AUTOMATION IN RURAL AMERICA

A REPORT BY THE CENTER ON RURAL INNOVATION
AND RURAL INNOVATION STRATEGIES, INC.

BUILDING INNOVATION IN RURAL AMERICA
FROM THE GROUND UP

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(Wilson, North Carolina; courtesy of the Center on Rural Innovation)

INTRODUCTION

Automation is a trend that has been both applauded and feared in American society for decades. In the simplest terms, automation represents hardware or software that is capable of doing things automatically, without human intervention (Shekhar, 2019). While in the 1960s, the pop culture cartoon The Jetsons portrayed a futuristic family living in a fully automated society as a work of fiction, today, this depiction is becoming more of a reality. From the steam-powered machines of the 19th century, driving unseen growth but also replacing hand-crafted products in the textile industry. To the automobile industry in the 20th century implementing machines to complete assembly line tasks like welding and spray painting. To now, where a car can be summoned or set to parallel park with just the touch of a button. The capabilities of automation are continuously expanding and changing the skills and needs of the labor force.

We are now seeing even more advancements of automation powered through technologies like artificial intelligence (AI), machine learning, and advanced robotics, taking industries to unprecedented production levels, but at the expense of automating many tasks originally performed by workers (Fitzpayne, McKay & Pollack, 2019). The world is now in what is known as the digital revolution, where we see a fusion of the digital, biological, and physical worlds, as well as the growing utilization of new technologies such as artificial intelligence, cloud computing, robotics, 3D printing, the Internet of Things, advanced wireless technologies, and advancements in automation. The digital revolution produced technology that is increasingly effective at automating intellectual and social tasks, like software to automate routine intellectual bookkeeping tasks previously completed by office staff or accountants, and payment processing systems to fulfill a transaction between a customer and salesperson. As automation has become more refined, its usage in both daily lives and industries have become increasingly integrated and accepted.

But automation is not just about large robots that can be used to build a car, or machines that can press large quantities of bottle caps within a minute: Automation has many positive implications, and is integrated into our everyday lives — from home appliances to cars, public transportation, and shopping, automation is everywhere (Frölich et. al., 2020). Even the simplest everyday tasks have a level of automation. Searching the internet for digital information has become easier than ever, through algorithms that have automated search engines to provide information in a matter of seconds without a physical person looking through a physical library or repository.

Automation is also credited for creating safer workplaces, increasing productivity, and advancing healthcare, and has also made it possible to control lights, heating and air conditioning, security systems, and certain appliances from anywhere in the world using automated cell phone applications (Folk, 2019).

From an economic development perspective, technological change and automation can create winners and losers. Rural economic development leaders need to understand these dynamics and incorporate them into their planning because without adaptive strategies, automation is expected to widen the gaps in economic opportunity between urban and rural places, and reinforce income inequality between workers with and without specialized skills (Autor, 2015). While rural areas and workers are expected to be disproportionately impacted by automation in the years ahead, they are not destined to experience economic losses due to automation. Efforts to reskill workers and support the formation and growth of technology startups in rural areas can mitigate the costs of automation — and even leverage automation trends to create new employment and rural prosperity. We explore these issues and others in this report, and conclude by offering a series of recommendations for rural economic and workforce development leaders on strategies to address the impacts of automation.

(Portsmouth, Ohio; courtesy of the Center on Rural Innovation)

A BRIEF HISTORY OF AUTOMATION AND ITS IMPACT ON EMPLOYMENT

Before delving into contemporary automation in rural America, it is essential to recognize that automation is not new to the 21st century, and is a topic that has been a center of economic discussions since the 1800s. Since the start of the first industrial revolution more than 250 years ago, technology has become increasingly sophisticated in automating routine activities. In its early forms during the first industrial revolution, there was a focus on automating physical tasks like manufacturing production lines, planting in agriculture, or excavation in mining through a process known as mechanization. Mechanization — which refers to the replacement of human (or animal) power with mechanical power of some form — was why industries like manufacturing, construction, production, and fabrication started to replace agriculture as the backbone of the economy (Britannica, 2021). In the most recent period of technological change, computers and digital technologies are driving a new era of automation, changing the way we work and transforming the economy.

(Platteville, Wisconsin; courtesy of the Center on Rural Innovation)

Each era in the history of automation has been accompanied by worries that technology will displace workers, and optimism that it will create new economic opportunities. In many cases, doom-and-gloom and overly optimistic scenarios have not played out as the proponents envisioned. Yet, technological advances have tended to have a dual effect of substituting for labor in some areas, leading to employment decline in certain industries and occupations, while also making other types of jobs more productive, leading to expansions in those areas. This has created a dynamic in which technological advancements and automation have created winners and losers, both between workers and places.

In their seminal work on automation, Frey and Osborne (2017) chart how the history of automation has created opportunities for some, while eroding it for others (Frey & Osbourne, 2017). As we will discuss later, much of the concern about automation today has been focused on its impact on workers with less specialized skills, for example, workers who have no postsecondary education. Yet, this hasn't always been the case. During the first industrial revolution of the 19th century, automation had the effect of reducing economic opportunity for highly skilled artisans who produced products by hand in small shops. The mechanization of production allowed for production to be broken down into smaller, discrete, and simplified tasks, enabling workers without specialized skills to work as part of the production process. This model of production led to the assembly line, pioneered by Henry Ford. As a result, wages and employment opportunities for workers with less-specialized skills increased dramatically, while economic opportunities for highly skilled craftspeople and artisans declined.

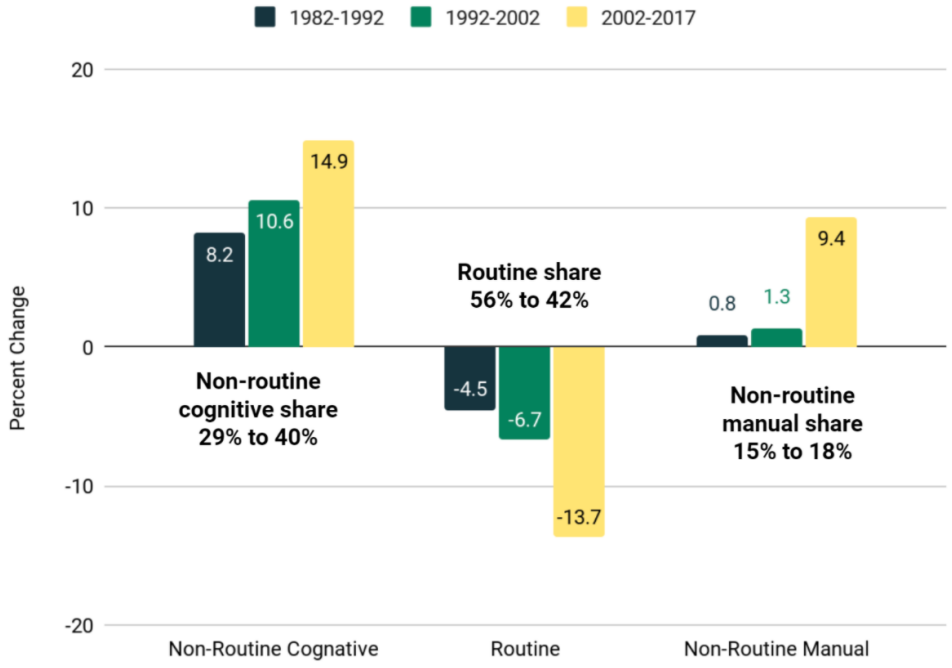
In the 20th century, electrification allowed manufacturers to increase the use of machinery to grow production, while the expansion of transportation systems allowed firms to become larger and more geographically dispersed, serving national markers. This evolution made business organizations more complex, requiring more management and administrative support roles. At the same time, new technologies were emerging to automate tasks related to processing information, like calculators, mimeograph machines (early printers), typewriters, audio recording systems, and punch cards. These advancements lowered the cost of processing information, and created significant demand for "white collar" office clerks and administrative staff, driving employment growth among these workers, many of whom were able to find employment with a high school degree and on-the-job training.

In the most recent period of technology-driven economic change — beginning around 1980 — computers and digital technologies have dramatically expanded the physical and information processing work that can be completed by machines. To explore this most recent dynamic in greater depth, our first brief on the future of work discussed how the prevalence of technologies in our work forces us to shift our perspective from thinking about our work in terms of jobs to thinking about work in terms of a bundle of tasks. Each job comprises a bundle of tasks, and the extent to which a job is impacted by automation is determined by the share of that job's tasks that can be automated by technologies.

Digitally enabled technologies are most effective at automating tasks that can be described by a codified series of steps and rules, and are regularly repeated. We refer to this as routine tasks. While all jobs include some degree of routine tasks, jobs that contain a high degree of routine tasks are most vulnerable to automation.

As a result, workers who perform routine tasks have been the ones most impacted by the most recent period of automation. Between 1982 and 2017, the share of occupations made up predominantly of routine tasks has fallen from 56% to 42% (Figure 1). Jobs that have a high degree of routine tasks have largely been concentrated in manufacturing production and business administration jobs. Thus, the same jobs that benefited from automation in the 18th and first half of the 19th centuries are now experiencing a decline in employment and wages for workers in these occupations (Acemoglu & Restrepo, 2018).

FIGURE 1:
PERCENT CHANGE IN EMPLOYMENT SHARES BY OCCUPATION GROUP



Source: Jaimovich & Siu (2018).

As we noted previously, automation in the late 19th and early 20th century expanded employment in jobs with a high degree of routine tasks that can be represented by a set of repeatable steps or rules, and favored skills learned on the job and through work experience. Thus, these jobs had been accessible to a wide range of workers with skills commonly found among people with a high school degree, such as the ability to read and follow a set of instructions, to execute a physical or mental action repeatedly with accuracy, and to perform basic mathematical calculations. As result, automation has led to a decline in employment in predominantly middle-income jobs, and their disappearance primarily impacted young and prime-aged men without postsecondary education (those with no more than a high school degree) in occupations like machine operators and production workers, and young and prime-aged women with intermediate education (non-degree post secondary training) in occupations like secretaries and administrative support workers.

While much of the focus in our understanding of automation has been on workers displaced by automation, U.S. employment has continued to increase throughout the past 40 years of the growing prevalence of automation. This is a result of the fact that automation creates more demand for jobs composed of tasks that are not easily automated. These tasks are challenging to codify into a set of steps or rules, and thus are best completed by human workers who can navigate undefined, uncertain, and unpredictable environments. These tasks include (Frey & Osbourne, 2017):

- Tasks that require perception and manipulation in complex and unstructured situations, such as driving in a congested city (although driving on a highway is more structured and suitable for autonomous driving).
- Tasks that require creative intelligence, such as coming up with original ideas or developing solutions to complex problems.
- Tasks that require social intelligence, such as being able to understand and respond to people's emotions and reactions in a social interaction or assisting and caring for others.

The reconfiguration of the workforce into jobs consisting of non-routine tasks can generally be described by two dynamics. In the first dynamic, automation has driven increased demand for specialized skills. Advanced or specialized skills include skills related to creative thinking, problem solving, and deep knowledge of specific domains like engineering, medicine, or law. These specialized skills are typically developed through postsecondary education, but can also include career technical training, micro-credentials, and certification programs. Specialized skills are often applied to non-routine tasks, and are complemented by technology which makes workers with these skills more productive. As a result, demand for jobs that use specialized skills has grown rapidly, leading to increases in employment in professional, technology, and managerial occupations. Three-fourths of jobs now require a moderate level of specialized skills (Muro et. al., 2017). Since specialized skills are not commonly found in the workforce, increasing demand for these skills has led to an expansion in employment opportunities and growing wages for workers with specialized skills and college degrees.

In the second dynamic, workers without specialized skills have faced fewer employment options. As we noted above, historically, many routine jobs in manufacturing or office administration paid middle-income wages, and leveraged skills learned on-the-job instead of specialized skills learned through education or training. The decline in demand for these jobs has led workers who do not possess specialized skills gained through education or training to shift their labor into the low-wage food service, customer service, or retail jobs, keeping wages in this sector relatively low.

These automation-driven dynamics have contributed to growing job polarization and income inequality in the U.S., a scenario in which employment growth occurs mostly among high-paying and low-paying jobs, with falling employment among middle-income jobs (Autor, 2015). This has led to growing income inequality between workers who have specialized skills and those who have commonly found skills.

Throughout history, technological change and automation have created winners and losers in the economy, both between workers and regions. As we will explore in the following section, the impact of automation is expected to disproportionately impact rural workers, industries, and communities.

THE IMPACT OF AUTOMATION ON OCCUPATIONS AND INDUSTRIES

When we think of rural economies, we generally think of jobs and industries, and it is critical to consider the impact of automation on rural America through those lenses. Every job can be thought of as a bundle of tasks — some of which are routine, and others are non-routine. Industries can be thought of as collections of jobs of different types that together complete a large set of tasks related to the work of that industry. For example, the manufacturing industry contains jobs in production, sales, management, technology, and transportation, while the healthcare industry contains jobs such as medical providers, life scientists, and business and financial professionals. The extent to which a given job or industry is likely to be impacted by automation depends on the extent to which the tasks within a job or industry are routine and easily completed by a computer or machine.

In a report published by the Brookings Institution in 2019, the share of tasks that could be automated by 2030 were estimated for major occupation groups (Munro et. al., 2017). Occupations such as food preparation, production, office and administration support, farming, transportation, and construction are estimated to be most impacted by automation, with more than 50% of tasks in each occupation that could be automated by 2030 (Table 1). Of these occupations, none require postsecondary education, and average wages range from just $23,900 (food preparation) to $48,900 (construction). The data brings clarity to the fact that rural workers are disproportionately impacted by automation. These occupations most likely to be impacted by automation account for 43% of total employment in rural areas in 2019, compared to just 34% in metro areas.

In contrast, occupations in arts and entertainment, architecture and engineering, education, and business and financial operations were the least vulnerable to automation, with fewer than 20% of tasks that could be automated. Of the occupations with the fewest tasks that could be automated, all but arts and entertainment jobs generally require a postsecondary degree, and average wages range from $54,500 (education) to $75,100 (business and financial operations) (Table 1). Rural workers are less likely to be working in jobs with fewer routine tasks, with these occupations representing just 15% of non-metro employment in 2019.

TABLE 1: THE IMPACT OF AUTOMATION ON OCCUPATIONS

Occupation	% of tasks that could be automated	Typical education required	Average Wages	% of non-metro employment	% of metro employment
Food Preparation and Serving Related Occupations	81%	Less than Bachelor's Degree	$23,900	5.7%	5.7%
Production Occupations	79%	Less than Bachelor's Degree	$37,200	9.2%	5.1%
Office and Administrative Support Occupations	60%	Less than Bachelor's Degree	$37,300	10.3%	10.7%
Farming, Fishing, and Forestry Occupations	56%	Less than Bachelor's Degree	$27,800	1.6%	0.5%
Transportation and Material Moving Occupations	55%	Less than Bachelor's Degree	$36,100	9.3%	7.4%
Construction and Extraction Occupations	50%	Less than Bachelor's Degree	$48,900	6.4%	5.0%
Installation, Maintenance, and Repair	49%	Less than Bachelor's Degree	$46,700	4.2%	2.9%
Sales and Related Occupations	43%	Less than Bachelor's Degree	$40,600	9.0%	9.9%
Healthcare Support Occupations	40%	Less than Bachelor's Degree	$30,500	3.9%	3.3%
Legal Occupations	38%	Bachelor's Degree or More	$106,000	0.5%	1.2%
Computer and Mathematical Occupations	37%	Bachelor's Degree or More	$87,900	1.2%	3.6%
Protective Service Occupations	36%	Less than Bachelor's Degree	$45,800	2.3%	2.2%
Personal Care and Service Occupations	34%	Less than Bachelor's Degree	$26,500	2.3%	2.8%
Healthcare Practitioners and Technical Occupations	33%	Bachelor's Degree or More	$79,200	6.0%	6.2%
Life, Physical, and Social Science Occupations	32%	Bachelor's Degree or More	$72,900	0.8%	1.1%
Management Occupations	23%	Bachelor's Degree or More	$118,000	9.6%	10.9%
Community and Social Services Occupations	22%	Bachelor's Degree or More	$47,200	1.9%	1.8%
Building and Grounds Cleaning and Maintenance Occupations	21%	Less than Bachelor's Degree	$28,000	4.2%	3.6%
Arts, Design, Entertainment, Sports, and Media Occupations	20%	Less than Bachelor's Degree	$58,400	1.1%	2.2%
Architecture and Engineering Occupations	19%	Bachelor's Degree or More	$84,300	1.4%	2.2%
Education, Training, and Library	18%	Bachelor's Degree or More	$54,500	6.1%	6.2%
Business and Financial Operations	14%	Bachelor's Degree or More	$75,100	6.1%	5.7%

Source: Task automation data, educational requirement, and average wages from Muro, M., Maxim, R., & Whiton, J. (2019). Share of non-metro and metro employment from the American Community Survey.

It is important to keep in mind that automation does not automatically mean that jobs will be terminated through mass layoffs. When an occupation is impacted by automation, a machine is used to perform tasks completely or reduce the human labor needed to complete the task. Job losses may not result from these labor changes. Although every job has a level of automation, less than 5% of occupations can be completely automated (Manyika et. al., 2017). More likely, the jobs that are most impacted by automation will experience a decrease in demand as technology takes on more of the work, requiring fewer human workers to complete those tasks, while at the same time creating demand for tasks that only humans can complete. Thus, automation will likely lead to changes in the tasks workers complete across occupations, and will require workers to develop specialized skills and the ability to work with technology. A study surveying Ohio manufacturing plants that were considered Small and Medium Enterprises (SMEs) found that small firm owners choose to automate in incremental phases in order to minimize worker disruptions while increasing factory productivity (Waldman-Brown, 2020). Most firm owners intended to complement incumbent workers' tasks rather than replace them. In cases where new technologies did replace human tasks, firm owners had no trouble finding new roles for their displaced workers.

Based on estimates from Brookings, the industries most likely to be impacted by automation by 2030 are accommodation and food services, manufacturing, transportation and warehousing, agriculture, retail, and mining (Table 2). These industries are primarily composed of jobs that are likely to be impacted by automation because they contain a high degree of routine tasks. Together these industries represented 42% of total employment in non-metro areas in 2019, compared to just 32% in metro areas.

TABLE 2: THE IMPACT OF AUTOMATION ON INDUSTRIES

Industry	% of tasks that could be automated	% of non-metro employment	% of metro employment
Accommodation and Food Services	73%	4.4%	5.2%
Manufacturing	59%	17.4%	11.4%
Transportation and Warehousing	58%	4.7%	5.2%
Agriculture, Forestry, Fishing and Hunting	57%	4.1%	0.8%
Retail Trade	53%	9.8%	9.2%
Mining, Quarrying, and Oil and Gas Extraction	51%	1.7%	0.4%
Other Services (except Public Administration)	49%	3.9%	4.2%
Construction	47%	8.0%	7.5%
Wholesale Trade	44%	2.6%	3.0%
Utilities	43%	1.5%	1.0%
Finance and Insurance	42%	3.3%	5.9%
Arts, Entertainment, and Recreation	41%	1.2%	1.6%
Administrative and Support and Waste Management and Remediation Services	41%	2.9%	4.2%
Real Estate and Rental and Leasing	40%	1.2%	2.0%
Government	37%	6.3%	5.4%
Health Care and Social Assistance	36%	14.2%	13.7%
Information	35%	1.1%	2.1%
Management of Companies and Enterprises	34%	0.1%	0.2%
Professional, Scientific, and Technical Services	34%	3.4%	8.8%
Educational Services	27%	8.3%	8.2%

Source: Task automation data, educational requirement, and average wages from Muro, M., Maxim, R., & Whiton, J. (2019). Share of non-metro and metro employment from the American Community Survey.

Considering the impact on rural areas through the lens of jobs and industries brings attention to the ways in which rural areas are likely to be disproportionately impacted by automation. While the impacts of automation are typically cast in a negative light in terms of jobs losses and economic decline, this does not have to be the case. Automation and technological change can offer new benefits and opportunities, such as increased productivity for businesses and workers, new products, services, and ways of working to serve customers, and new opportunities for entrepreneurship. Automation is already transforming industries that are core to the rural economy, and rural entrepreneurs are starting new companies to build the technology to power automation.

Healthcare

Complex health organizations, mountains of patient data, massive amounts of paperwork, and growing demand for high-tech treatments make healthcare a prime sector for automation. Today, nearly every healthcare professional uses a tool of automation in their work, from tracking patient symptoms, to performing machine assisted surgery, to billing insurance companies. With these technological advancements, not only is there a transformation in care delivery and medical progress for patients, but there is also the opportunity for reductions in the healthcare ecosystem that can be measured in billions of dollars. Technology and automation are also making it possible to help patients and doctors monitor health issues in real time, and connect patients to healthcare services when they need it most. Rural tech startup Arsana Health — based in Springfield, Vermont — developed a health risk management system that leverages sensors, data, and artificial intelligence to specifically address the challenges of protecting and caring for our most frail and vulnerable loved ones living in nursing homes or assisted-living facilities.

Local government

Local government engages in many routine tasks: collecting taxes, fees, and utilities, delivering public services, receiving public input, and communicating critical information to the public. Many of these routine tasks can be automated to improve efficiency, improve services, and strengthen public engagement, such as making it easier to pay taxes online, collecting input on policy using surveys and polls, or using apps to distribute critical public information. Rural tech startup MuniRevs — based in Durango, Colorado — developed technology that provides a streamlined, paperless solution for local governments to collect sales tax, lodging tax, and business license fees, increasing local government revenues and saving money.

Public Safety

Automation technology is used for security purposes like mine clearance, explosive ordnance disposal, search and rescue, combat support, intelligence, reconnaissance, and surveillance. It is also used for emergency services like neighborhood watch duties and fire fighting (Polly, 2020). Automation is used in the field of digital forensics, which is a branch of forensic science involving the application of computer science and

investigative procedures in the examination, recovery, identification, collection, and analysis of digital devices, evidence and data (Reith, Carr & Gunsch, 2002; National Institute of Standards and Technology). With the growing occurrence of digital crimes, there is a high demand for digital forensics to assess digital evidence and provide investigative support in criminal cases (Asquith & Horsman, 2019). Automation technologies combined with sensors are helping to identify public safety risks and coordinate responses. Rural tech startup Trinity Sound Technologies — founded by a former teacher in Baraboo, Wisconsin — has developed technology that uses innovative sensors to identify active shooters in public buildings like schools, alerts the police, and sends detailed information about the shooter's location.

Tourism

For many travelers, the entire process of booking a trip is facilitated by automation technologies: from searching for the cheapest flight to comparing lodging options, and using even an app to navigate while driving to a destination. These technologies have transformed the tourism industry and have driven increased demand for travel. Automation technologies have also enabled the growth of gig economy platforms like Airbnb, which makes it possible for homeowners to leverage their properties to earn additional income through the tourism economy. The outdoor sporting industry is also being impacted by automation, such as the growth in smart watches and other wearable devices that allow people to track the intensity of their activity while engaging in outdoor activities. Rural tech startup Rerouted — based in Durango, Colorado — is using automation technology to facilitate a marketplace for outdoor gear, creating income opportunities for outdoor enthusiasts, and promoting sustainability through reuse.

Education

Students and teachers often get bogged down by completing routine tasks that take away from meaningful classroom engagement, such as taking and reporting attendance, collecting homework and assignments, administering and grading tests, and managing class scheduling. Technologies are already emerging to streamline these processes so that students and teachers have more time for learning. Schools, colleges, and universities are also working to increasingly align their curriculum with the skills needed by employers. Collecting feedback from employers about the most in-demand skills can be a challenging task to complete manually, so educational institutions are leveraging technology and automation to learn from the labor market to do so more efficiently and effectively. The rural tech company EMSI — based in Moscow, Idaho — has been a pioneer in using technology and automation to surface labor market insights using data, and creating tools that can help educators develop curriculum and support their students as they start their careers.

(Courtesy of Center on Rural Innovation)

THE IMPACT OF AUTOMATION ON PLACES AND PEOPLE

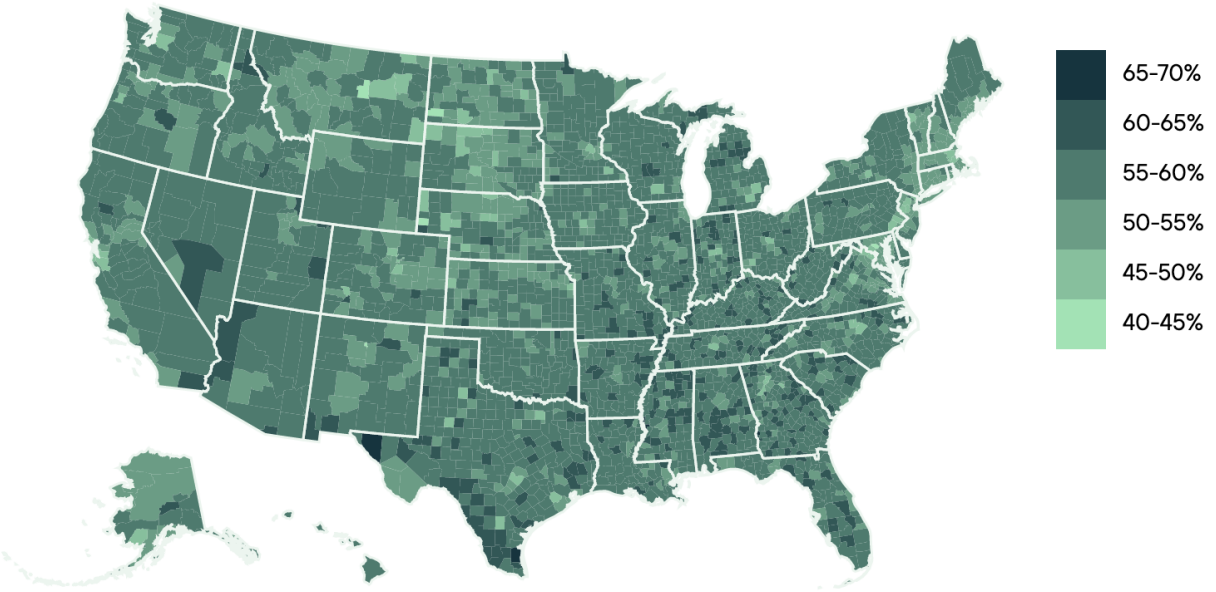
Just as the impact of automation on jobs and industries varies by the degree to which they contain routine tasks that could be automated, the impact on people and places varies based on the degree to which jobs impacted by automation are more concentrated in some places than others. Every region of the country will be impacted by automation, and it is estimated that more than 50% of jobs could be significantly impacted by automation in the average county (CORI analysis of Frey & Osbourne (2017) and Devaraj et. al. (2017); see Figure 2).

Figure 2 shows how the potential impact of automation on employment varies across regions. Considering the regional patterns challenges some of the dominant narratives about automation. For example, much of the focus on and concern around automation has focused on the Rust Belt in the upper Midwest, as many of the areas have already suffered job losses and plant closures driven by a combination of automation, globalization, and shifts in the geography of domestic production. Looking forward, the regions most likely to be impacted by automation are concentrated in the southeast. This reflects a decades-long trend of manufacturers relocating plants to the south to take advantage of growing workforces and laws that limit unionizing. This movement of domestic manufacturing to the south has created employment opportunities and investment in these regions, while concentrating economic activity in a sector that is likely to be impacted by automation moving forward. Additionally, areas along the south border of Texas which specialize in manufacturing, transportation and logistics, oil and gas production, and retail could be disproportionately impacted by automation.

Again, we emphasize that an area having a high share of employment in jobs that are likely to be impacted by automation does not mean that the area is destined to economic decline. While demand for certain occupations could decline due to automation, the much larger impact will be to change the task content of jobs, emphasizing tasks that are not easy to automate. This will require workers in these areas to increase their technical and specialized skills. The risks lie in the inability of a region to help workers make this transition. If workers are

unable to access training either through their employer or the workforce system, they may be ill-equipped to adjust to the new demands of jobs being impacted by automation, or to shift into a new occupation that is complemented by technology and automation. This dynamic can erode both business and worker productivity, making the region less competitive and prone to economic decline.

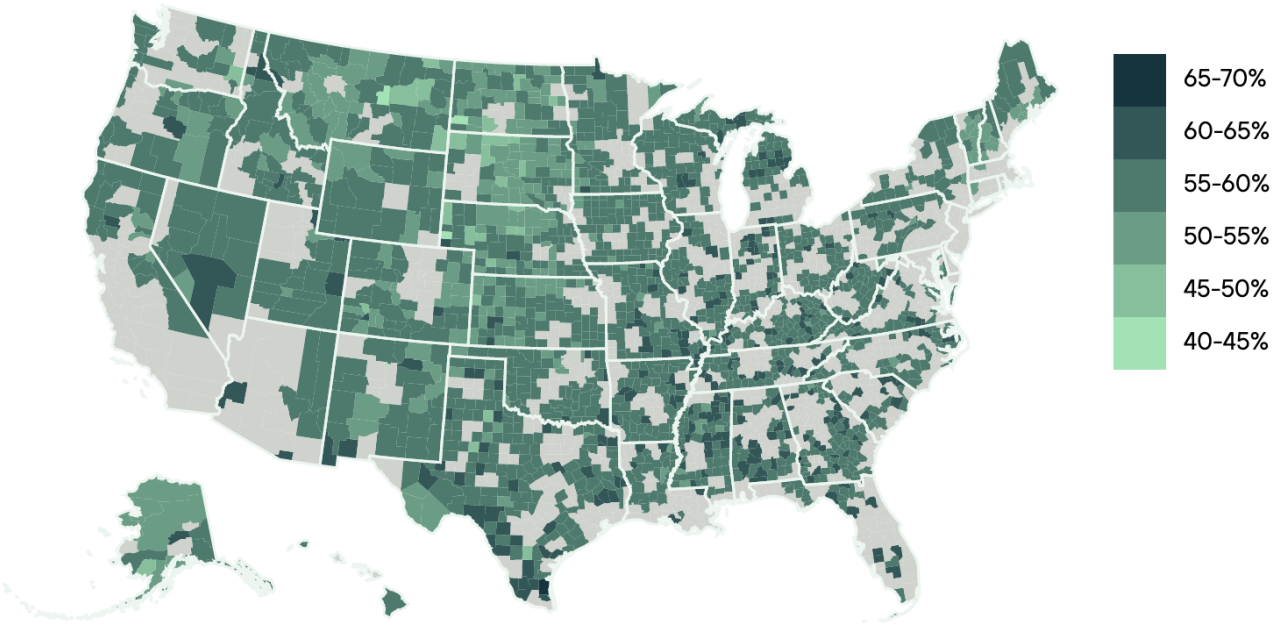
FIGURE 2: PERCENT OF JOBS AT RISK OF AUTOMATION IN U.S. COUNTIES



Source: CORI analysis of Frey and Osborne (2017), Devaraj et al. (2017), BLS, ACS 5-year estimates
**Automation risk was calculated using the methods from Frey and Osborne (2017) and Devaraj et al. (2017) using National BLS Occupation data to produce automation risk values for each occupation.The automation risk values were translated and aggregated to produce expectations for the five major ACS occupation categories from the 2019 ACS 5-year estimates to produce county level automation risk values. See Frey, C. B., & Osborne, M. A. (2017). The future of employment: How susceptible are jobs to computerisation? Technological forecasting and social change, 114, 254-280. ; Devaraj, S., Hicks, M., Wornell, E., & Faulk, D. (2017). How Vulnerable Are American Communities to Automation, Trade, & Urbanization? Ball State CBER & Rural Policy Research Institute.*

Figure 3 focuses just on non-metropolitan counties, highlighting that many of the areas that are most likely to be impacted by automation are rural. Of the 100 counties most likely to be impacted by automation, 83 are rural. Conversely, of the 100 counties least likely to be impacted by automation, just 35 are rural. Rural counties in specific states are expected to have a higher risk of automation than others, with many located in the southern regions of the U.S.(Table 3). South Carolina, Tennessee, Indiana, Florida, and Alabama had rural counties with employment most likely to be impacted by automation.

FIGURE 3: PERCENT OF JOBS AT RISK OF AUTOMATION IN U.S. RURAL COUNTIES



Source: CORI analysis of Frey and Osborne (2017), Devaraj et al. (2017), BLS, ACS 5-year estimates
**See note on Figure 2 for methodology.*

TABLE 3: TOP FIVE STATES WITH RURAL COUNTIES EXPERIENCING THE HIGHEST LEVEL OF AUTOMATION RISK AND RURAL EDUCATIONAL ATTAINMENT

States with rural areas with highest potential automation impact			States with rural areas with the lowest potential automation impact		
State Name	Rural Automation Risk	Rural population with a bachelor's degree or higher	State Name	Rural Automation Risk	Rural population with a bachelor's degree or higher
South Carolina	60%	18%	Massachusetts	53%	40%
Tennessee	59%	16%	Connecticut	53%	35%
Indiana	59%	17%	Vermont	54%	35%
Florida	59%	15%	New Hampshire	54%	34%
Alabama	59%	15%	Montana	54%	31%

Source: CORI analysis of Frey and Osborne (2017), Devaraj et al. (2017), BLS, ACS 5-year estimates
**See note on Figure 2 for methodology.*

A common factor among these states is that rural workers are less likely to have completed a postsecondary degree than the national average, making workers more vulnerable to automation and potentially impeding transition to higher-paying occupations that are complemented by technology. In contrast, the top five states with the lowest share of employment that is likely to be significantly impacted by automation — Massachusetts, Connecticut, Vermont, New Hampshire, and Montana — have a higher-than-average rural population with a bachelor's degree or more. Figure 4 illustrates the relationship between automation risk and educational attainment among rural counties, showing that areas with higher levels of educational attainment are less likely to experience the negative effects of automation than areas with lower levels of educational attainment.

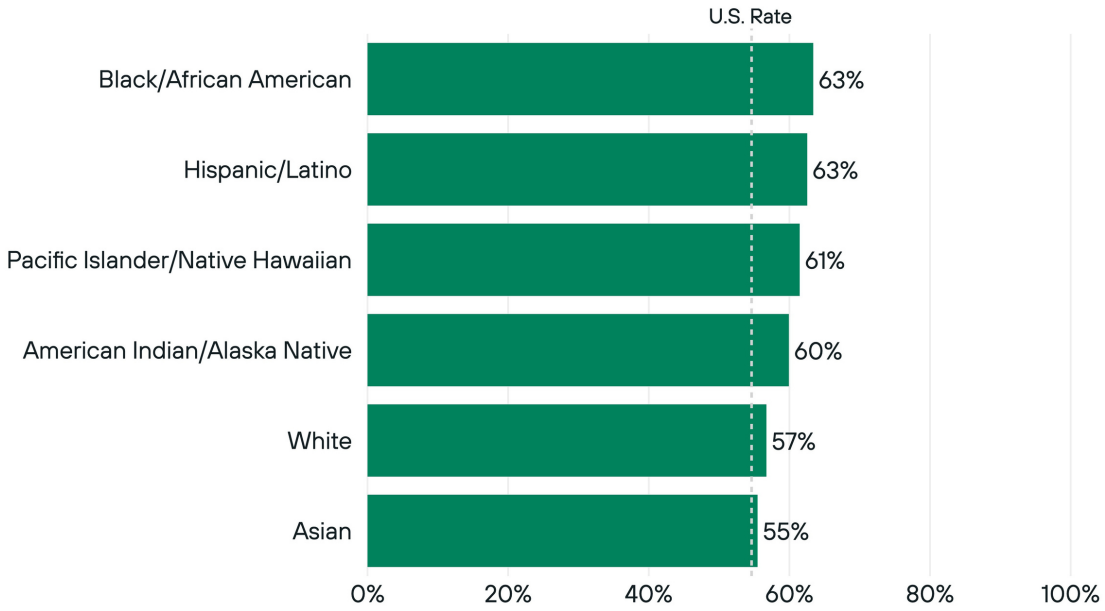
FIGURE 4: EDUCATIONAL ATTAINMENT AND AUTOMATION RISK OF NON-METROPOLITAN COUNTIES, 2019

Source: CORI analysis of Frey and Osborne (2017), Devaraj et al. (2017), BLS, ACS 5-year estimates, and Rural Urban Continuum Code (RUCC) data

Just as there is variation in the regions most likely to be impacted by automation, there is also variation in the demographics of the workers who are most likely to face job changes or displacement due to automation: General-skilled, less-educated, non-white, males, and workers in low-wage positions with low education levels — particularly workers who are male and of an ethnic minority face some of the highest risk (Ghimire, Skinner & Carnathan, 2020). This is especially true for Black males between the ages of 18-35, and those without college degrees, due to their overrepresentation in "support roles" such as truck drivers, food service workers, and office clerks (Cook et. al., 2019). On an educational level, workers with a high school diploma or less are over 50% more likely to be affected by automation compared to 29% of those with a college degree or higher.

Nationally, between 44-47% of jobs held by Latinx, Native American, and Black workers are at risk of potentially becoming automated. Even though Latinx workers account for less than 15% of the U.S. workforce, 32.6% of workers in construction and extraction trades are Latinx. Jobs in this industry are at risk of losing over half of their current tasks to automation (Table 2) (Muro, Maxim & Whiton, 2019). In rural areas, we see an even higher vulnerability to automation risk. Sixty-three percent of the jobs held by Black and Latinx workers are at risk of potentially becoming automated (Figure 5). Granted, rural Americans have a higher vulnerability to job automation risk, but these groups have the highest vulnerability in both rural and urban settings.

FIGURE 5: AVERAGE AUTOMATION POTENTIAL BY RACE, 2019



Source: CORI analysis of Frey and Osborne (2017), BLS, ACS 5-year estimate, and RUCC data

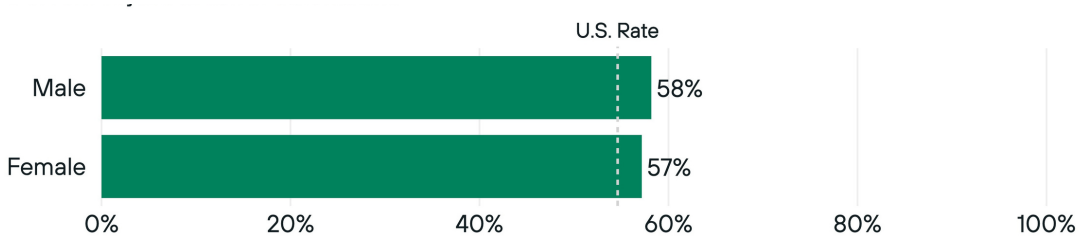
Although Black and Latinx workers account for 13% and 18% of the U.S. labor force, respectively, more than 31% of Latinx employees and 27% of Black employees are concentrated in the top 30 occupations that are at risk for automation (Broady et. al., 2021; Broady, 2017). This is due to a variety of factors. First, Black and Latinx workers are overrepresented in industries and occupations where there is a high risk of being eliminated or fundamentally changed by automation like office support, food services, agriculture, construction, leisure and hospitality, and production work industries. Furthermore, Black and Latinx workers are underrepresented in the occupational categories that are most resistant to automation-based displacement such as education, health, business, and legal, in which there could be a net gain in jobs. Compared to White workers, Black workers are 1.5 times more likely to be cashiers, cooks, combined food preparation and serving workers (including fast food), production workers, and laborers and freight/stock/material movers. They are also over three times more likely to be security guards, bus drivers, and taxi drivers/chauffeurs (Broady, 2017; Cook et. al., 2019). It is projected that by 2030, Black workers will be the population most affected by automation, and in the Black Rural South, almost a quarter of workers could be displaced due to automation (Cook et. al., 2019; Contractor & Overton, 2019).

(Pine Bluff, Arkansas; courtesy of the Center on Rural Innovation)

For Latinx workers, the narrative is similar. A UCLA study found that in just six states — Arizona, California, Florida, Illinois, New York, and Texas — 7.1 million workers, representing 40% of the Latinx workforce, are at risk of automation related displacement (Gonzalez et. al., 2020).

Through a gender lens, male workers have a higher vulnerability to potential automation compared to female workers. Male workers are oversaturated in production, transportation, and construction-installation occupations, which are industry areas that have an above-average projected automation exposure (Muro, Maxim & Whiton, 2019). In contrast, 70% of the workforce in automation-safe industries, like healthcare, personal services, and education, are female. Yet in rural communities, although male workers have a slightly higher risk of automation than female workers, the vulnerability is similar with male workers experiencing a 58% risk, and female workers experiencing a 57% risk (Figure 6).

FIGURE 6: AVERAGE AUTOMATION RISK BY GENDER, 2019



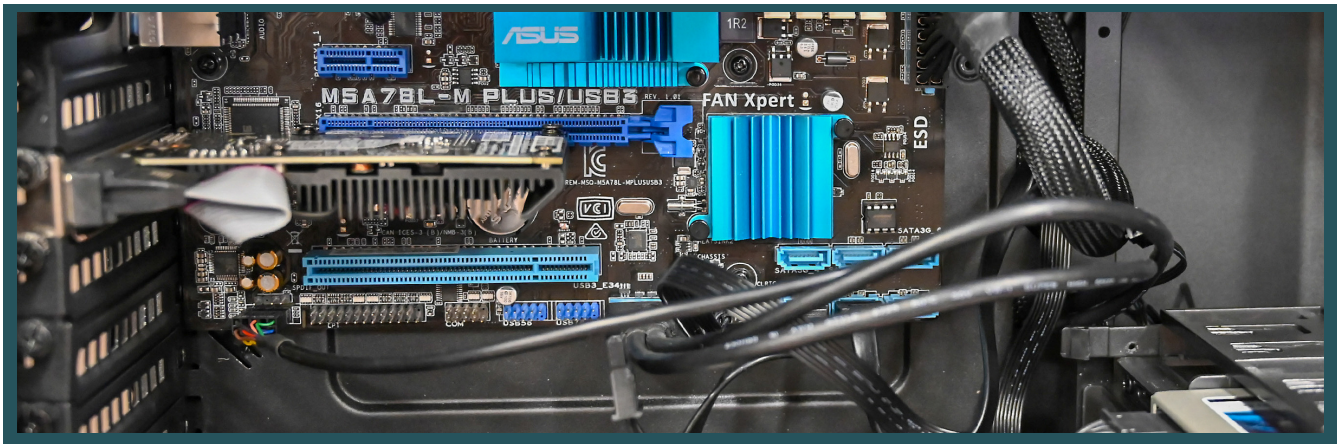
Source: CORI analysis of Frey and Osborne (2017), BLS, ACS 5-year estimate, and RUCC data

IMPLICATIONS FOR RURAL AMERICA

Technology and automation have been driving changes in the U.S. economy for more than 150 years. Throughout each era of technological change there have been winners and losers in the economy as technology shifts the types of activities and skills that create value. In this most recent period, computers and information technology have automated many routine tasks often associated with middle-income jobs in manufacturing and business administration. Looking ahead, technologies like artificial intelligence, blockchain, and virtual reality could expand the types of jobs and tasks impacted by automation.

Rural leaders need to pay attention to these trends because rural workers, industries, and regions are likely to be disproportionately impacted by automation in the years to come, as many already have. While it is not predetermined that automation will lead to economic decline, it is a serious risk that should be proactively addressed. Automation is likely to have an impact on more than half of workers by 2030, and workers will need to develop specialized skills and the ability to work with technology to remain productive. Supporting workers in upskilling is critical to maintaining regional competitiveness, and will require close collaboration between impacted workers, employers, economic and workforce development leaders, and traditional and non-traditional postsecondary training and education providers.

Rural leaders should also see automation as an opportunity. Technological change creates opportunities for innovative new companies that use automation to solve problems and create value. Historically, the firms building technology have largely been concentrated in a handful of metropolitan areas, but opportunities are emerging to establish tech startups in rural areas as broadband infrastructure is expanded and investors search for companies to support in unconventional places. As we noted in an earlier section, rural tech startups are already at the forefront of developing new technologies that use automation to solve problems and create value. These companies all have the potential to scale, creating high-paying jobs in their communities, and generating substantial wealth.



(Newport, Arkansas; courtesy of the Center on Rural Innovation)

We recommend that rural leaders consider the following when developing economic and workforce development programs and strategies:

Incorporate the impact of automation into economic development and workforce planning.
Adapting to the impacts of automation requires a proactive approach that involves economic development, workforce development, K-12 education, and postsecondary education. Developing this approach begins with understanding the makeup of local employment and how this employment might be impacted by automation. Local leaders can use Table 1 and Table 2 from this report which provide estimates for the share of tasks within major occupation and industry groups that could be automated by 2030. These groups match the occupation and industry groups used in the U.S. Census Bureau's American Community Survey, which provides estimates of employment by occupation and industries for all rural counties and towns. Simply use the U.S. Census Bureau's data.census.gov tool, and search for "Occupations + [your county/town]" or Industry + [your county/town]" to access employment estimates. Combining these two data sources can bring attention to local employment that could be impacted by automation, and serve as a starting point for developing plans to help businesses and workers adapt so that they can continue to thrive.

This is particularly important when considering tax incentives. Understanding the task composition of jobs that are promised by a new employer is critical to determining the long-term return on investment from offering incentives. If an employer is promising to create jobs that have a high degree of routine tasks, then it is less likely that the promised employment will be sustained in the long term. It would be best to scrutinize the opportunity to determine whether public incentives are viable.

Build local partnerships to support skilling and reskilling programs.
Workers who are vulnerable to the impact of automation will likely need to develop specialized skills and experience working with technology to broaden their work opportunities and increase their earnings. As we noted in the first section, workers that have been impacted by automation and lack specialized skills have found themselves limited to low-paying employment in service sectors. Thus, rural leaders should be focused on building cross-sector partnerships to support reskilling programs that help workers learn new skills that help them transition to a different job. In the face of automation, reskilling programs are a chance for workers to make themselves more employable, and for employers to invest in the workforce in the face of technological change.

Reskilling should begin while workers are still employed, as workers who switch directly from one job to another are less likely to experience a period of unemployment, and tend to have higher wages than those who seek a job while they are unemployed (Escobari, Seyal & Meany, 2019). For example, Levi & Strauss Co. — the classic American denim company — offered a portion of its retail employees the opportunity to go through a boot camp to learn skills related to statistics, coding, and machine learning that are valuable to the business industry. Verizon retrained 20,000 employees during the pandemic to learn digital sales and customer service, enabling them to shift toward roles that would enable them to stay

amidst a shifting economy (Kapner, 2021). In other words, if employers offer reskilling programs to workers whose jobs they know may be replaced by automation, it leaves workers — and by extension, the broader economy — better off.

Skills-based learning is also becoming a growing part of both higher education and primary education. On the community college level, education is also shifting to meet the demands of an economy that puts job skills as a central focus. More and more community colleges are shifting to non-credit bearing courses, which allow more non-traditional students to delve into new topics or refine skills without enrolling in a degree program, and are increasingly fostering connections with industry partners to enroll employees in these non-credit bearing courses. In addition, community colleges are seeking to offer more and more credentialing courses with the idea of facilitating more lifelong learning to adapt to an ever-shifting economy (Jacoby, 2019). In Newport, Arkansas, Arkansas State University-Newport fostered a collaboration with the Arkansas Center for Data Sciences and the Newport Economic Development Commission to help workers who are already employed in local industries to take classes in tech skills like coding and software development, which is seen as a benefit both for the worker-student and for the industry and broader community. On the K-12 education level, digital literacy skills have become a key tenet of curriculum. There is a growing emphasis on the role of experiential learning when it comes to technologies. Offering students more transferable skills is thought of as one way to help them navigate the economic reality that young workers between the ages of 18 and 24 are overrepresented in jobs that are automated (Van Drie, Smith & Casey, 2020; Muro, Maxim & Whiton, 2019).

Support businesses in adopting automation technologies to stay competitive. Adopting new technologies is critical for businesses to stay productive and competitive. Ensuring the businesses have the support they need to adopt emerging technologies is critical to the economic development of rural regions. Customized business services and local business roundtables that focus on the adoption of technology can help local businesses stay competitive. A successful model for this approach is the Manufacturing Extension Partnership (MEP) program. MEP offices, which are funded by federal, local, and state governments, provide guidance to small and medium manufacturing businesses to help them improve their competitiveness through supporting the adoption of emerging technologies related to automation, product design, and marketing. The W.E. Upjohn Institute found that the manufacturing extension partnerships lead to a return on investment of $14 for every $1 invested in the program, and a separate study found that these types of services have a relatively low cost per job-year at about $2,700, as compared to other policies like business tax cuts and tax incentives (Robey et. al., 2021; Bartik, 2018). For example, in Grand Rapids, Michigan, the city government made establishing a MEP office in the city a core part of its economic development strategy to help its business recover from major losses (Bartik, 2018). While the MEP focuses on manufacturing, the model of providing technical assistance to businesses around the adoption of automation technologies could be applied to other sectors.

Developing digital entrepreneurship ecosystems.
While the development of new automation technologies is often positioned as a risk, it is also an opportunity. Technology startups that develop new technologies that solve problems for a large market of buyers have the potential to scale from a few initial employees to companies employing dozens or hundreds of workers in high-paying technology, business, and finance occupations that are resilient to automation, as well as generating significant wealth for the community.

While the assumption has largely been that technology startups can only thrive in a handful of urban areas, rural communities across the country are showing that tech startups can thrive in rural places. Yet, potential startup founders need specific types of support to be successful: education on scalable business models, targeted business support provided by incubators or accelerators, mentorship from experienced founders and business leaders, and access to venture capital. Supporting technology startups requires building an ecosystem that brings together organizations around the common goal of increasing tech-based employment and supporting local entrepreneurs.

Rural communities across the country offer examples for this approach. In Red Wing, Minnesota, a nonprofit organization known as Red Wing Ignite helped to spearhead an initiative called the Entrepreneurs First (E1) Collaborative, which brings together 15 organizations from across southeast Minnesota to support local entrepreneurs, offering services that no one organization in any one rural town could offer. Additionally, in Waterville, Maine, the Central Maine Growth Council led a cross-sector partnership with local higher education institutions and entrepreneurship support organizations to found Dirigo Labs, a technology startup accelerator program aimed at reversing years of job losses resulting from declining employment in the mill and manufacturing industry. The types of ecosystems like those that exist in Red Wing and Waterville offer opportunities for local entrepreneurs to leverage technologies from their rural hometowns and build scalable businesses.

To build these ecosystems, rural leaders should consider federal programs aimed at building entrepreneurial ecosystems that support tech startups. The Economic Development Administration's Build to Scale, program, and the U.S. Department of Agriculture's Rural RISE program both offer targeted funding opportunities that help rural areas build digital entrepreneurship ecosystems.

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(Cover image: Black River Innovation Campus; Springfield, Vermont; courtesy of the Center on Rural Innovation)

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