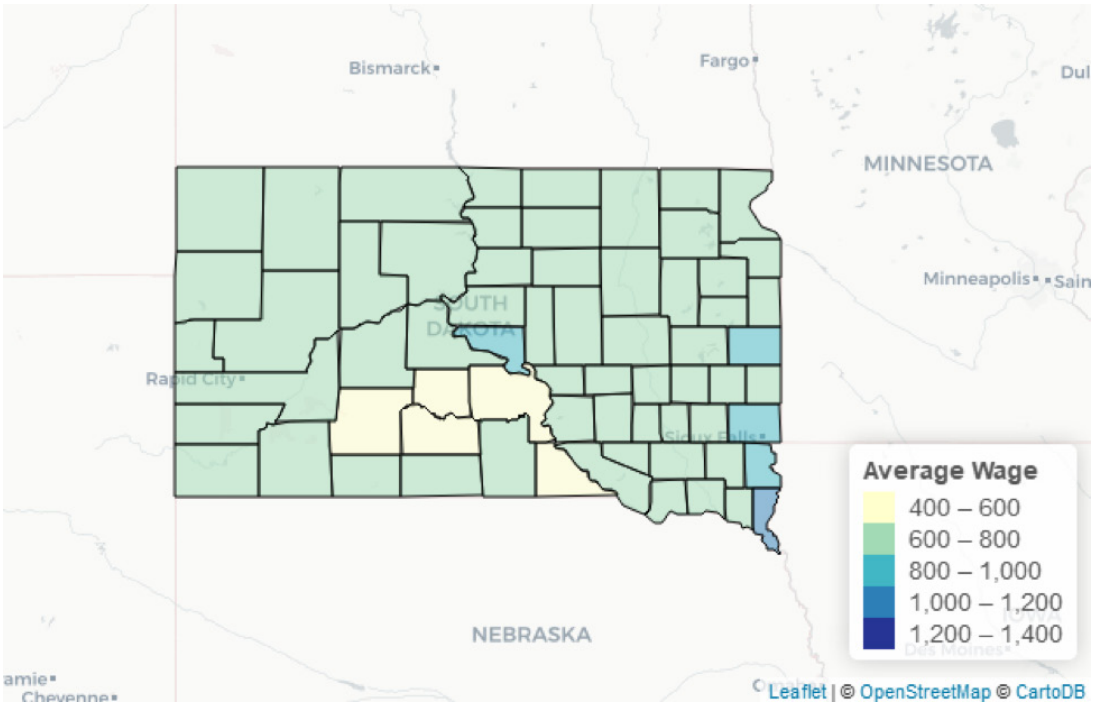
In Figure 18 below, we present the annual average weekly wage for South Dakota and neighboring states. We also adjust the annual average wages for regional prices to reflect the variations in the cost of living among the states. While the average annual weekly wage in South Dakota only exceeded that of Montana in 2017, when we account for regional prices, wages in South Dakota also exceed that of Montana. Wages in South Dakota, however, do lag the remaining neighboring states.

Figure 18. Average Annual Weekly Wages 2017



Source: Bureau of Labor Statistics, Quarterly Census of Employment and Wages, 2017. Annual averages.

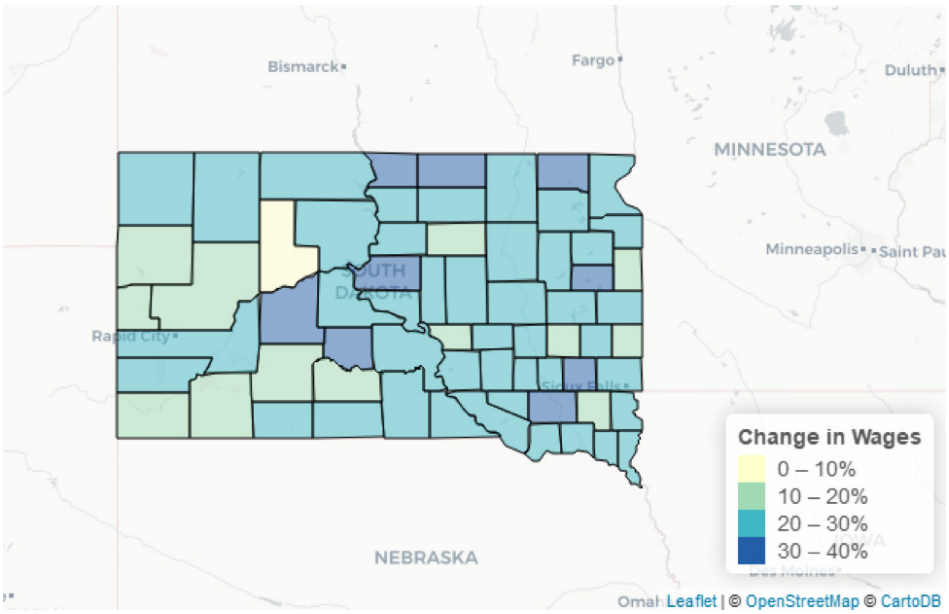
Figure 19. Average Weekly Wages South Dakota, 2017



Source: Bureau of Labor Statistics, Quarterly Census of Employment and Wages, 2017. Annual averages.

Figure 19 above illustrates that wages vary significantly across South Dakota. Wages tended to be the highest in the southeastern corner of the state. Union County ($1,047/week), Lincoln County ($932/week), and Minnehaha County ($913) had the highest weekly wages on average in 2017. No other county had an average weekly wage above $900 a week in 2017. Mellette County ($493/week), Jones County ($558/week), and Jackson County ($561/week) had the lowest average wages in South Dakota in 2017. The combination of a lack of jobs and low wages for those jobs that do exist plays a significant role in the relatively low labor force participation rates in these counties and higher rates of unemployment.

Figure 20. Percentage Change in Nominal Average Weekly Wages South Dakota, 2010-2017



Source: Bureau of Labor Statistics, Quarterly Census of Employment and Wages, 2017. Annual averages.

Wages evolve over time (Figure 20 above). Ziebach County and Oglala Lakota County had the lowest wage growth from 2010 to 2017. Ziebach County, however, is roughly one-sixth the size of Oglala Lakota County with a population of 2,756 in 2017, so the number of individuals affected was less than Oglala Lakota County. Nevertheless, Ziebach County's wage growth of 5 percent and Oglala Lakota County's growth of 12.8 percent reflects a dearth of economic opportunities. Some smaller counties, including Haakon County (38.9 percent) and Sully County (36.6 percent), saw wage growth that was about 3 times greater than the poorest performers. Wages also grew by over 20 percent in Minnehaha and Pennington County.

South Dakota's low wage situation does not appear to be problematic. As noted above, the state enjoys net in-migration of individuals from other states and net international migration from other countries. All things considered, workers are finding South Dakota an attractive place to be. For employers, low wages and low living costs are a boon and enable them to be more cost competitive in the markets in which they compete. The state's economic development message stresses this point.

A.4.4 Personal and Business Tax Competitiveness

Taxes constitute another important cost to business firms and individuals. Make no mistake—South Dakota is a low-tax state. South Dakota does not have an individual income tax or a corporate income tax, a policy decision that creates a favorable environment for investment and business activity. As illustrated in Table 7, South Dakota's state and local tax burden, measured as a percent of state income, ranked 49th among the 50 states in 2012 (Tax Foundation, 2016). The relatively low tax burden places South Dakota at a distinct advantage in the economic development arena. If individuals 'vote with their feet' with respect to taxes, then South Dakota's favorable tax environment should be considered an attractive force relative to higher tax states.

South Dakota also fares well with regards to state and local sales taxes. Table 8 presents state and average local sales tax rates for South Dakota and neighboring states. Among its neighbors, South Dakota is only bested by Wyoming (lower state and local sales tax rates) and Montana (which has no state or local sales tax). South Dakota's sales tax base, however, is broader than many neighboring states and South Dakota ranked 7th with regards to state and local general sales tax collections per capita in 2016 (Walczak & Drenkard, 2018).

Table 7. State-Local Tax Burden as Percent of State Income 2012

State	Rank	State-Local Tax Burden as Percent of State Income	State-Local Tax Burden per Capita
Iowa	31	9.2%	$4,037
Minnesota	8	10.8%	$5,185
Montana	38	8.7%	$3,389
Nebraska	30	9.2%	$4,197
North Dakota	33	9.0%	$4,867
South Dakota	**49**	**7.1%**	**$3,318**
Wyoming	48	7.1%	$4,407
United States Average	--	9.9%	$4,420

Source: Tax Foundation (2016), "State-Local Tax Burden Rankings, FY 2012."

States also levy taxes on real property (Table 9). Drawing comparisons across states is difficult due to the variations in tax structures. Homestead exemptions and millage rates vary across states (and sometimes localities). Some states have equalization agreements while others do not. As a percentage of owner-occupied value, South Dakota ranks as the 16th highest state. With regards to property tax collections per capita, however, South Dakota ranks 27th, suggesting that property taxes are not as onerous as the estimated mean rate suggests (Walczak, 2016).

Table 8. State and Local Sales Tax Rates as of January 1st, 2018

State	Rank	State Sales Tax Rate	Average Local Sales Tax Rate	Combined Sales Tax Rate	Combined Ranking	Sales Tax Collections per Capita Rank
Iowa	16	6.00%	0.80%	6.80%	27	25
Minnesota	6	6.875%	0.55%	7.72%	17	26
Montana	46	0.00%	0.00%	0.00%	46	46
Nebraska	29	5.50%	1.39%	6.89%	25	22
North Dakota	33	5.00%	1.80%	6.80%	26	3
South Dakota	**37**	**4.50%**	**1.90%**	**6.40%**	**31**	**7**
Wyoming	40	4.00%	1.46%	5.46%	43	4

Source: Tax Foundation (2016), "State-Local Tax Burden Rankings, FY 2012". States with no state or local sales taxes rank 46th.

Table 9. State and Local Property Tax Rates as of January 1st, 2018

State	Rank	State Estimated Property Tax Rate	Property Taxes Paid as Percentage of Owner-Occupied Value	State and Local Property Tax Collections per Capita	Property Tax Collections Rank
Iowa	13	1.42%	1.44%	$1,569	15
Minnesota	19	1.09%	1.12%	$1,534	17
Montana	33	0.75%	0.76%	$1,509	19
Nebraska	7	1.65%	1.67%	$1,895	12
North Dakota	25	0.95%	1.00%	$1,222	30
South Dakota	**16**	**1.22%**	**1.21%**	**$1,381**	**27**
Wyoming	47	0.51%	0.55%	$2,347	6

Source: Tax Foundation (2016), "How High Are Property Taxes in Your State?"

A favorable property tax environment is undoubtedly conducive to private investment. We also recognize that property taxes are not only paid by homeowners but also renters as these taxes are often capitalized in rents. Higher property taxes lead to higher rents, increase costs of doing business, and, all else being equal, discourage private investment.

South Dakota's decision to reform its tax and legal structure to provide a more conducive environment to business investment has spurred employment and wage growth for the state. Table 10 presents the business tax climate rankings from the Tax Foundation. While no ranking is perfect, South Dakota fares well nationally and regionally. Among the 50 states and the District of Columbia, South Dakota ranked 2nd, placing only behind Wyoming (Walczak, Drenkard, & Bishop-Henchman, 2017). While some challenges appear to remain, specifically with regards to the costs of unemployment insurance relative to other states, South Dakota's stance towards private businesses is commendable.

Table 10. 2018 State Business Tax Climate Index

State	Overall Rank	Corporate Tax Rate	Individual Income Tax Rank	Sales Tax Rank	Unemployment Insurance Rank	Property Tax Rank
Iowa	40	48	33	19	34	39
Minnesota	46	43	45	25	37	28
Montana	6	12	21	3	28	9
Nebraska	25	28	24	13	9	40
North Dakota	30	16	36	34	14	2
South Dakota	**2**	**1**	**1**	**33**	**39**	**25**
Wyoming	1	1	1	6	33	34

Source: Tax Foundation (2017), 2018 State Business Tax Climate Index.

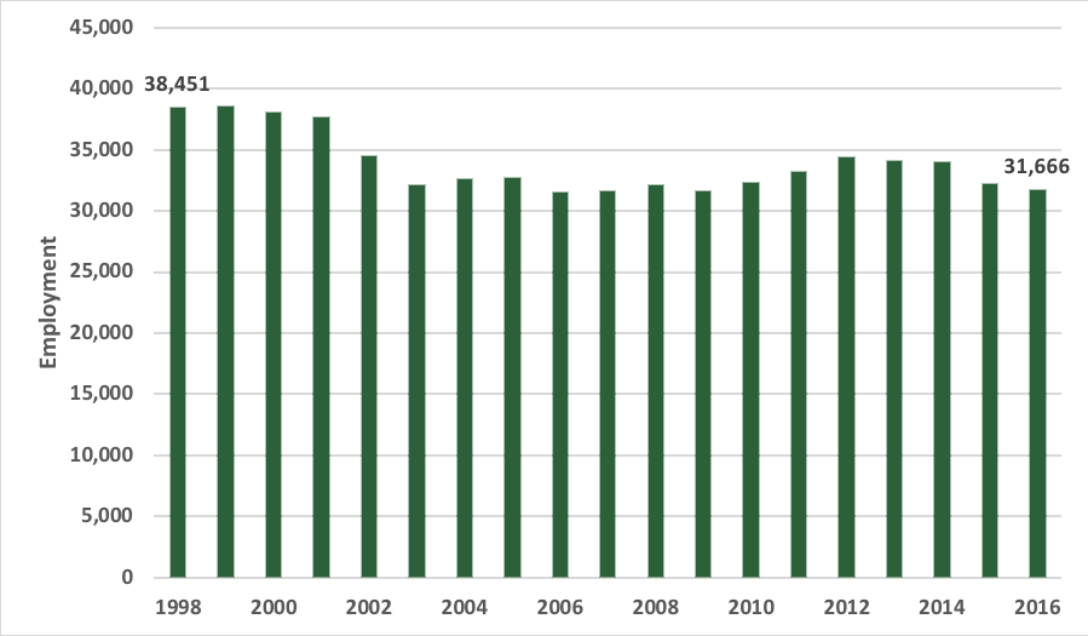
A.5 Economic Pillars: Health Care, Finance, and Agriculture

While agriculture is a traditional Midwestern commercial anchor, the ideal that agriculture is the largest employer and contributor to Gross Domestic Product (GDP) has faded into the past. The emergence of the financial sector and the continued expansion of health care and social insurance signal a continuing transition of the South Dakota economy.

A.5.1 The Changing Nature of Employment in South Dakota

Figure 21 illustrates that the number of full and part-time employees in the agricultural industry has declined over the last two decades. The decline in agricultural employment is tightly correlated with declines in population for many rural counties in South Dakota. While the rural economy has grown over time, the gains in economic activity have been driven by productivity, not gains in employment. Simply put, less people are producing more output. Rural wage growth has also lagged that of the metropolitan areas, creating an economic incentive for people to move, that is, people are following jobs and higher wages.

Figure 21. South Dakota Total Full-Time and Part-Time Farm Employment, 2016



Source: U.S. Bureau of Economic Analysis, Table SA25N, Total Full-Time and Part-Time Employment by Industry, 2016.

Table 11 displays total full-time and part-time employment by industry in South Dakota in 2016. The Health care and social assistance industry and retail trade industry each employed over 69,000 residents of South Dakota. 23 percent of employment in South Dakota was in these two industries. State and local government, manufacturing, and accommodation and food services rounded out the top five industries in terms of total employment.

Table 11. South Dakota, Total Full-Time and Part-Time Employment by Industry, 2016

Industry	Total Employment	Percent of Total Employment
Health care and social assistance	69,162	11.5%
Retail trade	69,037	11.5%
State and local government	65,999	11.0%
Manufacturing	44,490	7.4%
Accommodation and food services	44,488	7.4%
Finance and insurance	38,967	6.5%
Construction	34,578	5.8%
Farm employment	31,666	5.3%
Other services	30,837	5.1%
Real estate and rental and leasing	24,988	4.2%
Wholesale trade	23,756	4.0%
Professional, scientific, and technical services	22,017	3.7%
Administrative and support and waste management and remediation services	18,421	3.1%
Transportation and warehousing	16,643	2.8%
Arts, entertainment, and recreation	11,453	1.9%
Federal civilian	11,362	1.9%
Educational services	10,788	1.8%
Military	7,888	1.3%
Information	6,906	1.2%
Management of companies and enterprises	5,686	0.9%
Forestry, fishing, and related activities	5,418	0.9%
Mining, quarrying, and oil and gas extraction	2,883	0.5%
Utilities	2,154	0.4%

Source: U.S. Bureau of Economic Analysis, Table SA25N, Total Full-Time and Part-Time Employment by Industry, 2016. Other services exclude government activities.

Two sectors deserve attention: farming and finance and insurance. In 2000, farming accounted for 7.4 percent of full and part-time employment in South Dakota. By 2016, the decline in employees and growth in other industries meant that farming accounted for only 5.3 percent of all employees. While almost 32,000 South Dakotans were employed in farming in 2016, increases in productivity and employment growth in metropolitan areas are likely to lead to further declines in farming's share of total state employment in the future.

The finance and insurance industry have grown significantly since 2000, though this growth has tapered in recent years. In 2000, finance and insurance employed about 30,000 residents in South Dakota or 5.9 percent of all employees. In 2016, almost 39,000 residents were employed in this industry, down approximately 500 employees from 2015. The challenge for South Dakota is to retain its favorable business climate with regards to this industry and fend off challenges from other tax and credit-card rate favorable industries. As discussed below, prudent investments in education, workforce development, and infrastructure will be necessary to maintain (and possibly extend) South Dakota's favorable business climate.

Drawing back, we can examine the growth in employment in South Dakota from 1998 to 2016. We construct an index that is equal to 100 in 1998 and represents the growth or decline of each industry relative to 1998. As illustrated above in Table 12, while total non-farm employment increased by 25.4 percent over this period, total farm employment declined by 17.6 percent.

Table 12. South Dakota, Total Full-Time and Part-Time Employment by Industry, 1998 – 2016

Industry	Index of Employment (1998 = 100)
Real estate and rental and leasing	214.2
Professional, scientific, and technical services	165.6
Educational services	156.1
Management of companies and enterprises	154.8
Finance and insurance	142.9
Health care and social assistance	139.5
Mining, quarrying, and oil and gas extraction	135.7
Arts, entertainment, and recreation	132.2
Wholesale trade	131.6
Construction	131
Accommodation and food services	129.1
Nonfarm employment	125.4
Administrative and support and waste management and remediation services	124.6
Other services	120.7
Transportation and warehousing	119.4
State and local	115.8
Retail trade	110.1
Federal civilian	105.7
Manufacturing	103.1
Utilities	97.2
Military	95.5
Information	90.6
Farm employment	**82.4**

Source: U.S. Bureau of Economic Analysis, Table SA25N, Total Full-Time and Part-Time Employment by Industry, 2016. Other services exclude government activities.

On the other hand, the real estate industry doubled in terms of employment since 1998, followed by professional services, education, management of companies, and finance and insurance. The empirical evidence undermines the perception that agriculture dominates the South Dakota economy.

A.5.2 Contributions to Gross Domestic Product

If we focus, however, on the contribution of economic sectors to the South Dakota's Gross Domestic Product (GDP), then the finance, insurance, real estate, rental, and leasing sectors are the most important. As Table 13 reveals, fully one-quarter of the value of South Dakota's economic activity is generated by finance, insurance, real estate, rental, and leasing, dwarfing that sector's approximate 10.7 percent share of the state's employment. The state's traditional economic base, agriculture, accounted for 5.3 percent of total employment and 6.6 percent of economic output.

The finance, insurance, real estate, rental, and leasing sectors generated about $12.5 billion dollars of economic output in 2017. Within this industry, the finance and insurance sub-industry generated more than 50 percent of the total, accounting for $7.6 billion dollars of output. In other words, the finance and insurance sector generated more than 15 percent of South Dakota's GDP in 2017.

Table 13. Gross Domestic Product, South Dakota, 2017, Millions of Current Dollars

Industry	2017 Contribution to State GDP	Percentage Contribution to State GDP
Finance, insurance, real estate, rental, and leasing	$12,554	25.1%
Government and government enterprises	$5,837	11.7%
Educational services, health care, and social assistance	$4,930	9.9%
Manufacturing	$4,789	9.6%
Wholesale trade	$3,684	7.4%
Retail trade	$3,645	7.3%
Agriculture, forestry, fishing, and hunting	$3,307	6.6%
Professional and business services	$2,864	5.7%
Construction	$2,061	4.1%
Arts, entertainment, recreation, accommodation, and food	$1,833	3.7%
Transportation and warehousing	$1,179	2.4%
Information	$1,130	2.3%
Other services	$1,109	2.2%
Utilities	$839	1.7%
Mining, quarrying, and oil and gas extraction	$168	0.3%
Total	$49,929	

Source: U.S. Bureau of Economic Analysis, Gross Domestic Product by State. 2017 Annual data. Other services exclude government and government enterprises.

Real estate, rental, and leasing generated almost $5.0 billion dollars of output in the same year, accounting for almost 10 percent of South Dakota's GDP. The value produced by this industry can be directly traced to the favorable business climate in South Dakota.

The importance of finance in the economic life of South Dakota is visibly reflected in the presence of more than a half-dozen significant credit card companies in Sioux Falls and their supporting financial institutions. More than 29 percent of the state's population now resides in the Sioux Falls metropolitan area and average wage levels there are significantly higher than many other parts of the state. The Sioux Falls metropolitan area has also evolved into a significant medical center, and the largest two individual employers in the city are Sanford Health (9,600 workers) and Avera Health (7,000 workers in Sioux Falls and 16,000 statewide) (Fugleberg, 2018; Vanek Smith, 2009).

The importance of financial services, health care, agriculture, and tourism in the economic scene in South Dakota underlines the extent to which the state's economic base has evolved. In important ways, the South Dakota economy now more closely resembles those in more urbanized states along the nation's two coasts. However, just as it would be a mistake to ignore South Dakota's economic evolution, it would also be an error to overemphasize it. The most significant economic changes largely have been concentrated in two areas: the eastern edge of the state and the Black Hills region. Rapid City (with 74,000 residents in 2017 in its metropolitan region) gradually has transformed into a health care center and economic engine for the western end of the state. Outside of these metropolitan regions, the state retains its rural, agriculture-oriented character. Agriculture remains king in many rural areas, and declines in agricultural employment have led to declines in population. The challenge now is how to foster growth outside the metropolitan areas, otherwise economic activity and the population will continue to leave the countryside.

A.6 Education

Few things are more critical to economic progress and civic welfare than education. South Dakota presents a mixed picture in this regard. On one hand, the overall educational attainment of its citizens exceeds national averages at the K-12 level. Table 14 provides data on educational attainment for the population 25 years and older. Twelve percent of Americans failed to graduate high school according to the latest data from the U.S. Census, compared to 8.3 percent of South Dakotans. High school graduation rates are also higher in South Dakota, with 91.7 percent of adults having at least graduated from high school.

Educational attainment begins to taper off at the college level, however. While 28.1 percent of the state's residents have earned a bachelor's, graduate, or professional degree, this trails the United States average of 32.0 percent. Historically, this reflected the agricultural roots of the state and the perception that a college education was not necessary to farm or be otherwise engaged in agriculture. It is interesting to note that the gap between South Dakota and the United States disappears when we look at individuals aged 25 to 34. For this age group, roughly the same percentage of South Dakotans and Americans nationwide have completed a bachelor's degree or more (United States Census Bureau, 2018a).

While we recognize it is difficult to measure the quality of education, we follow accepted practice and utilize standardized test scores. There are two standardized tests available: the American College Test (ACT) and the Scholastic Aptitude Test (SAT). High school juniors and seniors take these exams as part of their effort to gain admission to institutions of higher learning. While 78 percent of South Dakota students took the ACT in 2016, only 3 percent took the SAT. The ACT scores are a better representation of educational outcomes in South Dakota.

Table 14. Educational Attainment, 2017 Population, 25 Years and Older

Educational Attainment	South Dakota	United States
Less than 9th Grade	2.9%	5.1%
9th to 12th Grade, No Diploma	5.4%	6.9%
High School Graduate	30.8%	27.1%
Some College, No Degree	22.0%	20.4%
Associate's Degree	10.8%	8.5%
Bachelor's Degree	19.1%	19.7%
Graduate or Professional Degree	9.0%	12.3%
High School Graduate or Higher	91.7%	88.0%
Bachelor's Degree or Higher	28.1%	32.0%

Source: U.S. Census Bureau, 2017 American Community Survey 1-Year Estimates.

Figure 22 presents the average ACT score achieved by students in South Dakota and neighboring states. The scores in Figure 22 have been adjusted to reflect participation rates. Low participation rates for a state often mean that only the most talented students in that state take an exam (Zhang, 2016). States with higher participation rates invariably have lower average ACT scores as the distribution of student aptitude is larger relative to states that have lower participation rates.

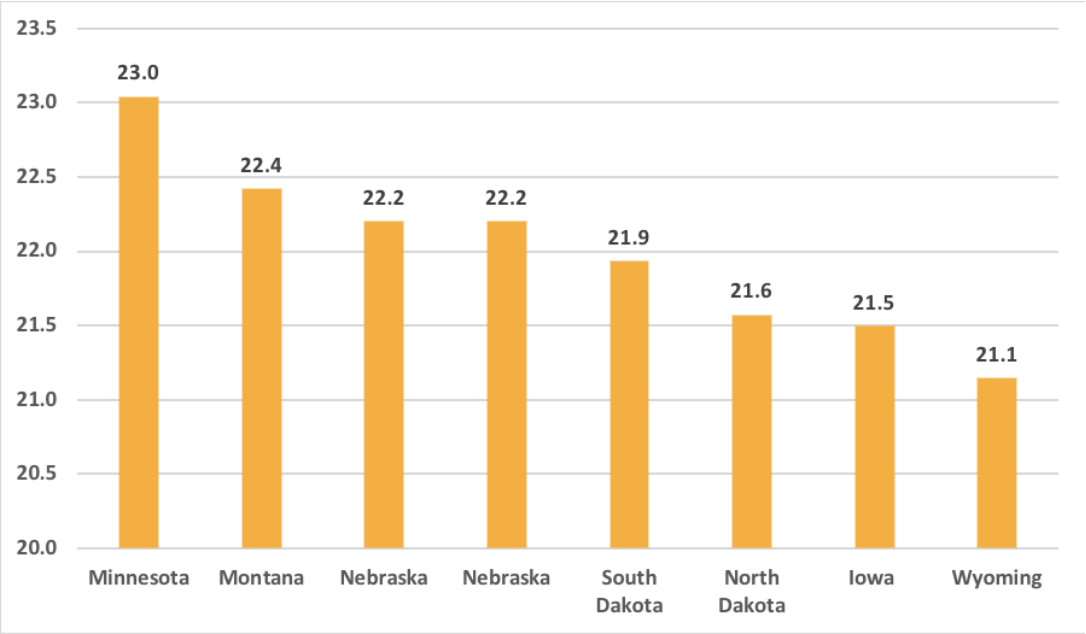
Regardless, students in South Dakota performed well on the ACT examination in comparison with their neighbors. If such scores are an appropriate measure of what students have learned and know at the end of their K-12 careers, then South Dakota's K-12 education system appears to be performing adequately in preparing students for college.

Modern economies typically thrive on technologically-driven developments and innovations generated by scientists and engineers. Frequently, these advances originate on university campuses. For that reason, the level of research and development activity on state university campuses is an important consideration.

One can see in Figure 23 that South Dakota's two flagship public universities, the University of South Dakota and South Dakota State University, do not fare so well in this regard. Together, their total research and development expenditures in 2016 were not even one-tenth of the those of the University of Minnesota, less than one-fifth of the University of Iowa (both are Big Ten institutions, of course), and less than one-half of the University of Montana and Montana State University combined.

South Dakota's laggard performance in this arena reflects several factors, one of which is the not especially generous levels of funding provided by the South Dakota legislature.

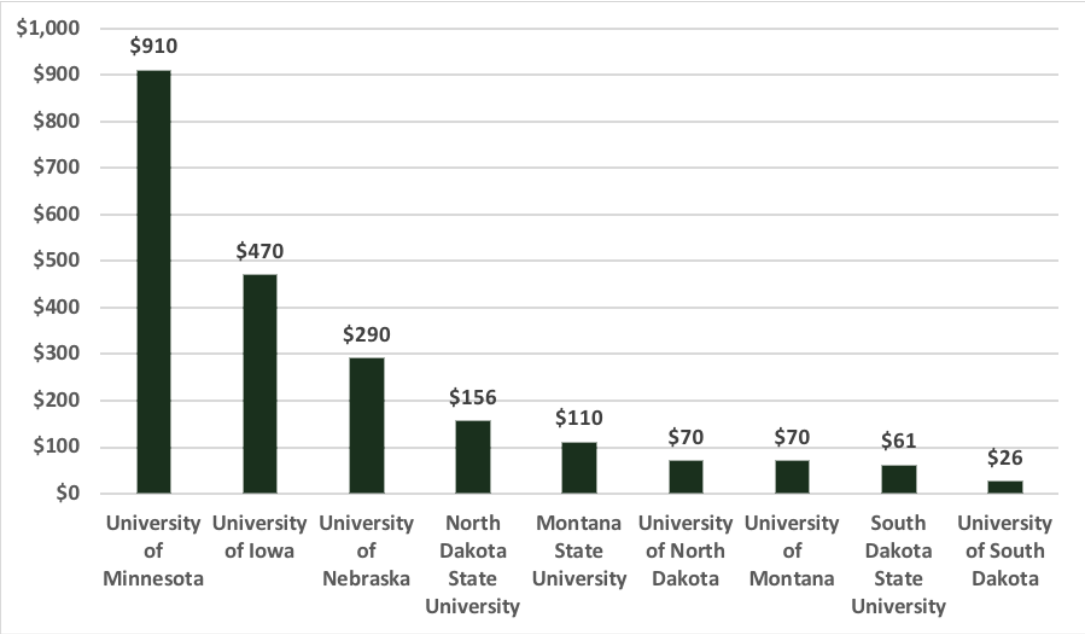
Figure 22. Average ACT Scores for Selected States, Adjusted for Participation, 2016



Source: Fred Zhang (2016), "Average SAT & ACT Scores Adjusted by State."

However, it also is true that the economic development path the state fortuitously chose in the 1980s (changing its banking laws to accommodate large financial institutions) is less dependent upon scientific and engineering research and development than possible alternatives focusing on the Internet, hard science, and engineering innovations. This fact underlines, however, how sensitive the state's economic prosperity is to banking laws and regulations. The reality is that the state does not possess a highly visible alternative path it might pursue instead.

Figure 23. Total State University Research and Development Expenditures, 2016, Millions of Dollars



Source: National Science Foundation, Rankings by total R&D Expenditures, 2016.

A.7 Putting It All Together

How attractive is South Dakota as a place to do business? CNBC has produced the most recent ranking of the economic climates across states. CNBC's rankings reflect 60 different measures of economic competiveness, ranging from the quality of a state's workforce and infrastructure to its cost of living and taxes. There are many different measures of economic performance and competitiveness, however, these rankings tend to be in general agreement. Table 15 presents CNBC's overall rankings for a number of states and its rankings for the states in several of its categories (CNBC, 2018). South Dakota's ranking (20th among the 50 states) was diminished by its below average scores in workforce and technology.

While South Dakota is judged to perform well on the cost of doing business (9th overall), the low cost of doing business is not the only thing that makes a location attractive to a business. Washington, for example, ranked only 33rd among the states in terms of the cost of doing business, yet ended up ranked second overall, substantially because of its excellent workforce and strong technology base. Infrastructure also remains a challenge for South Dakota, illustrating that there are substantial competitive reasons for investments to improve broadband and other associated technologies.

Table 15. CNBC's Rankings of the Business Climates of the 50 States

State	Overall Ranking	Workforce Ranking	Cost of Doing Business	Quality of Life	Technology
Texas	1	7	18	31	9
Washington	2	2	33	5	6
Utah	3	11	23	12	19
Virginia	4	3	34	19	15
Colorado	5	5	37	9	7
Nebraska	14	22	2	37	31
Iowa	18	39	6	34	26
South Dakota	**20**	**30**	**9**	**16**	**41**
California	25	12	48	21	1
North Dakota	29	30	29	4	42
Montana	34	45	14	7	39
Delaware	38	14	41	39	24
Mississippi	49	41	22	42	46
Alaska	50	33	47	25	45

Source: CNBC, "America's Top States for Doing Business," July 10, 2018.

Delaware remains one of South Dakota's major competitors in the financial services arena but is ranked by CNBC as only 38th among states in terms of its overall business climate. This suggests once again that the legal structure with which firms must deal is a very important determinant of where they choose to locate. Neither Delaware nor South Dakota are highly ranked with regards to infrastructure, suggesting that there is a possible competitive advantage to be had for a state willing to foster a climate that promotes investments in infrastructure. Of concern for South Dakota is its relatively poor ranking in technology, 41st out of 50 states.

If South Dakota wishes to broaden its economic base and participate in the scientific and engineering developments that propel many other states, it must consciously promote investments in technology. In the short-term, South Dakota should examine how to foster a climate to promote private investments in infrastructure that would be a complementary (and relatively low-cost) effort to increase investments in public research and development. South Dakota has experience in creating a favorable environment for the financial industry and should seek to lower artificial barriers to entry, continue to promote a favorable tax and business climate, and adapt its education system to produce a technologically-proficient workforce. Without public-private partnerships, South Dakota may continue to lag in the business rankings and fall further behind in retaining and attracting business investment.

A.8 Conclusion

South Dakota's economy has grown more rapidly than that of the United States, and its rate of unemployment has been consistently lower than the national rate.

Financial and related services now account for one-quarter of the value of South Dakota's output. The financial value-added per employee in the financial sector is substantially higher than health care (which employs more people) or agriculture (which has been a mainstay of the South Dakota economy). The *Marquette* decision in 1978 opened vast new opportunities for states to make themselves more attractive to financial services firms and banks. South Dakota was a first-mover among the states in this regard and has reaped the benefits over time.

If there is a problem here, it is that this success has caused the state to ignore other opportunities, notably in engineering, the sciences, and technology. South Dakota placed its economic bets on the continued prosperity of the financial services industry inside the state. Changes in the legal climate brought about by new court decisions and populist laws could potentially injure South Dakota. Technological advances could render it unnecessary for financial firms to have employees' feet on the ground in South Dakota. We cannot predict either, but prudent public policy makers in South Dakota should not ignore these possibilities.

Appendix B: Quality of Life Interviews & Web Survey Results

B.1 Introduction

The primary research question for this portion of the study was: *How does access (or lack of access) to broadband, and, in particular, mobile broadband affect the daily lives of people in rural communities?* As noted previously in this report, the population density of South Dakota is significantly lower, even in relatively more urban areas of the state, than many other metropolitan areas in the United States. The relatively low population density lowers the returns on scale for broadband providers, in particular, fixed broadband providers. Given the evolution of the consumption of the Internet towards mobile devices and the lower unit cost per customer of mobile broadband, we focused on mobile coverage, capacity, and speed in our interviews and surveys.

The Quality of Life (QOL) team consisted of researchers from the Social Science Research Center (SSRC) at Old Dominion University (ODU) and the University of South Dakota (USD). The team developed an in-depth interview protocol that included questions regarding:

- Current experiences and satisfaction with mobile phone/mobile data service providers regarding: speed, coverage, call clarity, call completion, and pricing/plan options.
- Limitations experienced with current smartphone/mobile phone.
- Impact of limitation on quality of life including: personal safety, personal finance, access to entertainment, and ability to perform work/school functions.
- Possibilities if improved connectivity were provided.
- Importance of improved cell service compared to other public services or infrastructure.

Respondents were also asked about willingness to change providers, concerns about the placement of towers and infrastructure, and (as appropriate) occupational/industry-specific functionality or issues with connectivity. The QOL team employed the following methodology to gather data about impacts including: (1) targeted snowball sampling starting from a sample of rural residents to provide qualitative context for the study; (2) in-depth interviews with community key informants to provide the framework for the broadband discussion to take place; and (3) a web-based survey, using a convenience sample of university students and rural residents, to obtain additional information about phone/data connectivity in more rural areas.[1] As a condition of the interviews and for human subjects research approval from the University, we have protected the identities of the interviewees and survey respondents throughout this report.

[1] As noted above, key informant interviews are qualitative interviews with individuals in a community that, by formal or informal position, understand the community. Key informants may be community leaders, professionals, or residents who have firsthand knowledge of a community.

A key member of the QOL team, Dr. David Earnest, is the chair of the Political Science Department at the University of South Dakota and Director of the W.O. Farber Center for Civic Leadership. As director for the Center, Dr. Earnest has many connections with community key informants across the state in the areas of public service, business, and higher education, as well as other organizations that would have an interest in potentially enhanced wireless service. He was also instrumental in recruiting university students to help conduct interviews.

The QOL team trained six USD students to conduct qualitative, in-depth interviews with people in their social circles and to ask for additional participants who might have useful experiences to share. This snowball approach proved useful as the respondents came from various areas in South Dakota as well as rural areas outside of the state. The team visited southeastern South Dakota in early September and established primary connections with key informants in Vermillion, South Dakota (population ~10,778) and quickly expanded to the nearby city of Yankton (population ~14,454).[2] These contacts led to interviews in smaller towns and places in southeastern South Dakota, such as Springfield (pop. ~1,950), Elk Point (pop. ~1,828), Tyndell (pop. ~1,049), Tabor (pop. ~413), and Wakonda (pop. ~321).

Recommendations from these contacts led to key informants in neighboring states' cities such as Akron, Iowa (pop. ~1,486) and Hartington, Nebraska (pop. ~1,700). Although the primary focus was on South Dakota, many respondents reported traveling and even living in contiguous states, thus the QOL team continued to reach out to additional residents and community representatives in South Dakota, Iowa, and Nebraska via email and telephone after concluding the on-site visit.

B.2 Decision to Use a Mixed-Methods Approach with Qualitative Interviews

One of the goals of this study was to understand the experiences and perceptions of rural residents regarding mobile technology and connectivity. Further, we wanted to understand those experiences and the impact on quality of life. The study team decided to use a qualitative approach to understand the social context of rural life as related to the issues of interest. Simply described, qualitative research is used to understand the deeper meaning of the "why" or the "how" of a phenomenon and includes data that is not easily reduced to numbers (Babbie, 1992). This contrasts with quantitative research which is more concerned with the measurement of "how many" and/or the causal and non-causal relationships between variables. "This means that qualitative researchers study things in their natural settings, attempting to make sense of, or interpret, phenomena in terms of the meanings people bring to them (Denzin & Luncoln, 2005)." Qualitative interviews were conducted which allowed the research team to "reach areas of reality that would otherwise remain inaccessible such as people's subjective experiences and attitudes (Denzin & Luncoln, 2005)."

The research focuses on a population—rural residents in South Dakota and surrounding rural areas.

[2] We note that we report Vermillion's 2017 population as measured by the United States Census. If we add in the 10,000 plus students from USD, the population would approach 22,000. As noted in this section, we conducted interviews with Vermillion residents and the student population.

The QOL team developed an interview protocol to address the overall research question and conducted multiple interviews to seek the patterns in experiences that will identify topics or issues of interest beginning with key informants. The use of key informants has a long history in the social sciences for collecting qualitative and quantitative data across a variety of social settings (Houston & Sudman, 1975; Seidler, 1974). The key informant technique has proven to be a particularly useful tool for qualitative research for surrounding issues of quality of life in rural and poor communities (Eby, Kitchen, & Williams, 2012; Matarrita-Cascante, 2010). Those recurring issues or topics are then developed into themes to help tell the story of what was learned through the qualitative approach. The QOL team further analyzed the data with a focus on not only the frequency with which feedback was given but also the specificity and extensiveness of the comments (Krueger & Casey, 2009).

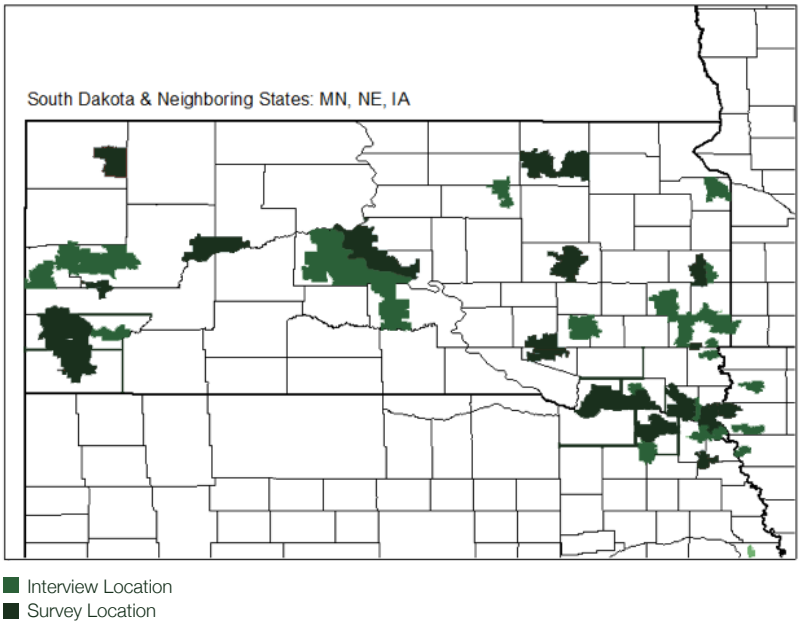
B.3 Description of Respondents

The USD interviewers conducted interviews with 39 people. Even though some of the interviewees were college students at USD in Vermillion, some of these students were from other areas in South Dakota including Sioux Falls, Brookings, Hot Springs, Rapid City, Huron, Aberdeen, Groton, and Pierre. Others were from out of state or even out of the country including Kansas City, Saudi Arabia, and Africa. Non-college students who were interviewed lived in towns such as Stickney, Pierre, Vermillion, Corsica, and Yankton. The USD interviews were thus geographically diverse in terms of interviewee origin. Those interviewed also worked in the following occupations/fields: human resources, finance counselor, county planner, appraisal officer, dance instructor, bartender, custodian, administrative support professionals, retail, information and technology, journalism, food service/restaurants, farming, education, and EMT and other medical services.

The QOL team visited southeast South Dakota and spent several days interviewing various community and industry representatives in the cities/towns of: Vermillion, Wakonda, Elk Point, Yankton, the county of Bon Homme, and Akron, Iowa. These respondents provided broader perspectives in terms of the impact of connectivity in the areas of: emergency services, city governance, public utilities, banking, agricultural services, library services, public and higher education, and health care. The QOL team conducted additional interviews via email and telephone with community representatives from Custer, Tea, Corsica, Summerset, Pennington County, Harding County, and Meade County in South Dakota, Verdigre and Hartington in Nebraska, and areas surrounding Akron, Iowa after returning to Virginia. A total of 29 interviews were conducted with these community key informants. The QOL team summarized the data from the 68 interviews and reviewed for issues and comments that were given with frequency and/or that illustrated unique challenges or issues. Some of the comments and issues identified through the USD interviewers were reinforced by the interviews with the community key informants.

Additionally, a web-based survey was developed and administered to gather quantitative data to provide additional context for the interviews. A total of 80 useable surveys were completed. Figure 1 shows the geographical spread of those participating in the qualitative interviews and responding to the web-based survey. The green areas denote where interview respondents reside, and black indicates where web-survey respondents reside. Those contributing to the QOL study came from various areas in and around South Dakota and reflect the varying experiences with and perceptions of mobile coverage, capacity, and speed.

Figure 1. Interview Survey Locations



B.4 Telling the Story: Location Matters

While many of those interviewed reported general satisfaction with their cell phone plan and general connectivity, some issues related to coverage and service quality were identified. Many of the USD interview respondents described their current experiences, satisfaction, and limitations with their cellular phones. Most reported that speed and call clarity were generally good. However, coverage and call completion are often dependent upon where one lives, works and travels. Connectivity throughout the state and into other states is not guaranteed.

Many respondents from Vermillion and other moderately sized cities/towns indicated that connectivity was good while in town, but worse even just outside of town or while driving through more rural and sparsely populated areas. As one respondent indicated, “some spots just don’t have the service of the cell tower.” “Dead spots” or spotty service were also noted in the west river area of South Dakota, all the way to Wyoming and Hartington, Nebraska. One respondent indicated that there is an interesting problem on the river: “…no connection where you dock [a boat] but you can get a signal 150 yards out and it’s okay.”

A respondent from a more rural area of Vermillion shared the difference just a few miles can make: “My husband and I use a Verizon hotspot. It is awful. A quarter-mile down the road my neighbor doesn’t have any issues with their Verizon hotspot. We always have dropped calls. We can no longer use the Internet on our computer in the house. Can’t do anything on it. If I drive 3 or 4 miles, I have four bars. We could get better service at our home, but it would cost us a lot. We have DISH for cable and DISH told us getting service from them would be so expensive.”

A respondent from Iowa shared issues with connectivity when crossing state lines. “South Dakota signals aren’t to cross in Iowa and Iowa signals aren’t

to cross into South Dakota. It is like there was a Berlin Wall there in whatever government regulations there were or whatever. Coming to town, sometimes we would bounce off of one tower and then we would lose signal when we got up here." Another respondent shared that they "have Straight Talk unlimited data and it works in most areas within town but not out in the rural areas…In western South Dakota and the entire state of Nebraska, I get no coverage. Drove from here to Denver and I had no coverage whatsoever until I got to Colorado."

The experiences of those living in moderately-sized cities and towns in southeast South Dakota varies from those living in the western part of the state or across the river in northeast Nebraska where the topography and geography is much different. Issues related to connectivity were often discussed as being dependent on line of sight with a tower. Line of sight is easier in the flatter, open expanses of southeast South Dakota. However, the western part of the state is more mountainous making line of sight access very difficult, if not impossible, in some areas.

The first two pictures below are from southeast South Dakota and show the flat terrain and openness of the topography.

This third picture below is from Custer State Park and shows the rolling hills and mountainous terrain in that part of the state. One public safety key informant indicated that there is poor connectivity out by the Black Hills and there is reportedly a "dead spot" where even the state radio system does not work.

A representative from Custer, South Dakota, shared their experiences with mobile connectivity in their part of the state. The city of Custer is about 1,800 people but serves as a tourist community for both Custer State Park and Mt. Rushmore resulting in millions of visitors each year. While the connectivity for western South Dakota has improved over the last 10 years, there are still issues and pockets where connectivity is problematic. Once leaving Custer and heading north and west, there is a 40-mile stretch to Newcastle, Wyoming with no service. Similarly, there is a 40 to 50

mile stretch with intermittent access on the highway between Newcastle and Sundance, Wyoming. Traveling south from Custer to Edgemont, SD and southwest to Lusk, WY, there is also no coverage.

As is the case elsewhere, this respondent shared that connectivity in Custer is dependent upon strength of signal. If the signal is strong, then there are not many issues with speed, coverage, call clarity, and call completion. If the signal is not strong, then there are issues. The respondent shared that coverage is buttressed by the tourism industry and that the hotels do, to some extent, help bring connectivity to the community.

Representatives from the village of Verdigre (population ~557) and the town of Hartington (population ~1,523) in Northeast Nebraska were willing to discuss mobile connectivity more generally for their area. Ironically, one of them was only willing to discuss via email because of poor phone connectivity, which would force many calls to voicemail. They stated, "For myself, many calls end up at voice mail and lots of phone tag." Regarding wanting to communicate via email rather than phone: "As I mention [sic], I don't need more telephone tag."

The main providers in these areas are US Cellular and Verizon. For the village of Verdigre, US Cellular has a new tower there and while there is signal in town, there is little to no signal in the county seat, which is less than 10 miles away, nor in the closest town (Niobrara), but there is signal in the state capitol. Within Hartington, signal/connectivity is "excellent" but going east to Yankton, South Dakota connectivity is bad and going to Sioux City, there is a 30-mile stretch where there is no service.

"Location matters" does not just apply to movement throughout the state but also within one's own home or other buildings. Some respondents gave examples including needing to go to certain areas within their home to have service (e.g., the porch, near the window, not in the basement, or not in areas with a lot of concrete). Other troublesome locations include some airports and parts of the hospital/medical school. While general reports indicate that the schools and medical facilities have adequate wired Internet and Wi-Fi access, at least one respondent from the schools explained the same is not true for cell phone coverage and clarity. "Making phone calls has been a challenge. If I'm at my desk…sometimes I'll have a voicemail pop up and the phone didn't even ring. If somebody does call me, being able to get to a place where I can hear them and they can hear me without a broken-up phone call is pretty rare. The cell service itself is not great, but for other types of messaging, I find it to be pretty good." Another education key informant speculated that colony schools in some of the Hutterite religious communities would have poor connectivity and have issues even checking emails. On the campus of USD, location also matters. One student explained that speed is better at home versus when at school and speed also depends on "congestion." In the dorms, connectivity is better compared to the main areas of campus where there may be more students. This student reported that the FaceTime connection is always poor on campus.

Location also matters when looking at access to brick and mortar retail stores as well. Many indicated that those were out of reach for smaller communities and would require commutes of one to two and a half hours to the nearest store. The respondent from Custer shared that the brick and mortar Verizon stores in Rapid City are 55 miles away. A community key informant from Harding County shared that the nearest retail store is 50-70 miles away. As one respondent indicated in regards to whether there were enough retail outlets, "If you're willing to drive an hour, then there's enough."
A community key informant from Hartington, Nebraska shared that residents would have to travel to Yankton, South Dakota to visit a Verizon store (about 30 miles). A few respondents reported that wait times/lines at

stores are or were long or just generally frustrating. A couple of respondents indicated that there were plenty of stores (quantity), but the quality of service was lacking (one community key information described it as "poor" and another felt that they are more interested in selling phones than providing service). Issues with trying to access online tech support are problematic if you have poor Internet connectivity to begin with. One respondent indicated that it was easier to Google a problem than sit on hold on the phone waiting for a response. Another respondent noted that there are no physical SmartTalk stores. Others were satisfied with in-person support and reported no issues with finding a retail outlet.

Many other respondents were not overly concerned with the placement of additional towers or infrastructure, noting that existing towers were already located in somewhat close proximity to towns, homes, and/or water towers. A couple of respondents did reiterate the need to respect "land rights" or to install them in places that "won't be disruptive." A few shared that there is plenty of open land and spaces to accommodate additional towers. One community key informant pondered how or if the existing electrical pole and wire system could be leveraged and modified to make way for the "web" needed for the 5G signal. Another shared that the towers may not be aesthetically pleasing and that environmental impacts should be taken into consideration but also stressed that it is not equivalent to a nuclear power plant coming in either.

B.5 Telling the Story: Population Density Matters

Comments by many of the interview respondents indicate that population density seems to be one of the key factors to consistent, high-quality service. As summarized above, traveling or living in more rural areas often coincides with less consistent service and coverage. As one key informant noted about Vermillion and the benefits of the University: "If we don't have the University here, I'm not sure we'd have the set-up that we have."

Lower population density, as noted previously, increases the per-customer costs of investments in telecommunications infrastructure, especially fixed broadband. One respondent noted that "it makes no financial sense to run lines" and others perceived that some current providers may not be willing to invest in more rural areas of the state. The perception appeared to be that more rural areas of the state would continue to lag relatively more populated areas. A key informant in Summerset noted that there is an insufficient number of towers currently for ubiquitous mobile service, highlighting the need to improve coverage and capacity in rural areas of the state.

It is important to note that even those areas that have generally good connectivity are negatively impacted by an influx of large numbers of people (e.g., fairs, concerts). One respondent shared their experiences while at a fair: "I am out here at the fair and it's really bad service and I can't get on things and it is really killing me…" Vermillion reportedly has good connectivity, but for large events, such as Dakota Days and the South Dakota State University versus USD football games, respondents shared that there are issues with getting signal, they may experience drops in speed, and they are sometimes unable to make calls.

One key informant shared that the police chief reportedly tried to make a call during Dakota Days and could not call out.

Another key informant from Vermillion gave a similar example:

"We did have a challenge where an off-duty law enforcement officer was trying to make a call at Dakota Days because of the system being overloaded. When we talk about connectivity there, it had to do with some of the very basic functions. This officer was trying to contact dispatch and having trouble getting through. Again, that is during an isolated event in the community, but that is when you need it."

However, these "large numbers of people" are not larger than those served in more urban areas. Even if the population doubled during those events in Vermillion, it would equate to only about 22,000 people in four square miles. For context, the upper east side of New York City has over 229,000 people in less than two square miles.

B.6 Telling the Story: Satisficing

"Verb (used without object) sat·is·ficed, sat·is·fic·ing: to choose or adopt the first satisfactory option that one comes across: the tendency of decision-makers to satisfice rather than look for the optimal solution."[16]

Respondents would often acknowledge that while they were generally satisfied with their cell phone service, they also realized that many rural areas in South Dakota and elsewhere were not tapping the full potential of connectivity. At least one respondent indicated that service is "not the fastest but not the slowest" and another key informant indicated that: "We're not on the forefront but we're not last." Another respondent intimated that they were not fully happy with their service, "but what are you going to do?" A community key informant from Yankton indicated that their "expectations are not terribly high." While speed and coverage were often not described as the best, respondents indicated that their phone "can handle what is necessary" and a couple of respondents indicated that their slow connection makes them have patience. "I have had issues in the past because of my location, but I have also learned over the years to be patient. Instead of grumbling under my breath, I just find places to stop."

One key informant, describing improved services over time, indicated, "…the issues that used to frustrate me….either don't bother me as bad because I know where I am going to have the issues…so maybe I have just gotten accustomed to it." One community key informant added that some people new to or visiting the area are surprised that less urban cities like Vermillion even have access to Internet and cell connectivity. One education key informant indicated, "[w]e are satisfied probably in all areas except for our coverage area. We have a few locations where we do not get strong signal, but we're satisfied in regards to speed, cost, connectivity - everything else once we have service." Finally, one county key informant commented that the nearest retail store is between 50-70 miles away, but most people in town are used to this.

This theme of satisficing may be apparent in other aspects of connectivity discussed by respondents and key informants. For example, one community key informant shared that the general trend was to offer wired fiber and wired broadband in many areas across South Dakota as opposed to going directly to wireless.

[16] *See* Definition of Satisfice, Dictionary.com, available at: https://www.dictionary.com/browse/satisfice.

Another community key informant speculated on the potential disparity that can be created between those in more densely populated areas compared with those in more sparsely populated areas.

B.7 Telling the Story: Expense of Service and Scarcity of High-Quality Providers

Respondents were asked about the choice of providers and the cost of service. Some respondents did not have a sense of the cost of their plan since they are college students and are covered on their parent's/ family plan. Even though many respondents expressed general satisfaction with their mobile provider and the customer service they receive, many also admitted that they had few options for high-quality broadband service. Thus, the lack of providers may force rural residents to satisfice in terms of their mobile service and the price that they pay. One respondent felt their plan was expensive because of having three children on it, yet indicated they get what they pay for and were generally satisfied. Another indicated that "it is what it is" and since they want a smartphone, they must pay for what they want.

Those living in Vermillion often identified Verizon as the main provider with a few mentions of Sprint or AT&T but often with the caveat that the coverage was not as good as Verizon. Other parts of the state have better coverage with other providers, but many respondents acknowledged that there were often only one or two reasonable choices for high quality connectivity.

Many recognized that additional providers would potentially improve service, provide additional plan options, and decrease costs. One respondent indicated that the lack of providers offering dependable connectivity was "definitely a huge limitation."

As one respondent said regarding the cost of their plan, "[it is] expensive as all get out" and they would welcome other providers. When calling for customer service, losing patience, and threatening to change providers, they feel like their provider laughs at them (not literally) because the provider knows they have no other options. One respondent reported that they do not like going into the store to resolve phone issues because they end up walking out with things they did not plan to buy or need. "[I'm] getting roped into getting something new, I'm like 'What just happened?'"

Some respondents described being tied to one provider to ensure consistent coverage for their jobs or for their household. While cheaper options are available, those options have lesser quality service and that is not acceptable for those who work in certain fields such as public safety or emergency services. As one respondent who was a recruiter/headhunter indicated: "Plans are all too high with cost…If I just needed a cell phone that wasn't tied to my job, I might go to another provider, but because I need that consistency and broader availability then I use Verizon. I would go to one of those cheaper ones to save money."

"... many respondents acknowledged that there were often only one or two reasonable choices for high quality connectivity. Many recognized that additional providers would potentially improve service, provide additional plan options, and decrease costs."

One community key informant from the healthcare field expressed concern for those in lower income households when it comes to choice and costs of plans:

"My biggest issue with cellular service in terms of smartphones is now getting to be the cost and the availability of competitors. Verizon is the predominant one here. You can get AT&T but coverage is an issue…I think cost for the average person in Vermillion, the average wage earner is an issue. My wife and I both have smartphones and my mother-in-law has a dumb phone and with the three phones it is about $200 month. That is kind of steep if you are making $12 an hour."

A community key informant from Verdigre expressed frustration with people not having equal access to connectivity. "The problem is not so much that the service is not here but the service is not provided equally." A key informant from one of the local libraries discussed how the library now loans out mobile hotspots. They shared that some library patrons, particularly those below the poverty level, cannot afford Internet access or data plans. However, the need to connect is increasing for citizens, but not everyone even has a smartphone. For some residents, being locked into a regular data agreement does not always work for them as they infrequently need to go online. They felt that plans should cater to the variety of needs and ways for people to get online.

Another example of cost concern came from a key informant with an agricultural support business. They described the scenario where their building is in the vicinity of three fiber optic lines but that it would take between $50,000 to $100,000 to hook into the fiber because the nearest node was in the next town. Their lower cost option was to hook-up a "jetpack" from Verizon which is a receiver for cell phones and then have a rifle-style antenna pointed at the cell tower in Vermillion. Everything in the office is then routed through Verizon wireless. Other respondents discussed investing in signal boosters, portable towers, and other technology to improve their coverage and service. These examples point to the lack of efficiencies when it comes to cellular connectivity in rural areas—residents have to pay more for additional devices to ensure their connectivity.

The majority of those interviewed indicated that they would be willing to switch providers, particularly if the service and/or price was better. As one respondent said, "God yes, marriage to businesses is old school." A fair number of respondents indicated that a variety of payment plans would also be beneficial. Examples given included prepaid plans, automatic payments, and a flat rate for unlimited everything. However, one respondent indicated, "[d]on't charge me to make it easier to pay you." One community key informant was skeptical about changing data plans. They shared how their provider was trying to move them from a 15 gigabyte plan to unlimited but they have not switched because they are concerned about throttling on the unlimited plan. "…[O]nce they move us over to unlimited I think they've got the capability and intel that they can straddle your speed once your usage gets to a certain point. They can't do that to us on the 15Gig plan so they kind of keep asking us if we'd switch over to the unlimited plan, but we don't want to."

A few respondents acknowledged that payment options were not all that important for them but recognized that it might be important for others. A couple of respondents indicated that the plans available did not match their needs or they could not find other options when looking for plans. For example, having only family plans available versus plans for couples/

two people. One respondent wanted to know about business plan options. Another respondent, who travels internationally, wished they could freeze their main phone and bill when traveling abroad so that they are not charged for a phone they are not using, but at the same time, they are able to keep their telephone number.

B.8 Impacts on Quality of Life

Respondents were asked about the various ways that limitations with connectivity might impact their quality of life. While some respondents did not perceive limitations with their cellular service and thus did not have corresponding impacts on their quality of life, a number of these respondents also engaged in satisficing behavior. Mobile networks were viewed as 'good enough' although respondents noted concerned about coverage and speed. In other words, while some respondents appeared to be satisfied with their mobile service, exploratory questions revealed complaints about coverage, capacity, or speed.

Some respondents included connectivity and the ability to communicate as part of the overall quality of life in each area. One respondent from Custer indicated that having good schools and health care systems are important, but another critical part is the communication system. Custer and other areas are "wonderful communities for people to live in" but those communities need to have a high-quality source of communication for businesses to prosper. The respondent indicated that "quality of life [is] matched with quality of place. Communication is a big part of that."

The issues with the costs of cellular plans discussed above are also examples of negative impacts on quality of life. One respondent indicated that there had been arguments in their family because of costly plans and a lack of options. Another respondent indicated that cell phone costs negatively impacted their budget where they had gotten behind on their bill, had service shut off, and had to pay data overages. They did not think that their cell phone provider had a plan that was suitable for their family.

For others who mentioned issues with coverage and lack of consistent service, some negative perceptions of security and personal safety emerged. This was particularly the case when traveling throughout the state into those sparsely populated areas where connectivity is questionable and where help is not physically close. Concerns about safety, either hypothetical or from real-life examples, were expressed by some of the respondents. The quote in the previous section about not having signal near the river but getting signal out in the water could be a potential safety issue for those who work or recreate near the river. Some acknowledged that if there is no signal, people cannot call for help if there is an accident or some other emergency—particularly while driving through the state in or through rural areas. As one respondent said, "[it is] unsafe to be [in] an area without phone coverage at all and I think that should be handled if someone is going to implement new networks in the area – just to increase the safety of everybody."

One respondent was concerned that the route they regularly travel to Wyoming to pick up/drop off their child has spotty coverage which would limit their ability to communicate delays or emergencies. For those who rely on their phone's mapping applications to guide them through unfamiliar areas, service drops can be disconcerting. As one respondent indicated, "[w]hen I don't have good cell reception, I feel really unsafe because I share my location with all my friends when

I am going out and I rely on my maps to get really anywhere outside of Vermillion or Sioux Falls. If I don't have cell service, I don't really know where I am going." One respondent shared, "I literally have had vehicle breakdowns and issues and walked to the top of the nearest hill to get cell coverage to call for help…" Another respondent shared a situation where they were driving with their infant and their animals and got a flat tire on a very hot day. There was no service, so they could not call for assistance and could not change the tire themselves. They ultimately ended up driving on the rim to get help. In Northeast Nebraska, a scenario was given where a 911 call was made from a cell phone, but the caller was disconnected or hung up before their location could be given. The police went to the location where they thought the call was made, however, the call was made from three miles away. Another community key informant shared that a member of a search and rescue team lives on a lake nearby and has "zero reception" and even their pager is delayed. "I think that is a pretty critical area. I don't think that is too much to ask. I don't expect everyone to have 100% access all the time. But at least a bar so I can at least make an emergency call."

A community key informant from the health care field indicated that there are many people who rely on their smartphones/cell phones while on-call. Healthcare workers and other emergency personnel must rely on their phones in the case of a broad recall for large-scale crisis events. Another community key informant in the education field described potential challenges of needing to call during an emergency situation: "… the cell reception and connectivity is what I probably find most challenging and you know, in the moment of an emergency is really what we're going to suffer – being able to make contact with emergency services and have them hear us clearly. If we're not near a landline, I think we're going to struggle to be able to get communication as quick as we need to."

A couple of respondents mentioned needing good connectivity to be able to be aware of and respond to severe weather like thunderstorms and snow storms. One respondent who works in agricultural support indicated that monitoring the weather in real time is important during the spring and summer months. He looks at the radar on his devices to know where to send crews. "I think one of the key attributes of a successful well driller and other farm service providers is to be able to turn on a dime and leave a nickel's change."

B.9 Impacts on School, Work, and Entertainment

Given that some of the study interviewers and respondents were college students, there were comments about how much this population relies on their phones and other devices. One student described their phone as follows: "Well, it's kinda my life – I use it for everything – texting, calling, Facebook, keeping in contact with everyone. I use it for everything – I would die without it." A student who works with the USD Student Government Association stressed the importance of their phone with the following: "I get texts all the time from other students asking about funding or I'll get an email that requires a response later in the day. I'd say I'm probably on my phone or laptop at least five or six hours a day." There were also examples of poor connectivity limiting the ability to meet school and/or work demands. One student shared that their phone "…has my schedule – my phone helps me. When it's not working, [I] don't have that extra help."

One student reported missing out on opportunities for volunteer/shadowing work as these opportunities

are given on a first come, first serve basis and communicated via email. If connectivity is poor, then this communication is not timely, and opportunities are missed. Another reported that there are bandwidth issues and students cannot complete tasks/ assignments when everyone is using the same program or application and are in the same general area. One of the community key informants from the healthcare field shared that a staff member who was a student at the University and lived outside of Alcester could not do their classes online because of connectivity. They had to come into the office in Vermillion to do their classes on nights and weekends (at least a 30-mile drive).

A community key informant from higher education described some of the challenges for students taking classes from a distance or living in more rural areas given the unique topography:

"I know that nationally many students want to do their coursework on their smartphone. I know that many use their smartphone as a wireless modem to the cellular network and use their PC to do their coursework so they are basically using their phone to use the hotspot…This prehistorically was an inland ocean and we have geographic features called buttes, which are areas that did not sink when the water left the area so they are 100-plus feet tall rocky formations and they interrupt cell phone coverage. With the population so sparsely distributed, people sometimes set up a tent near the butte and do their coursework and typing from there. When wireless started to become available and telephone calls were free, they would go to the top of the butte to make their calls."

In addition to impacts on work or school, respondents also discussed impacts of poor connectivity on their ability to use their phones for entertainment. A few students and others reported issues with speed and connectivity in terms of being able to watch movies or other streaming content on applications like Netflix. One respondent indicated it would take 30 minutes to load content from Netflix or music streaming sources. One respondent thought that if service was faster then they could probably stream higher quality videos. Another respondent reported needing to use their PC to download audio books because it is too slow to download on their phone.

One respondent summed it up as: "If the Taliban can upload videos in Afghanistan, how can I not get Netflix to play in America?... just don't know. It is 2018…and we are smart people. We should be able to watch a movie without it buffering."

B.10 Mobile Service and Limitations on Economic Growth and Use of Technology

While some of the respondents were generally satisfied with their cellular provider and service with caveats and exceptions, some respondents did have thoughts or concerns about being able to take advantage of what technology has to offer and to improve economic growth or quality of life in rural areas. This sentiment was often expressed by the community key informants as they discussed mobile connectivity in their respective fields or communities. Community leaders reflected on the needs of their businesses in regard to connectivity: "If you are a data intensive business sometimes you might overload the system and that is why we need the additional tower that we are going to have to put up. I think presently it might diminish some of their service. I have not heard a lot of complaints about it, but certainly if you are a data intensive business, you really need that extra capacity." Another community leader stressed that the importance of connectivity is "100 percent absolute." For economic development and quality of life as well as recruiting new businesses, communities need access that is easy, affordable, and readily accessible. When working with potential new businesses, this community leader feels that businesses will often evaluate access to high speed Internet along with other quality of life considerations. Potential new businesses want to know about access to Internet in their buildings and then will move to other aspects like affordable housing, schools, and healthcare.

Potential new businesses and residents will only consider an equal or better transition and if connectivity is perceived as slower or worse than other areas, this would be "substandard" and could slow down growth. This observation not only refers to fixed broadband but, as businesses increasingly rely on mobile services, to mobile broadband. A key informant from Custer agrees and shared that public needs like education and hospitals are likely higher priorities than mobile communication and connectivity. However, in the big picture, you "can't separate it from the broader assessment if this is a community people want to live in." The respondent indicated that a holistic approach is needed for community needs and people are looking for good quality services all around.

A community leader from Akron, Iowa shared the following about the limitations poor connectivity brings to rural communities:

"If we had better cell coverage here like you can get in the city, I think Akron would be a growing town. Then you would have more people living here and enjoying the small rural life, but maybe their job is in California. More businesses would be willing to put up a building here because they wouldn't have to worry about access. That has been a detriment the whole time I have been here."

Another community key informant from public utilities shared that better connectivity through 5G may help with real time access to their SCADA (supervisory control and data acquisition) systems that allow them to track poles, wires, and the flow of electricity. This key

informant also shared that younger customers want to know the minute they lose power why and how long the outage will be. Better broadband coverage would allow them to roll out SCADA systems in more areas. Better coverage would allow them to use their mobile devices, such as iPads, to discover where outages are located and to have real time access to mapping of their poles and wires while out in the field. Instead, currently they must store information and go back to the office to download.

A community key informant from financial services discussed their perceptions of connectivity as it relates to banking as well as agriculture. "Coverage is improving but not at the pace that technology is improving. I think it lags." They discussed the need for timely information for farmers regarding the market and grain prices. Grain market prices are constantly changing, and up-to-date information is needed as to when to sell, use commodity brokers or hedge accounts, when to transact their sales, or to bid on land. "…But to be able to do that and to get your bid in timely, you got to have good broadband and good Internet access on your phone or Internet at home… [farmers] need to have good connections. You don't want to be bidding on a piece of land and lose your connection. The communication piece is very critical." This key informant shared that they can use remote operations to transact business with farmers in the field. "We can go to them if we do a farm visit or have them sign loan documents remotely on a screen or on an iPad and then send them copies through a secure portal. More and more technologies are coming into play in the way we operate, and the way farmers conduct their business. [We] can sign loan documents out in the field if connectivity is good." However, diminished efficiencies exist in the more remote areas where connectivity is not always good or guaranteed. "We can't utilize the technology that the bank has paid for and wants to use in those areas that are more remote, but that is where the farm operations are."

One of the areas discussed in terms of possibilities and limitations is health care and telehealth. One community key informant from health care shared that they are about one and half to two years away from using small mobile medical devices that would allow patients to take their blood pressure, pulse, and other vital signs. "Once we are able to roll [out] these things, there are some other populations that we will be able to provide care for that we currently can't." However, those populations need to have adequate connectivity. Another respondent who works in the medical field shared that Internet access is key to using and sharing electronic medical records. "Most of the time when I have seen physicians contact other physicians regarding a patient or a history or a consult, they pick up their cell phone – they don't go to a landline."

One EMS volunteer also discussed the ability to transmit EKG information directly to the hospital, but it does have limitations: "…if we get down in some of those places [where there is no signal], it's not going to transmit because it relies on that coverage on the cellular providers…" This community key informant also shared that given the longer transport time to the nearest city hospital from rural areas, "…we have a lot of time that we can be doing some front end work that really helps medical providers in the hospitals." The key is to have the technology and the necessary connectivity to relay such information to the hospital prior to arrival instead of relying on written reports or brief communications over the radio.

Increasing mobile capacity for communities allows residents to take advantage of the possibilities that technology offers. When asked about the need for better connectivity compared with other services or infrastructure, one community leader responded: "Not an either or. We need all of the above. I know we have a lot of people that are very intensive users that control everything in their [home] from wherever they are through their cell phones. I think we are

going to see more and more through the use of cell phones. I think we have to provide the capacity to do that." The key informant from public utilities shared examples of smart technology and as that technology continues to change and improve, customers will want and need better connectivity to control things like their thermostat, hot water heater setting, and air conditioning systems remotely.

A community key informant from Custer, who has their own small business, indicated that any limitations with coverage or speed do not personally impact his own business other than wanting "everything to work like McDonalds where we have everything in 32 seconds." For other (larger) businesses with more customers and different needs, there would be impacts. Greater mobile capacity may be a consideration for those who might relocate a business to Custer. The respondent further indicated that one element of the overall enhancement or viability of small communities is to have the ability to connect to a high-speed signal. It is important for communities to be able to say that they can provide prospective businesses or citizens with that access.

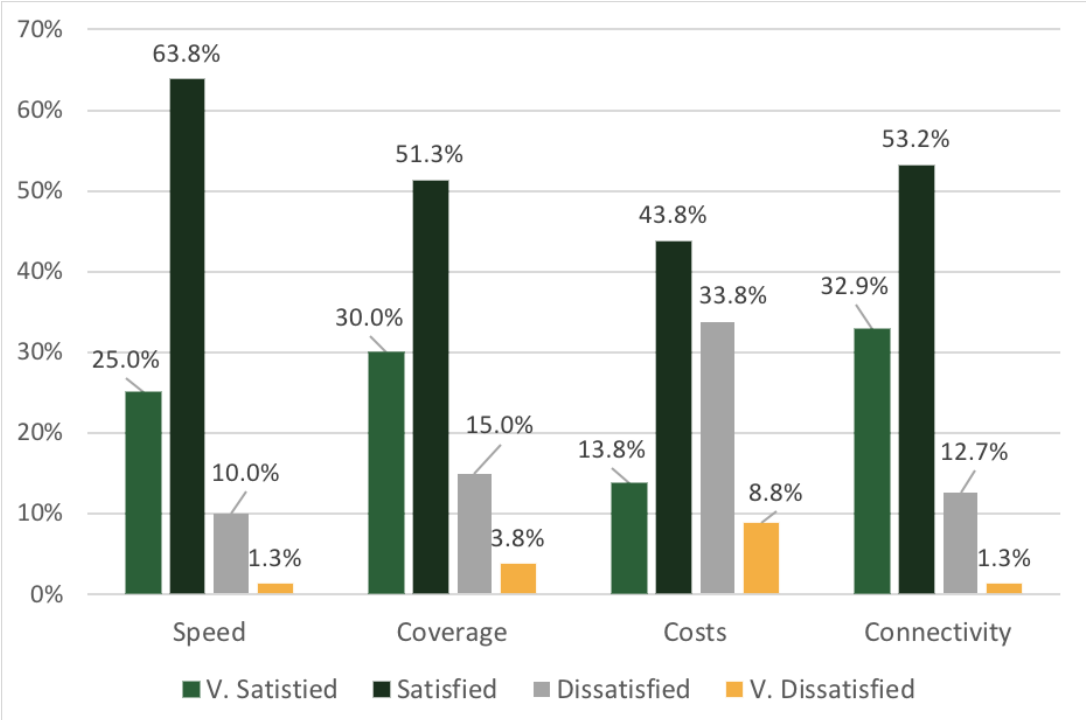
When asked about the future and what might be possible with improved connectivity, some respondents described improved efficiencies in communication. This includes being able to communicate more easily or reliably. One respondent indicated that they could talk to family members without the phone dropping the call several times. Another indicated that they could send a text without having to get up and go to the porch. One respondent indicated they could use their phone outside of the house—currently they have a service booster but if they step outside of their house, they have no service. Others indicated they could talk more if they had an unlimited plan option, make calls without being frustrated, or get help during an emergency if they had coverage in current dead spots. Another respondent wondered about having international cell phone service. A couple of respondents commented on potential improved productivity or general knowledge. If connectivity were faster, "I might be able to use technologies I didn't know existed if I had the option." Another indicated that they could learn more about smartphone capabilities and potentially make their job easier. Another indicated that they might have more time to do other things.

B.11 Web-Based Surveys

The QOL team developed a web-based survey to obtain additional information about the perceptions of cellular service and impacts on quality of life. The survey was distributed to students at the University of South Dakota and South Dakota State University. Students come from all over the state as well as from rural areas in neighboring states. A similar survey instrument was also developed for the public and was made available via the Vermillion Library Facebook page. The QOL team also distributed handouts with the survey link at a community event in Vermillion that was attended by the public. The survey data is not intended to be representative of the South Dakota population, but rather to provide additional context and support for the qualitative interviews.

A total of 80 usable surveys were collected from students and residents, mostly from South Dakota and some from the neighboring states of Nebraska, Iowa, and Minnesota. In part, because of the small sample size but also because of the homogeneity of the environments included (i.e., rural residents in towns and small cities of the mid-west), there were no statistically significant differences between the two groups. As such, the results of the surveys were combined and are presented for the sample. Figure 2 presents the results of the survey.

Figure 2. Satisfaction with Aspects of Mobile/Smart Phone Data & Service Provider



Source: Old Dominion University and University of South Dakota (2018).

Most respondents were satisfied or very satisfied with their mobile/smartphone service in terms of speed (88.8 percent), connectivity/call completion (86.1 percent), coverage area (81.3 percent), and cost (57.6 percent). That still leaves a substantial minority who are dissatisfied with speed (11.3 percent), call connectivity/call completion (14 percent), coverage area (18.8 percent), and especially cost (42.6 percent). A majority of respondents, nearly fifty-four percent (53.8 percent), are dissatisfied with their service in ***at least one*** area or another.

Figure 3 presents data on the comparison of cell service quality. Respondents were asked to compare their perceptions of phone service coverage/connectivity in other areas with where they live now (college students were asked to reference their home town instead of campus). Only a small proportion thought that their coverage/connectivity was worse than other rural areas of South Dakota (17.7 percent). Almost one-third (31.3 percent) felt that the coverage/connectivity was worse than in other larger cities of South Dakota (or the university for college students).

An even larger proportion (45 percent) reported that their service was worse than in larger cities of the country like New York, Chicago, or Minneapolis. Open-ended responses to these questions suggested some uncertainty about comparing connectivity locally with other countries and 5 percent of the survey responses where simply “don’t know.” Still, nearly a third (31.6 percent) reported that their service was likely worse than in other countries like China, South Korea, or Germany.

Figure 3. Comparison of Coverage/Connectivity to Other Areas

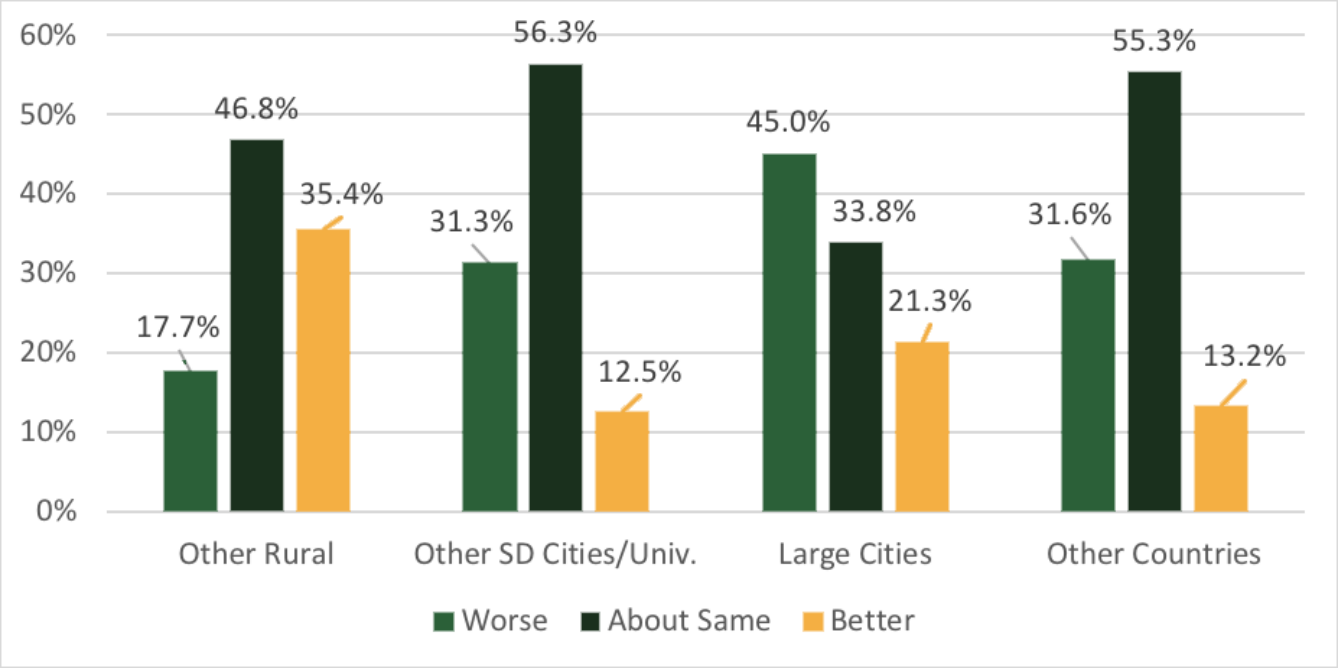


Figure 4. Extent of Problems with Current Smart/Mobile Phone Service

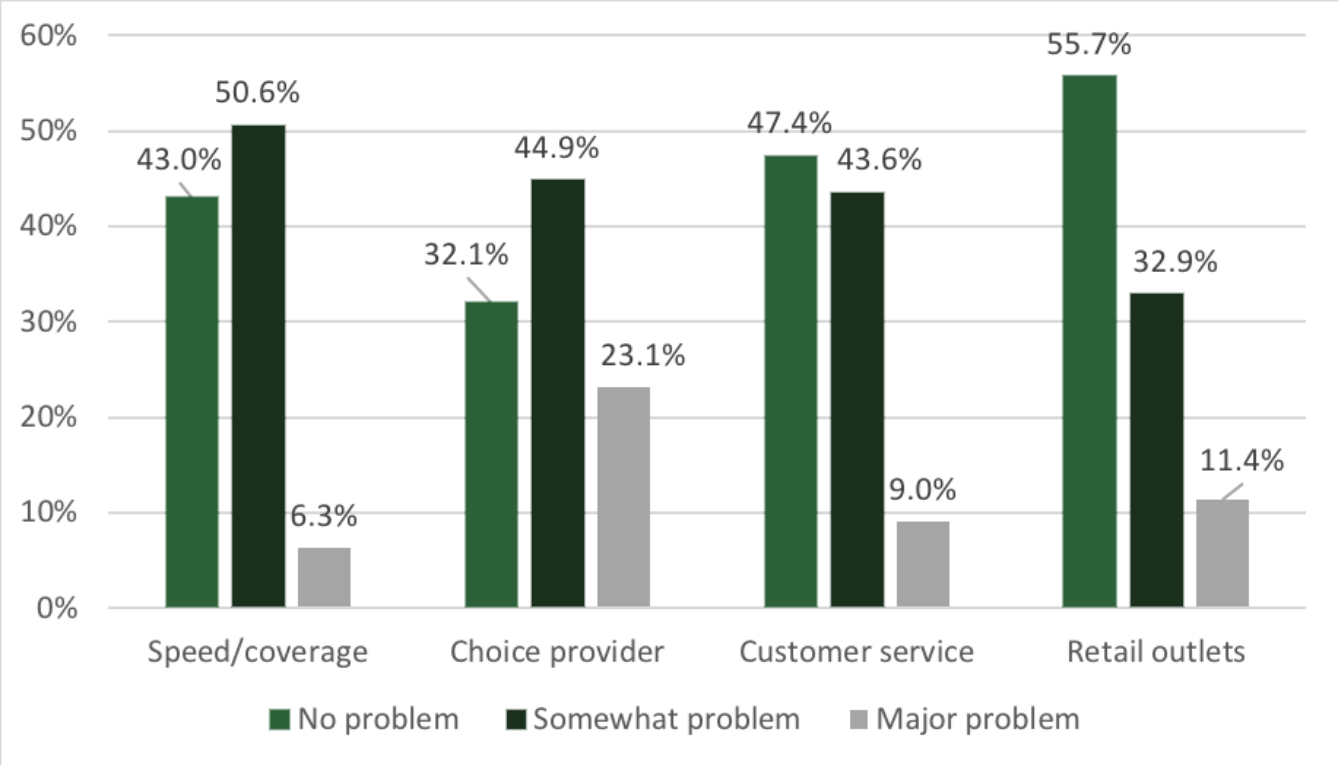
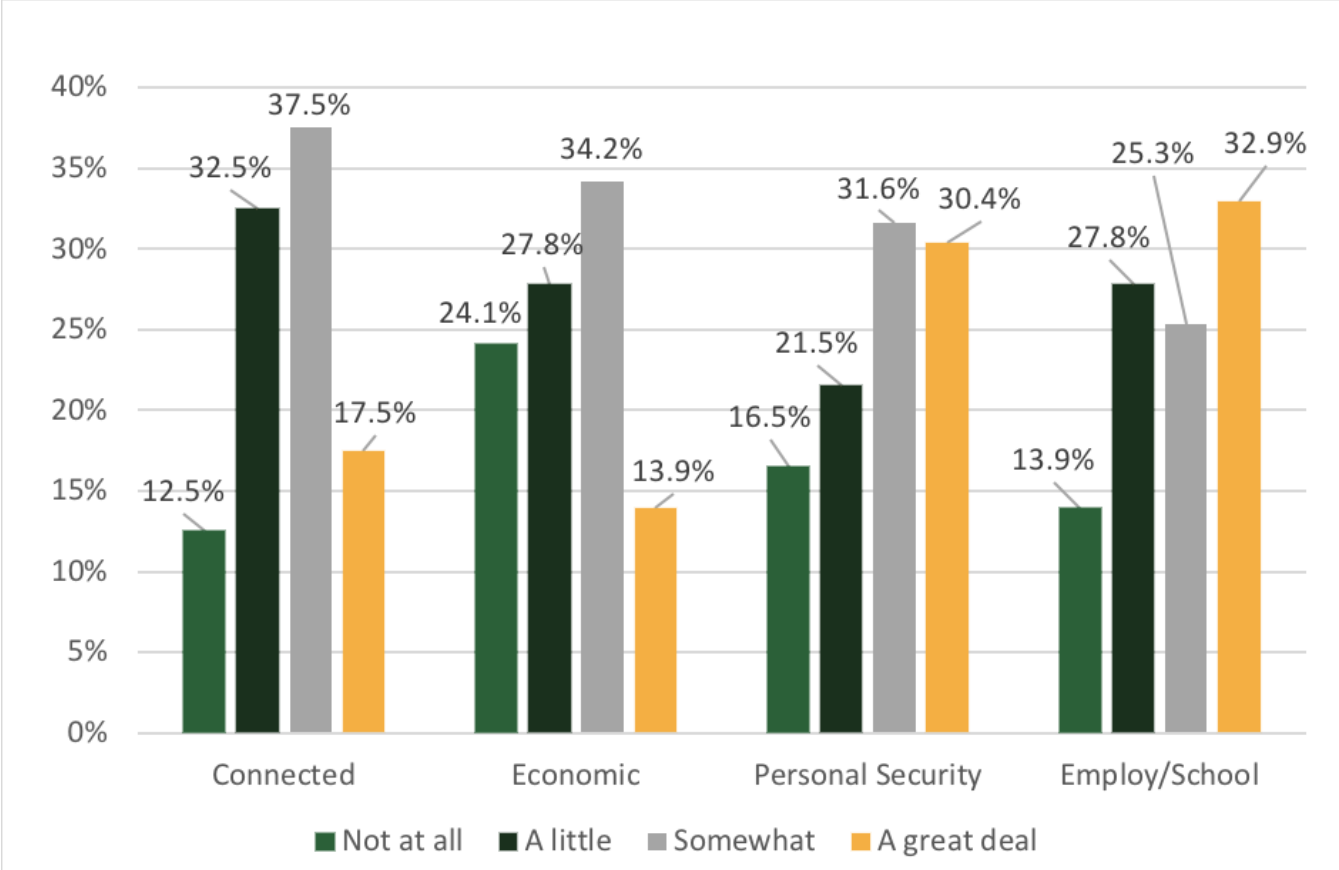


Figure 4 illustrates responses regarding limitations of service. Of those surveyed about problems associated with smart/mobile phone service, half (50 percent) reported that quality of service (e.g., speed/coverage/stability) was somewhat of a problem and an additional 6.3 percent reported that is a major problem. When combined, a significant majority (67 percent) reported that a limited choice of **reliable** providers was somewhat of a problem (44.9 percent) or a major problem (23.1 percent). Combined, over half (52.6 percent) felt that customer service/technical support was somewhat of a problem (43.6 percent) or a major problem (9 percent). Access to retail outlets and cell phone stores was also a common concern with 32.9 percent reporting it to be somewhat of a problem and 11.4 percent reporting it to be a major problem (totaling 44.3 percent). Virtually all respondents (90 percent) identified at least one cell phone limitation and nearly half (47.5 percent) reported at least some cell phone issues as a major problem.

Figure 5 presents data regarding connectivity and the quality of life. When examining the perceived prospects of improved cell phone service as it relates to quality of life, the vast majority saw the potential for at least a little (i.e., a little, somewhat, or a great deal) improvement for: ones' economic well-being (75.9 percent), personal security/feeling safe (83.5 percent), meeting

Figure 5. Extent of Improved Connectivity on Quality of Life



employment/school demands (86.1 percent), and a general feeling of connectedness through consistent/stable Internet access (87.5 percent). In particular, some respondents felt that improved cell service could have a great deal of influence in terms of economic well-being (13.9 percent) and feelings of connectedness (17.5 percent). Almost one-third thought it could help a great deal in terms of personal security (30.4 percent) and meeting employment/school demands (32.9 percent). Considering all the listed areas, 45 percent thought that improved cell service could provide a great deal of improvement in at least one of the listed areas.

B.12 Conclusion

The web-survey results and qualitative interviews paint a picture of rural residents who report general satisfaction with their mobile phone provider. However, when looking at more specific issues related to coverage and connectivity, the conclusion might be better framed as "it depends." Connectivity depends on location and population density. Geographic obstacles in some locations limit coverage and connectivity. Others believe that better service is unlikely because their community is very sparsely populated, and it may not make economic sense to invest in better service for so few people. There is also a fair amount of satisficing occurring with some rural residents settling for less than ideal service. Concerns about safety, impacts on quality of life, potential diminished community growth, high costs and few providers, and lagging current technological advances were some of the themes emerging from the data. While some respondents recognize the limitations of their market share and size, there are those who also recognize the potential negative impacts of continued limited connectivity. Some are doubtful that investment in better communication services, like 5G, would be reasonable or even possible for new providers. Without more high-quality connectivity, opportunities to attract businesses and new residents may force some of the smaller cities and towns to continue struggling both socially and economically.

The overall good quality of life experienced in these smaller cities and towns could be further enhanced by investments in communication. Those who participated in the quality of life study generally appear willing to try new providers if better service and costs are made available to them. As previously discussed in the overview of the South Dakota economy, rural residents recognize the need to foster growth in the less metropolitan areas of the state or otherwise face continued population decline and reduced economic activity and growth. The rural residents we interviewed and surveyed also understand the potential that better connectivity can provide through improved access to information, financial services, educational services, health care services, and improving communication in general. The key informants across communities seemed to understand that increasing the capability and capacity of metropolitan and rural wireless networks in South Dakota is likely to have positive impacts on the quality of life of South Dakotans. The positive impacts of 5G implementation would address many of the concerns noted by respondents while also providing the opportunity for future economic and social growth.

Appendix C: Information and Communication Technologies (ICT) in Developing Economies

C.1 Introduction

An important question is whether investments in information and communication technologies (ICT) will spur economic development and, if so, by how much. To understand the potential impact of ICT investments in rural America and, specifically, South Dakota, we examine the academic literature on ICT and ICT's purported impact. These studies will not only help us identify potential impacts of ICT investment but also the possible magnitude of these hypothesized impacts. The purpose of this literature review is to identify common themes that may apply in South Dakota, recognizing that South Dakota is an advanced economy with a skilled workforce. The urban-rural divide that characterizes South Dakota is, however, also prevalent in many countries and thus the empirical evidence on the impact of ICT on rural areas may have application in South Dakota.

Proponents of ICT argue that there is a consensus in the literature that effective investments in ICT facilitate economic development (Kabbiri et al., 2018). Improvements in ICT may reduce disparities in information between rural and urban areas, lower the cost of information to rural communities, and improve economic productivity. Individuals and communities may "leapfrog" outdated technologies and gain access to a broad array of financial, health, recreation, and other services. Competition among service providers for rural customers may result in increased choices and lower service costs, improving the quality of life for these customers. Improvements in ICT may also strengthen connections between the citizens and the public sector. The public sector may also be able to increase quality, depth, and breadth of government services. As more services move from the physical to digital domain, access to widespread and fast ICT is becoming an integral part of life for many communities.

While investments in ICT may have numerous potential benefits, others note that ICT investments and associated outcomes are not evenly distributed at the local, state, or country level. Communities that are relatively disadvantaged with respect to ICT may fail to reap the digital dividends associated with access to ICT. There are also divergent views over the nature and scope of contributions that ICT in general and mobile phones, in particular, can make to economic development (Owusu, Yankson, & Frimpong, 2018).

Even though the level and breadth of ICT is significantly greater in many countries in Asia, Europe, and North America, countries in Africa and Southwest Asia have been able to take advantage of existing and emerging technologies (Fuchs & Horak, 2008; Kabbiri, Dora, Kumar, Elepu, & Gellynck, 2018). Some studies argue, however, a "digital divide" or a "strikingly differential extent to which rich and poor countries are enjoying the benefits of information technology" continues to exist (James, 2003, p. 45). A digital divide occurs

when groups of individuals or regions lack access or have degraded access to ICT when compared with other groups or regions (Rouse, 2014). Within the United States, for example, we may observe a digital divide between urban and rural areas, higher and lower income neighborhoods, and among different races and ethnicities.

As such, this chapter provides a review of the impact of ICT technologies on developing and transitional economies, with specific focus on access to and improvements in mobile phone technology. We readily acknowledge that the ICT literature is vast and rapidly growing and do not claim to review all the literature. We curtail our analysis to 2005 to present and to the literature that is most appropriate to the research question at hand.

The remainder of this chapter is structured as follows. We first discuss how geographical coverage impacts the usage of mobile phones. We then discuss how mobile technology impacts difference sectors. We conclude with a discussion of challenges associated with mobile technology.

C.2 Geographical Coverage of Research on Mobile Phone Impacts

According to the Groupe Spéciale Mobile Association (GSMA), the use of mobile phones has expanded significantly over the last decade. About 63 percent of the world's population subscribed to a mobile service in 2015 and the number of subscribers is projected to reach three-quarters of the global population by 2020 (GSMA, 2016). For developed countries, the average mobile phone adoption rate reached 65 percent at the end of 2015, ranging from 59 percent in Europe to 74 percent in North America (GSMA, 2016). Growth has slowed in some developed economies due to market saturation, but we also note that growth possibilities remain in underserved, mainly rural, markets.

Mobile phone, and specifically smartphone, adoption continues to accelerate across developing economies, with large increases in the Asia Pacific region and Latin America. These regions achieved a 40 percent subscription rate by the end of 2015, illustrating the possibilities for future growth (Kabbiri et al., 2018). Mobile phone penetration is also increasing in Africa and illustrates the potential for growth outside urban areas (Asongu & Le Roux, 2017). The adoption of mobile phones also has enabled many countries to leapfrog landline infrastructure and associated technology, reducing the cost of ICT investments and increasing mobile phone market penetration (James, 2009).

In fact, much of the research on the impacts associated with mobile phone adoption and improvements in mobile phone technology have focused on developing economies (Albiman & Sulong, 2016). The gains from adoption and improvements in technology tend to be more visible in these economies and thus provide insight into the potential impacts of improving mobile phone infrastructure in the United States, especially for rural areas.

In Sub-Saharan Africa, mobile phones have, in many cases, been the first widely available form of ICT as countries either lacked sufficient capital to construct landline-based ICT and maintain infrastructure if it was built, or sufficient managerial capacity to efficiently operate these networks (Aker, 2008). The advent of mobile phones, however, had two immediate impacts. First, the private, not public, sector invested capital to build out networks and provide mobile connections and services. Second, the cost of developing the networks was significantly less than landline technologies, avoiding the "last mile" problem that

plagued many of these countries' previous attempts to build ICT infrastructure.

The literature on the impact of the advent and use of mobile phones in developing economies is quite large. Agricultural productivity and livelihoods appear to have been positively influenced by the adoption of mobile phones (Haftu, 2018). The literature also examines whether mobile phone usage impacts human development, income inequality, and institutional development in Africa (Asongu, 2015; Asongu & Le Roux, 2017; Asongu & Nwachukwu, 2016). Other parts of the literature examine similar questions for Indonesia, India, and the Philippines (Chase & Labonne, 2009; Jensen, 2007; Nabhani, Daryanto, & Rifin, 2016). Curiously, there appears to be significantly less research with regards to Latin America. Mansell (2012) argues that much of the research on the impact of mobile phones fragmented, focusing on one aspect of how mobile phones impact livelihoods rather than employing a systematic approach.

In general, mobile and other digital technologies influence market transparency, farm productivity, logistics, and financial services, especially in rural communities. Improved access to mobile technology, for example, reduces information asymmetries and thus possibilities for urban consumers to gain from arbitrage due to these asymmetries (Baumüller, 2018; Deichmann, Goyal, & Mishra, 2016; Donner, 2008). Increased access also positively influences the acquisition of human capital, which, in turn, improves rural productivity. Rural customers gain access to extension services, digital education, and other services that improve their ability to produce goods and services.

Lastly, the efficiency of supply chain management increases for rural customers. Rural farmers, for example, can access a wider array of inputs (including, but not limited to, seeds and fertilizers) and information on how to more effectively use these inputs. Information that was once costly to obtain has a significantly lower cost that, in some cases, may now approach zero (weather information, for example). Mobile phone access may also reduce transaction costs with respect to the rural supply chain by improving the ability of farmers to find markets that offer the highest return. Farmers are more able to determine which crops to plant, how to adapt to climate and weather patterns, and, once goods are produced and sold, how to gain access to financial services and markets (Baumüller, 2018).

Improvements in productivity may not produce increases in incomes if farmers and other rural producers cannot move their goods to market. Some studies have explicitly assumed that access to mobile networks will enable "leap-frogging" or "catching-up" by developing economies. While there is anecdotal and empirical evidence suggesting that the "leap- frogging" effect does, in fact, exist, we caution that it may not occur in all circumstances. The challenge is to identify the circumstances that may degrade the influence of increased mobile phone access and usage. We can then determine whether these conditions exist in South Dakota and, if so, determine what policy actions may be necessary to mitigate these concerns.

C.3 Economic Growth and Well-Being

Does ICT have a more significant impact in developed or developing countries? Yousefi (2011) argued that ICT had a stronger positive impact in developed countries relative to developing countries. In high income countries, ICT contributed 0.20 percent to annual GDP growth, almost double that of the contribution of 0.11 percent for low income countries (Gruber & Koutroumpis, 2011). On the other hand, Waverman, Meschi, and Fuss (2007) estimated that

the impact of ICT may be double that of developed countries. Unlike developed countries that have established landline infrastructure, these countries tend to employ mobile phones for the primary communication network. This result extends to mobile broadband. Lower income countries derived significantly more benefit than higher income countries from mobile broadband services, again due to the lack of capacity of landline infrastructure in developing countries (Thompson Jr & Garbacz, 2011). At the macroeconomic level, from a sample of developing countries from 2000 to 2002, increases in fixed and mobile networks appeared to lead to increases in Foreign Direct Investment (Lydon & Williams, 2005). While there may be a lack of consensus on where the influence of ICT is higher, there is a significant degree of consensus that ICT raises economic growth over time.

In general, Chavula (2013) found that fixed and mobile telephone services had a positive impact on economic development but failed to detect a significant impact of Internet penetration. Albiman and Sulong (2016), for example, studied the role of ICT use to the economic growth in Sub-Saharan Africa and concluded that mobile phone usage and Internet access had a host of positive economic outcomes. Once mobile phones have sufficient market penetration, mobile phone access and usage positively affected human capital, domestic investment, and institutional quality. The hypothesized gains in financial sector efficiency, however, did not materialize, most likely due to structural weaknesses in the financial sector. A similar story emerges for the case of China from 1991 to 2010. Mobile services, on average, contributed more significantly to economic growth than landline services (Thompson Jr & Garbacz, 2011; Ward & Zheng, 2016). In some cases, fixed broadband had no significant contribution to GDP growth, specifically in countries that lacked the appropriate level of infrastructure (Thompson Jr & Garbacz, 2011).

What is the quantifiable impact on Gross Domestic Product (GDP)? In general, higher levels of mobile phone penetration lead to higher rates of GDP growth, particularly among low-income developing countries (Gruber & Koutroumpis, 2011; Waverman et al., 2007). In high-income countries, the contribution of ICT capital to GDP growth has fallen from 0.7 percentage points in 1995 to 1999 to 0.4 percentage points in 2010 to 2014 (World Bank Group, 2016). The contributions to GDP growth in lower-income countries have been smaller, primarily due to lower levels of investment.

The broader mobile ecosystem in Sub-Saharan Africa generated an estimated 5.7 percent of GDP, with a contribution of approximately $100 billion in economic value (Aker, 2010; James & Versteeg, 2007). In Bangladesh, Malaysia, Pakistan, Serbia, Thailand, and Ukraine, for example, mobile phone usage accounted for between 3.7 percent to 6.2 percent of GDP in 2007 (Jain, Hong, & Pankanti, 2008). In Sub-Saharan Africa during 2006-2015, a 10 percent increase in mobile phone penetration results in a 1.2 percent change in GDP per capita (Haftu, 2018). Mobile telephony in India also appears to positively influence economic growth in that a 1 percentage point increase in mobile telephone usage is associated with a 0.09 percent increase in economic growth (Ghosh, 2016). Lastly, the continued migration of ICT services towards mobile in Sub-Saharan Africa will likely increase the contribution of ICT to economic growth, primarily as a result of improved subnational growth (Asongu & Le Roux, 2017).

At household level, Beuermann, McKelvey, and Vakis (2012) suggested that mobile coverage expansion significantly improved household wellbeing in rural Peru from 2004 to 2009. Real household consumption increased by almost 11 percent for the duration of the study. The largest increases in consumption were for health expenditures (a real increase of 23.7 percent), transportation expenditures (19.2 percent), and mobile phone expenditures (231.0 percent).

Increases in mobile phone access and usage led to an approximately 8 percent decline in household poverty during the sample period. Furthermore, mobile phone penetration had positive spillovers as non-owners also gained access to mobile phone services. In other words, increases in mobile phone access and usage had positive benefits to owners and non-owners alike.

In the case of Uganda, Blauw and Franses (2016) argued that mobile phone access and usage had a positive impact on household development. Information and travel costs are substantially lower for those who have a mobile device and the duration of mobile phone ownership is positively correlated with household development. Lee and Bellemare (2013) studied the intra-household distribution of mobile phones in the Philippines and concluded that farmers received higher prices when the head of the household owned a mobile phone.

Mobile phone penetration appears to be beneficial for the poor, as it has a positive income-redistributive effect. Mobile money with phone-based money transfer and pocket banks in Africa increase the access to financial services for the previously unbanked. Mobile phone usage can also stabilize a households' budget in the face of economic shocks through the promotion of better financial management and savings behavior. Lastly, mobile phones can empower women to engage in small businesses, enabling them to earn an income and increase their financial independence, thereby reducing gender income inequality (Asongu, 2015).

In summary, the consensus in the literature is that increases in mobile phone market penetration and usage improves not only economic growth at the macroeconomic level but also economic development at the household level. A significant finding from the literature is that improving rural access to mobile telephony reduces rural poverty, increases rural productivity, and improves human capital accumulation. Areas that are relatively poorer appear to receive a more significant impact from mobile phone penetration and usage. These findings suggest that investments in 5G in rural areas of South Dakota should have significant and positive impacts on a host of economic outcomes, especially as the initial stock of human capital and institutional quality is higher in South Dakota than many developing countries.

C.4 Sectoral Impacts of Mobile Phone Access and Usage

As discussed previously in this report, South Dakota's economy has several pillars, including financial services, agriculture, and tourism. In this section, we briefly examine the impact of mobile phones on a variety of economic sectors.

C.4.1 Agricultural Economy

Agriculture happens to be the dominant sector in terms of employment and value added for many developing economies (Nabhani et al., 2016). In general, many rural, agriculture-based communities lacked access to ICT infrastructure. The advent of wireless communications has had a discernable impact on rural communities, increasing access and consumption of information. Mobile phone access and usage increases the ability of rural producers, whether they are in the agricultural sector or not, to gain information on the prices of inputs and outputs, allowing producers to make more efficient decisions (Deichmann et al., 2016). The access to information through the mobile device tends to reduce persistent information asymmetries caused by a reliance on market intermediaries.

Mobile phone access also positively influences the accumulation of human capital through mobile extension services (which improve sectoral productivity) and educational services, in general. Mobile financial services also increase in breadth and depth, allowing the unbanked to gain access to financial markets and an opportunity to increase the accumulation of financial capital. The access to and usage of a mobile phone also increases the network of clients of rural producers and strengthens the relationships within this expanding network. The frequency and costs associated with travel are reduced and transaction costs in agriculture fall with access and usage (Aker & Ksoll, 2016).

New mobile phone service has reduced price dispersion, that is, drastically different prices for the same products in markets that are only short distances apart. Aker (2008) found that the introduction of mobile phones is associated with a 20 percent reduction in grain price differences across markets, with a larger impact for markets that are farther apart and those that are linked by poor-quality roads. The introduction of mobile phones also reduced price dispersion reduction for fisherman (Abraham, 2007; Jensen, 2007), illustrating the "near-perfect adherence to the Law of One Price" in the South-Indian fisheries sector following the adoption of mobile phones. Another recent study found that mobile phone coverage reduces the spatial dispersion of prices for perishable commodities but has no discernable impact on non-perishable products (Aker & Fafchamps, 2014). Perishable commodities must be sold and consumed within a specific period and farmers are unable to store the product in anticipation of higher prices in the future. Mobile phone access allows farmers to diminish information asymmetries and ensure that price disparities are minimized across geographically dispersed markets.

Mobile phones link farmers to markets. A recent study of farmers conducted in Bangladesh, China, India, and Vietnam found that 80 percent of farmers in these countries owned a mobile phone and used them to connect with agents and traders to estimate market demand and selling prices (T. Reardon, Chen, Minten, & Adriano, 2012). More than 50 percent of these farmers would negotiate the sales of their product on the mobile device. Farmers were not only able to expand their networks but were also able to establish contacts directly with other buyers. Muto and Yamano (2009) also found that mobile phone coverage expansion increased market participation in Uganda for farmers growing perishable crops in remote areas. More than 90 percent of the farmers used their mobile phones for access to agricultural inputs, information of output prices, monitoring of financial transactions, and coping with agricultural emergency situations. Nearly 50 percent of farmers consulted with experts via mobile phones (Ahuja et al., 2015). Recent evidence suggests that surveyed farmers may rely more on mobile phones for normal communications rather than agricultural activities (Kabbiri et al., 2018), however, we should note that previously, the farmers were unable to communicate in an expeditious manner. In other words, farmers can spend less time using mobile devices for work-related activities because the mobile devices have significantly lowered the cost and increased the access to agricultural-related information.

A number of recent empirical papers have investigated the effects of better market information on producer prices (Deichmann et al., 2016). The evidence is mixed. Svensson and Yanagizawa (2009) found that having access to regular market information via radio was associated with 15 percent higher farm gate prices in Uganda. The results from an experiment in Rwanda, on the other hand, found no effect of having a mobile phone on prices received by farmers (Futch & McIntosh, 2009). SMS-based agricultural information on producer prices in India did not significantly increase farm-gate prices (Fafchamps & Minten, 2012). Muto and Yamano (2009), on the other hand, found that, in Uganda, mobile phone coverage had a positive effect

on farm-gate prices for bananas. The authors, however, did not find a significant impact on prices for maize. Shimamoto, Yamada, and Gummert (2014) looked at rice sales in 20 villages in Cambodia and found that farmers who have access to market information through the use of mobile phones were more likely to sell their rice at a higher price. Rural households in Nigeria who increased their access and usage of information technology planted a more diverse basket of crops, particularly marginal cash crops grown by women. There was, however, no discernable impact on farm-gate prices (Aker & Ksoll, 2016).

Mobile phone use also raises on-farm productivity. Mobile phones (given that many countries also do not have enough fixed ICT capability) enable the transformation of traditional agricultural extension into e-extension. E-extension is the reinvention of the traditional face-to-face extension model and increases the delivery of information to farmers at a lower cost. Costs per farmer may decline significantly as extension agents can employ a combination of voice, text, videos, and Internet services (apps, for example) instead of having to travel to visit rural communities (Mittal et al., 2012). Similarly, governments, in partnership with mobile operators, use phones to coordinate the distribution of improved seeds and subsidized fertilizers in remote areas through e-vouchers, as in Nigeria's large-scale e-wallet initiative (Deichmann et al., 2016).

Cole and Fernando (2012) show that, in rural India, information provided via mobile phones to farmers increased their knowledge of available options for inputs such as seeds and fertilizers as well as choices of different crops. This information led to farmers changing their investment decisions and eventually planting more profitable crops. In addition, digital tools can provide support information through voice or SMS, including weather forecasts and market information. A high-quality mobile network allows the automation of irrigation pumps such as the Nano Ganesh system in Pune, India. Farmers then save water, energy, and time by remotely controlling their irrigation pumps (Tulsian & Saini, 2014). There is some evidence that the impact of mobile phones may be dependent on local conditions in that mobile phone usage had no appreciable impact on agricultural product for a sample of African countries (Chavula, 2013). The study noted, however, the fixed (landline) telephones had a significant impact, suggesting that if an economy already has functional ICT infrastructure, the gains from increasing mobile phone access and usage may not be statistically significant. However, we also note the preponderance of evidence supports the conclusion that mobile phones improve economic output, efficiency, and the quality of life of rural communities.

For water security, innovations in mobile communications have created an inclusive, secure, and low-cost architecture for financial and data flows to reduce risk and enhance water security (Hope, Foster, Money, & Rouse, 2012). Water users without formal banking services are now able to use mobile water payment services in Kenya, Tanzania, Uganda, and Zambia. In Uganda, the reported minimum savings from avoided costs for payment security, labor, and payment collection facilities were not trivial. The mobile tools are not limited merely to financial services. Smart metering technologies, which can remotely transmit water flow data and control supply in automated metering reading or advanced metering infrastructure, improve the efficiency of the overall water system and reporting to the individual customer. However, emerging mobile water initiatives are fragmented, privately driven, and the overall impact is not yet quantified with any degree of precision. We do observe, however, that these systems are proliferating across developed and developing countries.

C.4.2 Business and Logistics

The literature suggests that increasing mobile phone access and usage positively influences entrepreneurial activity. Small enterprises predominately use mobile phones and these businesses often accrue similar impacts as agricultural communities. Samuel and Shah (2005) revealed that mobile phones played a part in small business start-ups. In South Africa, 29 percent of respondents from non-mobile phone related firms were influenced to some extent by the availability of mobile phones in starting up their business, compared with 26 percent in Egypt. This was particularly true for small businesses operating in the service sector. In some cases, access to mobile phones increased the range of offered services. Donner (2006) surveyed microentrepreneurs in Kigali, Rwanda. These entrepreneurs faced significant challenges and mobile devices allowed them to develop and maintain business contacts.

Jagun, Heeks, and Whalley (2008) studied the impact of mobile phones on the cloth weaving sector in developing countries. Mobile phones had an economizing effect on supply chain processes, but no significant restructuring effect on the organization of supply chains. Boateng (2011) found that traders used mobile phones primarily for during-trade activities including monitoring goods and pricing strategies, scheduling deliveries, and addressing inquiries and complaints which may have incremental and transformational effects. Boateng, Hinson, Galadima, and Olumide (2014) showed that mobile phones are used to communicate and exchange information which relate to pre-trade, during-trade and post-trade activities leading to enhanced communication and trading process. As a consequence, mobile phone use indirectly improves revenue and enhances decision making and control, and thereby economically empowers traders.

C.4.3 Banking and Financial Services

Mobile financial applications known as m-money or m-banking has emerged in developing countries and, in many cases, is on the forefront of mobile finance. Mobile finance usually involves a set of applications that facilitate a variety of financial transactions via a mobile phone, including transmitting airtime, paying bills, and transferring money between individuals. Mobile money applications have emerged in Asia, Latin America, and Africa and, in some cases, lead rather than trail developed countries (Aker & Mbiti, 2010).

The introduction of mobile finance provides a unique opportunity to examine how access to these services influences economic outcomes. The transfer of money via mobile phone, for example, can reduce the costs associated with social protection and other public programs. Mobile money transfer can also reduce the likelihood of leakages as intermediaries are removed from the transaction chain (Muralidharan, Niehaus, & Sukhtankar, 2016). Mobile money transfer systems lower the transaction costs for senders and recipients of funds, provided there is reasonable access to mobile money transfer agents (Blumenstock, Callen, & Ghani, 2014). Mobile finance systems may not only increase access for private agents to transfer funds to each other, but may also facilitate financial capital accumulation for the unbanked (Jack & Suri, 2014; Mbiti & Weil, 2011).

Several articles review the uses and economic impacts in Kenya of the mobile money transfer system known as “M-Pesa”. M-Pesa became the dominant money transfer mechanism within 2 years of its inception. Vaughan (2007) noted that some individuals stored money in M-Pesa due to safety considerations, especially when travelling across the country.

Morawczynski and Pickens (2009) found ethnographic evidence that M-Pesa changed savings behavior, the pattern of remittances, and increased rural livelihoods. For instance, users often keep a balance on their M-Pesa accounts, thereby using the system as a rudimentary bank account even though the system does not provide interest. M-Pesa offered a significantly cheaper method of instantly transferring funds. The cost of sending $100 to a non-registered user by M-Pesa was approximately $2.50 in early 2008, much lower than traditional financial methods. The cost of sending to a registered user was even lower (Mbiti & Weil, 2011).

In addition, M-Pesa led to decreases in the prices of competing money transfer services, including Western Union. While individuals keep a balance as a transactional buffer, there is no empirical evidence to suggest that M-Pesa is used to store wealth for longer periods of time (most likely due to the lack of interest on balances). M-Pesa improves individual outcomes by promoting banking and increasing transfers between individuals and institutions. Using ethnographic methods in three communities, Plyler, Haas, and Nagarajan (2010) argued that M-Pesa enabled small businesses to expand and grow and increased the circulation of money in these communities.

In another study in selected countries in Sub-Saharan Africa, the availability and usage of mobile phones to provide financial services promotes the likelihood of saving as well as the amount saved at the household level. The frequency and convenience with which such transactions can be undertaken using a mobile phone impacts saving behavior. Both forms of savings, basic mobile phone savings stored in the phone and bank integrated mobile savings, are promoted by use of mobile phones. Thus, growing and deepening the scope of mobile phone financial services is an avenue for promoting savings mobilization, especially among the poor and low-income groups with constrained access to formal financial services (Ouma, Odongo, & Were, 2017).

In a mobile money cash transfer experiment in Niger, an intervention that provided a cash transfer via the mobile phone strongly reduced the costs of program recipients in obtaining the cash transfer. Costs declined by 20 percent relative to manual distribution. In addition, m-transfer program recipients spent less time in obtaining their transfer relative to those who received their distribution in the traditional manner. The time savings was not trivial, 2.5 days over a 5-month period. Program recipients, all of whom were women, reported that the m-transfer was less observable to other household members, thereby allowing them to temporarily conceal the arrival of the transfer which might have shifted women's bargaining power within the household (Aker, Boumnijel, McClelland, & Tierney, 2016).

In an example from Asia, Ghosh (2016) used data on Indian states from 2001 to 2012 to analyze the impact of mobile phone penetration on financial inclusion. By lowering costs and improving the speed of transfer, mobile phone access and usage exerted a noticeable impact on financial inclusion. A one standard deviation increase in mobile penetration is estimated to improve the outreach of bank offices by 31 percent. However, mobile penetration does not appear to exert any perceptible impact on geographic branch penetration. In addition, the biggest impact of mobile penetration is on the use of services and, more specifically, on the use of deposit and loan accounts. For instance, an increase in mobile penetration by 40 percent will lead to an increase in the use of deposit accounts by roughly 37 percent and the use of loan accounts by nearly 60 percent. Economically, one would expect mobile telephony to exert a more pronounced impact on deposits as it improves the flexibility of remittances, akin to the M-Pesa experience in Kenya. The evidence in the Indian case appears to suggest that mobile telephony

improves the information set of customers regarding the use of loan products relative to deposit products.

C.4.4 Good Governance

Mobile phone access and usage also appears to aid in the diffusion of knowledge for better governance (Bailard, 2009). For a sample of Sub-Saharan countries, there is an unconditional positive effect of mobile phone penetration on good governance. Second, the net effects on political, economic, and institutional governances that are associated with the interaction of the mobile phone with knowledge diffusion variables are positive for the most part (Asongu & Nwachukwu, 2016). The positive net effects are apparent because the knowledge diffusion variables complement mobile phones in reducing information asymmetry and monopoly that create conducive conditions for bad governance. Third, countries with low levels of governance are catching-up to their counterparts with higher levels of governance.

Decentralizing information and communication diminish opportunities available to engage in corruption, while increasing the potential of detection and punishment. As mobile phone penetration increases, the perceived level of corruption declines. Country level evidence from Namibia found that increased mobile phone coverage is statistically significantly associated with decreased perceptions of corruption (Bailard, 2009). Mobile phones not only allow citizens to monitor government activities, they also appear to increase interaction of citizens with their government (Aker, 2010).

C.4.5 Education

Valk, Rashid, and Elder (2010) examine the concept of mobile learning in the developing world through an examination of whether mobile phones improve educational outcomes in some projects in Asia. Broadly, it appears that, for the sample countries, mobile phone access and usage improves educational outcomes, but the channels by which this influence occurs are diffuse. Aker and Mbiti (2010) find that simple and affordable mobile phones can be used to promote literacy for adults in Africa. Although the text messages are cheaper compared to voice calls in Niger, the use of text messages has been relatively limited, in part due to high illiteracy rates. In addition to the normal literacy curriculum, adult learners in Niger are taught where to find letters and numbers on a mobile phone and how to send and receive text messages. Preliminary results suggest that the mobile phone-based literacy students have higher test scores than students in normal literacy classes, and these results are maintained six months after the end of classes (Aker, Ksoll, & Lybert, 2010). Similar mobile literacy projects are starting in Senegal, and others in India are using smartphones and mobile games for children.

C.4.6 Health Care

Mobile health initiatives have been adopted by many countries, however the level of adoption is varied across countries. The most common mobile health initiative was the formation of health call centers, where individuals can call and discuss health conditions with a nurse or doctor. After that, mobile phones were used for SMS reminders, telemedicine, accessing records, and patient monitoring (West, 2012). There is, of course, significant variation among countries as to the adoption of mobile health services, with developed countries leading the way. Of course, the scope of the medical sector is much greater in developed countries, so the amount of capital to investment in mobile health services is significantly greater than in developing countries.

The mobile health service transformation can be quite disruptive to the traditional health care delivery system. When there is a significant number of uninsured (or those who completely lack access to health care),

mobile health services may be the only contact with a health service provider. Mobile health services can not only educate the health care consumer but also can be used to quickly disseminate information to the public at large (Accelerator; Pop-Eleches et al., 2011).

Pilot projects in India and Sri Lanka have found that mobile devices are very helpful in monitoring outbreaks of Dengue Fever. In the world before mobile communications, it generally took the provinces 15 to 30 days to report data on disease outbreaks to central authorities. The time lost here slowed treatment responses and aggravated the spread of infectious diseases. However, with the onset of mobile and digital communications such as the Real-Time Biosurveillance Program (RTBP) and mHealthSurvey mobile phone software including real-time digitization of clinical information at hospitals, the wait time on infectious diseases has dropped considerably (Waidyanatha, Dubrawski, Ganesan, & Gow, 2011).

Shahid, Mahar, Shaikh, and Shaikh (2015) examine mobile phone intervention to improve diabetes care in rural areas of Pakistan. The findings indicate that mobile phone technology in rural areas of Pakistan was helpful in lowering HbA1c levels in intervention group through direct communication with the diabetic patients. Lowering LDL and following diabetic diet plan can reduce HbA1c in these patients and help in preventing future complications.

Beratarrechea et al. (2014) conducted a systematic review of the impact of m-health on chronic diseases in developing countries, and the results for m-health interventions showed a positive impact on chronic diseases in low- and medium-income countries. Positive impacts were identified in all assessment categories such as process of care, costs, and clinical outcomes. Patients who transferred daily glucose readings to physicians using a mobile system and received telephone medication regimen feedback had better diabetic glycemic control relative to control subject (Wojcicki et al., 2001).

C.5 Challenges

Of course, while there are significant benefits to increasing mobile phone penetration in the literature, there are also negative outcomes. Xie, Zhao, Xie, and Lei (2016) investigate how the attitudes towards mobile phones as social status symbols affected life satisfaction of adolescents living in rural areas of China. The results showed that the attitude towards mobile phones as social status symbols reduced life satisfaction. This attitude not only was reflected in personal life satisfaction but also interaction with other individuals, including teachers and fellow students. Seo, Park, Kim, and Park (2016) studied mobile phone dependency and its impacts on adolescents' social and academic behaviors in South Korea using a national sample of 2,159 middle and high school students. The findings of this study showed that mobile phone dependency increases attention and depression problems for middle school students. These problems, in turn, impact social relationships with teachers and friends and also academic achievement. While middle school students' academic achievement in language arts and mathematics was not directly influenced by mobile phone dependency; the emotional states were dependent on mobile phones. Also, the mediating roles of attention, depression, and relationships with friends were found between mobile phone dependency and the academic achievement of middle and high school students in South Korea.

In Southern Mozambique, most people have a story about themselves or a couple they know who split up "because of the phone." Although some stories are more dramatic than others, the kinds of misunderstandings they represent were described as the mobile phone's biggest drawback. Based on

research on mobile phone use among young adults in the city of Inhambane, Soleil Archambault (2011) focused on instances when connections backfire and when mobile phone communication generates conflict. The results of analysis suggest that mobile phone communication plays a role in mundane affairs and might, in fact, have much broader transformative implications and create consequences.

The challenges with regards to mobile phones appear to be personal, that is, how do we adapt to a life that now can be continuously streamed, pictured, and posted?

C.6 Conclusion

The question is what will be the impact of increasing investments in mobile access and capacity in South Dakota? The majority of South Dakota's population still lives outside of metropolitan areas and agriculture remains a key component of the South Dakota economy. A lack of economic opportunity is transforming the rural character of South Dakota and the challenge is to foster an economic climate to promote rural employment and wage growth. Even in the metropolitan areas, access to dependable and scalable mobile services is questionable.

Increasing the capability and capacity of metropolitan and rural wireless networks in South Dakota is, given our review of the literature, likely to have significant impacts on the quality of life of South Dakotans. The literature highlights a virtuous cycle of economic development, especially in rural areas and areas where incomes are relatively low and unemployment is relatively high. Improved access to information, financial services, educational services, health care services, and improving communication will, based on the evidence to date, improve economic productivity and output. Many rural South Dakotans, who must now travel to consult with a physician or public official, will find access and quality of services will increase as rural networks increase. Improvements in mobile networks will, given the empirical evidence, improve the lives of South Dakotans.

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