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SPECIAL ISSUE The Future of Public Transportation

Future of Rural Transit

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Abstract

This paper provides a contemplative description of the future of rural public transportation. It considers emerging technologies along with their long-term implications and corresponding impacts on rural communities. The authors used their collective knowledge to identify key drivers of change in rural areas. As a result, the authors expect the future definition of rural areas to change and a new geographical classification to emerge. This classification is a continuum of population density gradient from highly populated urban areas to sparsely populated areas. The paper also suggests that automated vehicles and hologram telecommuting could dominate the U.S. transportation industry, even in rural settings.

Keywords: *Future of transportation, rural public transportation, emerging technologies, automated vehicles, hologram telecommuting*

Introduction

Rural populations make up approximately 20% of the United States population. Rural residents live in numerous rural communities throughout the United States. The communities vary substantially from one another, as McKinley (1998, p. 14) stated, "When you've seen one rural community…you've seen one rural community."

The U.S. Census Bureau's simple definition for *rural* is any population, housing, or territory not in an urban area. It refers to any areas with fewer than 2,500 residents. However, the definition could change as it previously has (U.S. Census Bureau 2017). Having a clear definition of rural for the future requires evaluating how these areas may be impacted with impending change. Rural America will continue to change, but will never be a thing of the past. However, technology likely will have a large influence on the rural population. This paper explores some of the potential technological changes and their impacts.

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During the 1980s, rural or non-metro areas accounted for 26% of the U.S. population and continued to experience population out-migration. During the 1990s, this decades-long trend saw some moderate reversal with some in-migration to rural areas (U.S. Department of Agriculture - Economic Research Service 2017a). The out-migration reduced the tax base of communities in rural areas, which affected the services offered there. Families dependent upon agriculture continued to leave rural areas into the 1990s, but rural areas did experience individuals moving to smaller-scale places for non-economic quality-of-life reasons (Rogers 1999a, 1999b; Fagan and Reeder 1996; Stallmann and Siegel 1995; Snyder 1994). Some of them were retired, but most were working-age families or were people who retired early but were still economically active (U.S. Department of Agriculture - Economic Research Service 2017a).

Although rural communities are not homogeneous, there are some commonalities in the demographics as presented in Table 1. First, the rural population tends to be older, with a median age of 43 compared to the urban median age of 36 years. About 17% of rural residents are 65 years or older; whereas 14% of urban dwellers are 65 years or older. Aging in place is common, with most of rural residents over age 65 wanting to remain in the homes where they have lived for most of their lives. Further, rural areas have a higher percentage of individuals with disabilities, 15% versus 12% in urban areas. Rural areas are home to 24% of the 20 million military veterans in the United States (U.S. Department of Veterans Affairs 2016). Moreover, many Native American Indian reservations have population densities of less than six residents per square mile. These reservations are home to 1.5 million Native American Indians who are highly likely to stay where they live due to cultural and societal backgrounds (Mielke 2011).

TABLE 1.
Characteristics of U.S. Urban and Rural Populations

	United States	Urban	Rural
Total Population (million people)	319.00	258.00	60.00
Average Household Size	2.65	2.66	2.62
Gender (%)			
Male	49.20	48.90	50.60
Female	50.80	51.10	49.40
Age			
Median age	37.70	36.50	43.40
65 or older (%)	14.50	13.80	17.50
85 or older (%)	1.90	1.90	1.70
Population with a Disability (%)	12.60	12.00	15.30
Race (%)			
White	75.90	72.70	89.90
Black or African-American	13.90	15.50	6.60
American Indian and Alaska Native	1.70	1.50	2.50
Asian	6.20	7.30	1.20
Hispanic or Latino	17.30	20.00	6.10
Foreign Born (%)	13.30	15.60	3.40
Highest Education Level Completed (%)			
Did not complete high school	13.10	13.10	13.00
High school	27.70	25.80	35.50
Some college, no college	21.00	20.80	21.40
Associate's degree	8.20	8.00	8.80
Bachelor's degree	18.70	19.90	13.60
Advanced degree	11.40	12.30	7.60
Economic Characteristics			
Individuals below the poverty line (%)	15.50	16.00	13.30
Median household income (thousand dollars)	53.60	54.10	52.20

Source: (Mattson 2016)

Rural areas historically are less ethnically diverse. However, minorities are the fastest growing segment of America's rural population (Bogren 2014). From 2000 to 2010 rural areas experienced a rapid growth of Hispanic population. Because of this growth, informational and marketing materials for rural transportation continue to be available in other languages.

Education levels are similar between rural and urban for individuals that have completed high school, but urban areas do have a higher percentage of residents with college degrees. The median household income is higher in urban areas, but a higher percentage of urban residents live below the poverty level partly because of the higher cost of living.

Transportation is essential to the vitality of rural communities. It provides access to employment, health care, education, and other services. In 1978, The Urban Mass Transportation Act included Section 18, which established a formula grant program for non-urbanized areas. Today this program is known as the Section 5311 program. It provides for investment in rural public transportation resulting in increased transit services in rural areas.

Public transportation has played an important role in rural America. Although often limited to demand response during limited hours, the service has allowed seniors to age in place and allowed others to enjoy the rural environment and use public transportation to reach their destinations.

The Future of Rural America

The economy, technology, and population will continue to be key factors influencing rural America.

Economy

Agriculture and farming, compared with other industries, no longer dominate the rural American workforce. Roughly 9.3% of employment and 11.0% of earnings come from farming, mining, forestry, fishery, and related industries in non-metro areas (U.S. Department of Agriculture - Economic Research Service 2017b). The Food and Agriculture Organization (FAO) predicts the world population will rise to 9.1 billion by 2050, which will require an increase in food production to feed a population that will be more than a third larger than the current population. Rural America continues to play a role on the front lines of international markets for agricultural products (FAO 2017). Population growth will increase pressure on farming and agricultural production. Changes in agricultural technologies and structures such as the advent of smart farming, vertical farming, and corporate farming, coupled with a growing global demand for food, will drive changes in rural America. Today's farms are increasingly managed and run like factories, with tightly controlled operations that produce reliable products and increased yields, while decreasing the effects of disease, insects, and drought. The agriculture industry appears to be using the retail food industry as a blueprint to determine production requirements to meet future product demands at domestic and international levels.

Population

U.S. population growth is slowing, continuing to age, and becoming more diverse. The change varies extensively across rural and small-town America. Over the past couple of centuries, rural residents have maintained their share of roughly 60 million of the U.S. population, but the percentage of this dropped from 54.4% in 1910 to 19.3% by 2010. As Figure 1 illustrates (The World Bank 2017), the annual percentage of population growth in rural America continues to decrease. The U.S. Census Bureau has also classified the rurality for counties into three levels as shown in Table 2.

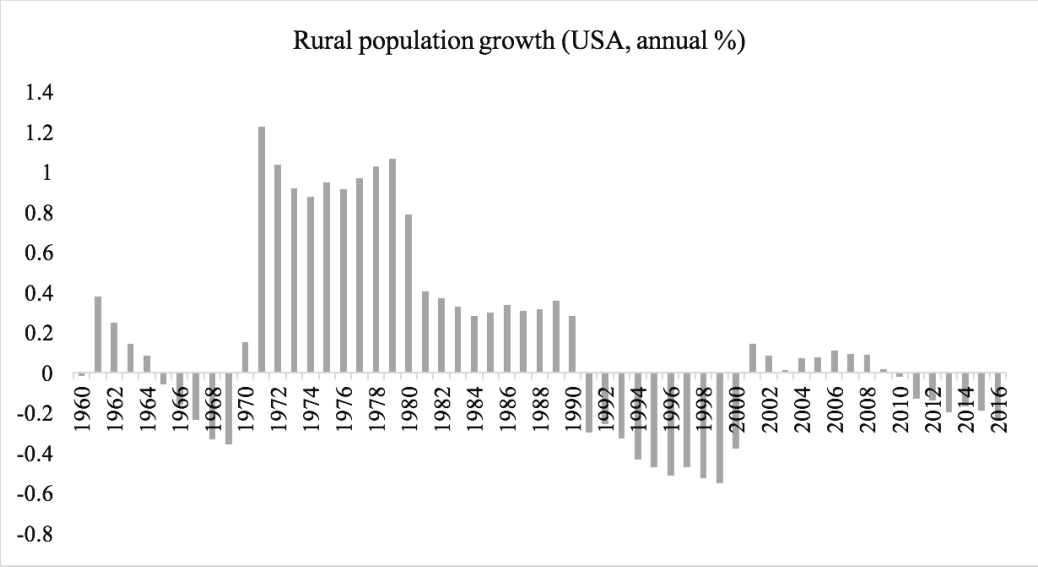

FIGURE 1.
Rural population growth

TABLE 2.
Levels of Rurality for Counties

	Number of counties	2010 Census population (millions)	2010 Census population %
Total counties	3,142	308.8	100.0
Mostly urban (Less than 50.0% rural)	1,253	266.6	86.3
Mostly rural (50.- -99.9% rural)	1,185	36.8	11.9
Completely rural (100% rural)	704	5.4	1.7

Classifying counties into three groups furthers the understanding that the populations of rural areas and communities will look much different than they have in the past. As Table 2 states, urban clusters will continue to develop, making the traditional definitions of urban and rural areas obsolete. Instead, rural areas will be defined as mostly urban, mostly rural, or all rural. However, such a pattern does not mean the rural areas will continue to be diminished: there will be a transition in the population makeup. It will be a continuum of population density gradient from highly populated areas (metropolitan areas) to sparsely populated areas characterized by rural family homes. By 2050, the rural areas might still exist, but they will exist as a place for retirement and recreation rather than as a critical geographic, economic unit of the United States. Note that the definition of rural might change as migration patterns change. Changes in technologies have accelerated such phenomena in the past.

Impact of Technology on Rural Transit Systems

Rural public transportation systems typically consist of demand response public transportation, traditional and deviated fixed route services, vanpool, or reimbursement programs. All provide mobility and accessibility to employment, goods, and services to older adults, persons with disabilities, and low-income persons (U.S. Department of Transportation 2015). Access to this system is limited by distance (travel time), weather, the frequency of service, and cost. Remoteness increases the impact of these limiting factors particularly during periods of economic distress. Rural areas have a polarized travel pattern. Rural driving patterns may be distinguished from urban travel patterns by slightly more trips, spending more time traveling, and traveling much farther. The factors that increase the cost and reduce accessibility in rural areas can only be overcome by technology, which comes at its own cost. The cost of invention and adoption to overcome mobility challenges will be reliant on the intensity of demand.

We consider two plausible scenarios for the future of rural America: "the green countryside" and "rural growth development along corridors."

These are not two contrasting scenarios and they could occur simultaneously. Rural areas may experience people abandoning small and less-attractive cities and moving to more urban clusters with a perceived improvement in liveability (more services). This move of population will result in urban clusters that sprawl over wider geographical areas, connecting metro cities to formerly rural communities. Rodrigue et al. (2017) described how changes in the location of populations as impacted by technology explained the transition in passenger mobility over time. Both motorized and non-motorized transportation will be present in the future, but the collective and non-motorized approaches will be more prevalent in urban areas because of sustainability concerns. Less populated areas will use motorized, individual modes of transportation (Rodrigue et al. 2017).

A change in the way urban and rural areas are defined, from an "either/or" definition to a continuum of population density, will not only reflect changes in rural populations brought about by new technology, but will also allow a more systematic approach for applying new technologies and existing transit modes in rural areas. For example, transit modes used in large urban centers could be adapted with changes in management or applications of new technology to work well in rural population centers or development corridors.

Technology and Plausible Practices

Technology multiplies the effectiveness and efficiency of existing transportation systems. This section presents an overview of some technologies as well as plausible practices that have been or may be potentially developed in the future. Automated vehicles of many types and holograms could change the landscape of rural transportation.

Automated Vehicles (AVs)

An automated vehicle system is a combination of hardware and software (both remote and onboard) that performs a driving function, with or without a human actively monitoring the driving environment (U.S. Department of Transportation - National Highway Traffic Safety

Administration 2017). Early use dates to the 1920s with the introduction of the first radio-controlled car. Given giant investments by companies such as Apple, Baidu, Google, Intel, and Tesla, the market is in transition to the driverless vehicle. Regardless of the terminology used (autonomous vs. automated), the option for human interaction will be available for those who want to have the driving experience. What are the advantages of such technologies for rural areas? Rural, as previously described, has two main features: less spatially constrained areas and longer transportation networks. Moreover, population trends indicate older adults may live in rural areas after retirement and people with disabilities live in rural areas with less accessibility to main modes of transportation. Consequently, automated vehicles will provide a flexible, accessible, and convenient transportation alternative. Because various programs offer travel solutions to veterans, Native Americans, those with disabilities, and other specialized clientele, it is likely that future transit agencies could centralize their services under one umbrella and offer an integrated transportation solution to residents.

Air/Aerial Automated Vehicle (AAV)

The flying vehicle is not a new concept, but the need for a pilot with navigation ability makes it less accessible than other modes. With the advent of automated systems, many firms are now considering AAVs as an alternative mode of transportation. For example, Airbus unveiled a modular, self-piloting flying automobile concept in 2017 (Airbus 2017). It is possible that someone living in a rural area may fly by a convertible flying car to the nearest megacity, land at a designated landing site, and then use the vehicle or another ground transportation mode to reach destinations within the city. Daimler has invested in a start-up called Volocopter, which is an 18-rotor automated air taxi. The Volocopter was tested in Dubai in 2017. Uber is also developing a flying car under its program, Uber Elevate (Uber 2016). These concepts are well-suited for sparsely populated geographical locations with much more open air space for travel than urban areas. The concepts will meet the needs for frequent long distance travel and more flexibility. However, AAVs will be seen as a premium mode of transportation not available for everyone. Costs for maintenance and ownership will likely be obstacles to ownership and use. These problems may be addressed in two ways:

- On-demand mobility service (offering different flying range, capacity, class, and services)
- Private/personal commute – since the aerial vehicle is automated, there could be companies that would rent the personal vehicle when it is idle to generate revenue for the owner and the renter.

Ground Automated Vehicle (GAV)

This mode of transportation mainly consists of automated cars or buses. GAVs may provide a more affordable and accessible option than AAVs. A large number of research studies focus on designing batteries that charge quickly and last longer (Van Noorden 2014), a key feature that enables GAV use in rural areas. These studies are beyond the scope of this paper.

Formal or informal vehicle sharing arrangements (like the current Zipcar or Facebook groups) for certain time/certain geographical locations (hours, days, weeks) may make GAVs more accessible for rural residents. Under these arrangements, owners allow others to rent the vehicles for timely

round-trips or the vehicle can return home automatically. Transit agencies could take advantage of GAVs for making paratransit service more efficient, responsive, and accessible.

Autonomous buses of various sizes (imagine 10 to 30 person capacity) could be assigned to specific routes based on time of day and route demand. Small buses could be used for a car hailing service when the demand is low for other public transportation, such as in the evening or late at night. These vehicles would be equipped with dynamic routing capability (adaptive routing) in a way that surveillance cameras at bus stops could communicate expected demand to the bus, and the bus could manage its capacity based on demand and route.

Parking and related issues have been growing concerns and some suggest that automated vehicles may offer a solution. However, it's not likely that automated vehicles will reduce the problem. Unless a ridesharing culture grows, parking issues may become worse. Urban areas, particularly city cores, have limited parking areas. It will not be possible to accommodate parking demand from automated cars, flying cars, light rail, bikesharing, and other modes.

Automated Bike (AB)

With the advent of geofencing, solar-powered/electric bikes, and automated technology, a smartphone app will allow travelers to book a bike at the desired location, use it as desired, and leave the bike behind when it is no longer needed. The technology adds flexibility to bike riding, making it a fun and healthy mode of transportation. In the future, those on the non-urban continuum will likely embrace biking as a means of transportation. Residents in urban clusters will use apps to book bikes wherever needed, ride to their destinations, and leave the bikes. A centralized control system will automatically return, arrange, and optimize the existing bike fleet for the next expected trips.

Service Robot

Utilizing drones or robots, future robotic systems will help residents avoid unnecessary trips to grocery stores, shopping centers, and other destinations for purchasing goods. This technology will also allow them to manage their personal package deliveries 24/7. Imagine a family living in a rural area ordering, either online or from the nearest grocery store, their groceries for tomorrow's meals. Robotic delivery via drone or car can occur while they are traveling elsewhere in their flying car or engaged in some other activity miles away from the stores. Amazon Prime Air made its first commercial drone delivery to a rural customer in December 2016. UPS is testing the pilot project for paring a drone with truck-based delivery. Postmates and DoorDash are collaborating to use robots to make deliveries in urban areas. Many other similar projects are also in development.

Supporting Technologies

There are many technologies that support transportation systems: real-time analytics, satellite navigation, location-based services, wireless, and cloud technologies. This section focuses on two known technologies that are not yet fully practical.

Hologram Telecommuting

Holographic telepresence means recording a 3D image in one location to show in another location. The image can be transmitted over the Internet in less than a second to simulate real time communication. Such technologies will diminish the need for physical presence, reducing the dependency on the corporate workspace and personal physical movement. This technology can be expected to enhance productivity and accessibility and may reduce the need for personal mobility, including public transportation. For instance, a bank manager with hologram telecommuting office space in his home can conduct business with a customer anywhere in the United States. Consequently, the bank manager may decide to live in a rural area with greater perceived livability because he will no longer need to commute to work. Similarly, a clergy member may conduct religious services for multiple locations without commuting from a single location by using hologram telecommuting technology. Hologram telecommuting is an enhancement over current video telephone and computer technology because it enhances the ability of the user to actively interact with the other person in a simulated world.

Teleportation

Teleportation, or teletransportation, once perceived as a theoretical concept suitable only for science fiction, is now a promising technology. It's generally defined as the transfer of matter or energy from one location to the other without travelling through the physical space. China has recently teleported a photon from ground to orbit (Ren et al. 2017). Current efforts focus on creating unhackable communication networks. When this and other related advancements are achieved, teleportation of people will be possible. Once this technology is fully and safely implemented for humans, transportation will be obsolete.

Given the two potential technologies described here, the number of personal trips will drop significantly and your place of residency will no longer be dependent on your place of work.

Practices

With the aid of automated vehicles, real-time data analytics, and algorithms, transit agencies will adopt new business models to improve the traveler experience. They are likely to shift away from a focus on physical transportation services to becoming agencies focused on providing broader access to goods and services. They will offer ride matching for better resource optimization and finding a lowest possible price for sharing a ride. They will share fleets of shared automated vehicles (SAVs) offering dynamic and fixed routing as well as mobility on demand by using multiple automated buses of various capacities.

Conclusion

Over the past centuries, humans have endeavored to diminish geographical barriers and to better connect people. This is likely to continue in the coming years. The future of today's rural areas will likely be exurbanization as more city dwellers and urbanites move to the countryside where there is greater perceived livability. The technologies described in this paper

as well as others that are likely to be developed will make rural areas viable and accessible options for recreation, retirement, and residence.

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