The Benefits of Carpooling

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THIS WORK WAS PERFORMED BY THE AUTHORS AS INDEPENDENT CONSULTANTS. WE WOULD LIKE TO THANK GOOGLE FOR GENEROUSLY FUNDING THIS EFFORT. WE WOULD ALSO LIKE TO THANK LEW PRATSCH WHO PROVIDED VALUABLE INSIGHTS. ALL OPINIONS CONTAINED IN THIS REPORT REFLECT THE INDEPENDENT VIEWS AND ANALYSIS OF THE AUTHORS.

THE BENEFITS OF CARPOOLING

THE ENVIRONMENTAL AND ECONOMIC VALUE OF SHARING A RIDE

CARPOOLING IS A DEMAND MANAGEMENT STRATEGY THAT CAN REDUCE CONGESTION, EMISSIONS, AND FOSSIL FUEL DEPENDENCY.

OVERVIEW

CARPOOLING IMPACTS AND MOTIVATORS

Carpooling allows travelers to share a ride to a common destination and can include several forms of sharing a ride, such as casual carpooling and real-time carpooling. Because carpooling reduces the number of automobiles needed by travelers, it is often associated with numerous societal benefits including: 1) reductions in energy consumption and emissions, 2) congestion mitigation, and 3) reduced parking infrastructure demand.

INNOVATIONS AND TRENDS IN MOBILITY

In recent years, economic, environmental, and social forces coupled with technological innovations are encouraging shared and pooled services. Shared mobility is changing how people travel and is having a transformative impact on mobility. This chapter reviews key trends impacting the mobility marketplace including the growth of shared mobility and key demographic indicators, such as an aging population and Millennials entering the workforce.

HOW GOVERNMENT AND EMPLOYERS CAN SUPPORT CARPOOLING

For decades, carpooling has been used as a strategy by numerous public agencies and employers as a strategy to address a range of climate, environmental, and congestion mitigation goals, while simultaneously increasing roadway and parking capacity. This chapter discusses how employers and public agencies can support carpooling.

CONCLUSION

This chapter concludes with a summary of key findings from the report.

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CARPOOLING IMPACTS AND MOTIVATORS

WHAT IS CARPOOLING?

Carpooling allows travelers to share a ride to a common destination. Carpooling can include several forms of sharing a ride (Shaheen and Cohen, 2018a; Chan and Shaheen, 2012; SAE International, 2018).

Common carpooling terms include:

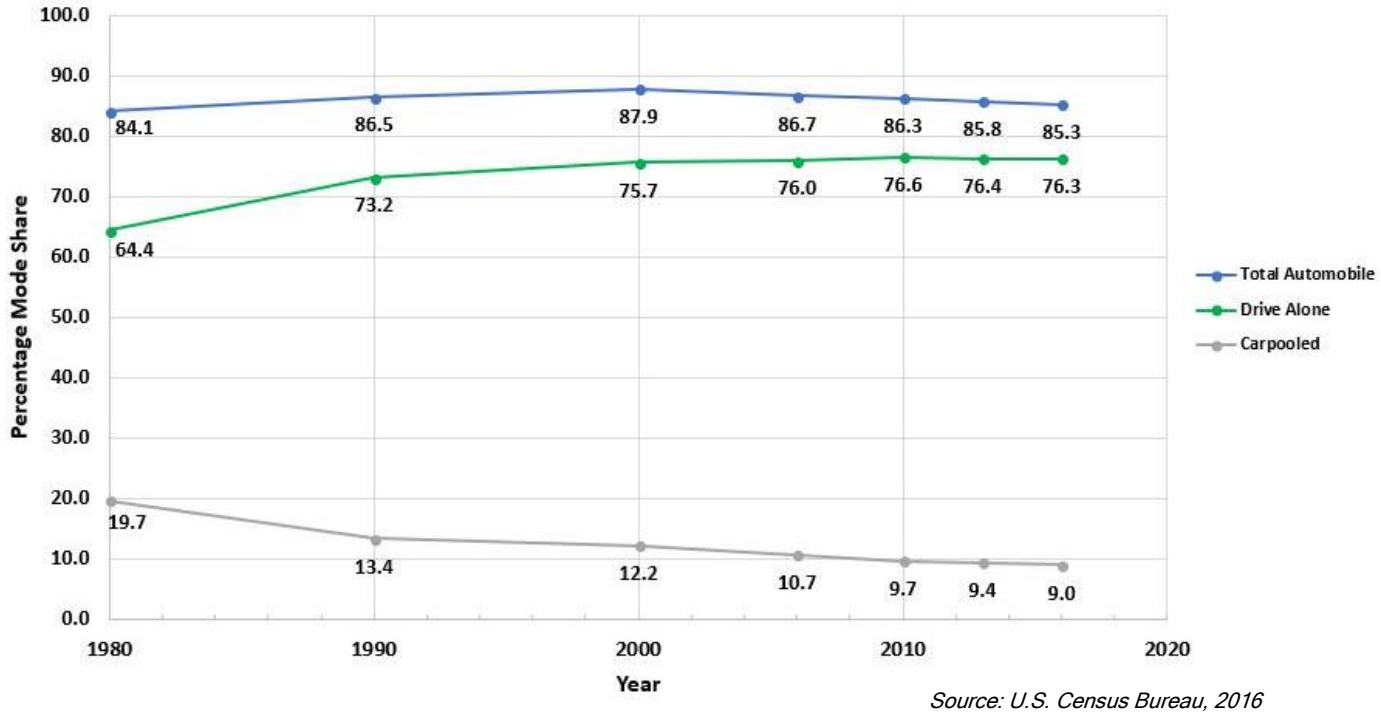
- *Casual Carpooling*, also known as "*slugging*" and "*flexible carpooling*" is a form of ad hoc, informal carpooling among strangers. Typically, no money exchanges hands or passengers pay a nominal amount to reimburse drivers for actual travel expenses, such as tolls, gas, etc. In some regions, casual carpooling locations may be designated where drivers can pick-up passengers waiting for a shared ride.
- *Real-Time Carpooling,* also known as "*app-based carpooling"* and "*dynamic carpooling"* allows people to arrange ad hoc rides on-demand (or very short notice) using smartphone apps or a website. Typically, passengers are picked-up at their current location or a mutually agreed upon pick-up location.
- *Vanpooling* typically consists of 7 to 15 passengers sharing the cost of a van and may share driving responsibility.

CARPOOLING DIFFERS FROM FOR-HIRE VEHICLE SERVICES, SUCH AS RIDESOURCING, RIDEHAILING, OR TRANSPORTATION NETWORK COMPANIES (TNCs) IN ITS FINANCIAL MOTIVATION. WHEN A CARPOOL PAYMENT IS COLLECTED, IT PARTIALLY COVERS THE DRIVER'S COST AND IS NOT INTENDED TO RESULT IN A FINANCIAL GAIN. ADDITIONALLY, THE DRIVER HAS A COMMON ORIGIN AND/OR DESTINATION WITH THE PASSENGERS.

While taxis are often regulated to charge static fares, ridesourcing/TNCs often uses market-rate pricing, popularly known as "surge pricing" when prices usually go up during periods of high demand to incentivize more drivers to take ride requests. While some ridesourcing/TNC services offer shared rides for more than one traveler, these services are commonly referred to as "ridesplitting," "pooling," and "taxi sharing," the latter used to describe sharing a taxi cab (SAE International, 2018). While a user may request a shared ride for a lower fare through a ridesplitting service, a pooled ride is not guaranteed.

CARPOOLING IS THE SECOND MOST COMMON TRAVEL MODE TO WORK IN THE UNITED STATES AFTER DRIVING ALONE. HOWEVER, TOTAL PERCENTAGES HAVE DECLINED IN RECENT DECADES. MORE POLICY SUPPORT IS NEEDED TO REVERSE THIS TREND AND INCREASE CARPOOLING MODAL SHARE, PARTICULARLY IN AN AUTOMATED VEHICLE FUTURE.

FIGURE 1.1 U.S. CENSUS COMMUTING BY AUTOMOBILE: 1980 TO 2016



Source: U.S. Census Bureau, 2016

IMPACTS OF CARPOOLING

A number of social, environmental, and behavioral impacts have been attributed to carpooling, and an increasing body of empirical evidence supports many of these relationships—although more research is needed as carpooling is difficult for researchers to observe and record. Empirical and anecdotal evidence indicates that carpooling provides numerous societal benefits, such as: 1) reductions in energy consumption and emissions, 2) congestion mitigation, and 3) reduced parking infrastructure demand. Individually, carpooling users can benefit from: 1) shared travel costs, 2) travel time savings from high occupancy vehicle lanes, 3) reduced commute stress, and 4) often preferential parking and other incentives (Cohen and Shaheen 2016) (Chan and Shaheen 2012). This chapter reviews three categories of carpooling impacts: societal, employer, and individual benefits.

SOCIETAL BENEFITS

Carpooling can provide numerous societal benefits, such as:

- Reduced vehicle miles traveled;
- Reductions in fuel consumption and greenhouse gas (GHG) emissions;
- Reductions in adverse air pollution impacts on low-income, minority, and other environmental justice populations; and
- Cost savings for public agencies and employers.

Each of these topics are discussed in greater detail in the sections that follow.

REDUCED VEHICLE MILES TRAVELED (VMT)

Vehicle miles traveled (VMT) is a travel demand metric that measures the sum of the number of miles traveled by each vehicle. A study by the Federal Highway Administration during the 1970s energy crisis found a 23% reduction in vehicle miles traveled (VMT) (Pratsch, 1979). Employee-based trip reduction (EBTR) and transportation demand management (TDM) programs are recognized as a best practice to support VMT reduction goals. However, many of these programs lack performance monitoring and assessment and only a handful of empirical studies have examined the VMT impacts of these policies. One study found that employees participating in the program had 4.2% to 4.8% lower VMT than employees at the same worksite who did not participate (Herzog et al., 2006). Studies assessing the implementation of Washington State's Commute Trip Reduction Law have found similar effects. Lagerberg et al. (1997) found an average VMT reduction of 6% for employees at worksites subject to the law. Boarnet et al. (2010) estimates that these programs can reduce VMT for workplace commutes by 4% to 6% (or approximately 1% regionally).

Only two studies estimated VMT reduction for the entire region or metropolitan area. Hillsman et al. (2001) used survey data from employers to estimate the number of commute trips eliminated by Washington State's commute trip reduction (CTR) program. The study estimated declines in total VMT of 1.33% on all roadways and a reduction in freeway VMT of 1.07% for the four central counties in metropolitan Seattle. That is a smaller impact than other studies because the authors examined all travel during the morning peak including: commute trips to non-participating sites and non-commute trips. A separate study by the Commute Trip Reduction Task Force using different years in the same data set analyzed by Hillsman et al. (2001) estimated a 1.6% reduction in total VMT (Commute Trip Reduction Task Force, 2005).

It is important to note that carpooling could lead to induced demand due to reduced travel times and costs. So, this should be factored into calculations of the net VMT impacts of this mode.

REDUCED FUEL CONSUMPTION

Every year, the average passenger car and sports utility vehicle consumes an estimated 550 and 915 gallons of fuel, respectively. Noland et al. (2006) assert that enacting policies to increase carpooling is the most effective strategy to reduce energy consumption besides prohibiting driving. Another study by Jacobson and King (2009) estimates a potential fuel savings of 0.80 to 0.82 billion gallons of gasoline per year in the United States, if one additional passenger was added in every 100 vehicles. The same study also estimates a potential annual fuel savings of 7.54 to 7.74 billion gallons per year in the U.S., if one additional passenger was added to every 10 vehicles.

Another study found that carpooling could save 33 million gallons of gasoline daily, if each average commuting vehicle carried one additional passenger (PACommutes, 2016). Regionally, carpooling can have a notable impact on fuel savings as well. For example, in the San Francisco Bay Area, a study estimated an annual reduction of 450,000 to 900,000 gallons of gasoline; the majority of this savings is attributable to

carpooling's congestion reduction impact on the rest of traffic (Minett and Pearce, 2011).

STUDIES HAVE FOUND THAT CARPOOLING CAN SAVE FUEL AND REDUCE GREENHOUSE GAS EMISSIONS FOR CARPOOLING USERS AND NON-USERS, THE LATTER BY REDUCING CONGESTION OF GENERAL PURPOSE TRAFFIC.

REDUCED GREENHOUSE GAS (GHG) EMISSIONS

By reducing fuel consumption, a number of studies have found that carpooling can reduce greenhouse gas (GHG) emissions. Using a simulation model, Herzog et al. (2006) forecasts that individually carpoolers reduce personal commute GHG emissions by approximately 4% to 5% after joining an employer trip reduction program. A study by Jacobson and King (2009) estimates savings of 7.2 million tons of GHG emissions annually in the U.S., if one additional passenger were added to every 100 vehicles. The study also estimates a savings of 68.0 million tons of GHG emissions annually in the U.S., if one passenger were added to every 10 vehicles (Jacobson and King 2009). In another study, the SMART 2020 report estimates that employing information and communication technology (ICT), such as app-based carpooling to optimize roadway performance could abate 70 to 190 million metric tons of carbon dioxide emissions (Global e-Sustainability Initiative, 2008).

REDUCING TRAFFIC-RELATED EMISSIONS FOR LOW-INCOME AND MINORITY HOUSEHOLDS

Low-income and minority households commonly bear disproportionate exposure to vehicular emissions along congested roadways. Approximately 4% of Americans (11.3 million people) live within 500 feet of a major highway. Research indicates that certain populations (e.g., members of minority communities, foreign-born persons, and persons who speak a non-English language at home) are likely to be at a higher risk for exposure to traffic-related air pollution as a result of residential proximity to major highways (Schweitzer and Valenzuela, 2004; Downey et al., 2008; Lopez, 2002; Morello-Frosch and Jesdale, 2006; Schweitzer and Zhou, 2010). Urban outdoor air pollution is one of the top 10 causes of death in high-income nations (World Health Organization 2013). As such, carpooling can serve as one primary prevention strategy to reduce traffic-related emissions to these communities.

COST SAVINGS FOR PUBLIC AGENCIES AND EMPLOYERS

By improving infrastructure capacity and person throughput, carpooling is a cost-effective strategy to mitigate congestion and reduce the need for additional roadway and public transit capacity. In Seattle, a Commute Trip Reduction Ordinance has contributed to a 11% reduction in single-occupant vehicle trips (City of Seattle, 2017). Another study found that casual carpooling has the potential to notably reduce energy consumption for 150 commuters equivalent to providing an express bus service implementation for the same number of commuters but at a lower cost (Dorinson et al., 2009).

EMPLOYER BENEFITS

Employers benefit from carpooling in a number of ways. For employers, carpooling can:

- Reduce the need for parking;
- Increase the productivity and morale of employees; and
- Provide financial and tax benefits for employers.

Each of these topics are discussed in greater detail in the sections that follow.

REDUCED NEED FOR PARKING

By reducing the number of vehicle trips, public and private sector employees can reduce parking demand thereby saving capital costs of $15,000 to $45,000 USD per parking space (depending on design and land availability) and operational costs of approximately $360 to $2,000 USD annually per parking space (Shoup, 2011; Environmental Protection Agency, 2005).

INCREASED PRODUCTIVITY AND MORALE

Although research is limited, anecdotal evidence suggests that employees who carpool may enjoy reduced commute stress associated with driving and increased convenience associated with high occupancy vehicle (HOV) lane time savings and preferential parking at their destination. These benefits can in turn improve employee morale and increase overall satisfaction and productivity.

FINANCIAL AND TAX BENEFITS

Carpooling provides a number of financial and tax benefits to both employers and employees. Section 132(f) of the U.S. Internal Revenue Code provides a way for employers to provide parking, public transit, vanpool, and bicycle expenses on a tax-free basis. The monthly cap for the parking, public transit, and vanpool benefits are now at $260 USD/month and are subject to annual cost of living increases. Previously employers could deduct the subsidy portion of a commuter's expenses that were paid for by the employer. This tax benefit was eliminated with the passage of the Tax Cut and Jobs Act of 2017, which removed this employer deduction. Employers can still subsidize these expenses; however, they can no longer deduct the subsidized portion of their commuters' expenses.

However, a number of states have implemented state level commuter tax benefits and tax credits for carpooling. For example, Maryland offers a tax credit of 50% of the eligible costs of providing commuter benefits. Employers and non-profits [501(c)(3) and (4)] can claim a credit for 50% of the eligible costs up to a maximum of $100 USD per employee per month. The tax credit can be taken against state personal income tax, corporate income tax, or the insurance premium tax and is applicable to public transit passes, employer vanpool programs, guaranteed ride home programs, and parking cash out programs (Comptroller of Maryland, 2018).

In Georgia, employers can receive an annual $25 USD tax credit for each employee that uses a federal qualified transportation fringe benefit. To qualify, employees must use the commute alternative at least 10 times per month. This credit is available to employers that pay the Georgia corporate income tax and provide public transit pass subsidies or vanpool subsidies for employees or qualified carpool/vanpool parking on or near the business premises (Georgia Code 48-7-29.3).

Finally, in Washington state, employers and property managers who are taxable and provide financial incentives to their employees for carpooling (carrying two or more passengers), carsharing, public transportation, and non-motorized commuting before January 1, 2024 are allowed a credit against taxes payable or amounts paid to or on behalf of employees up to $60 USD per employee per fiscal year. The maximum eligible tax credit is $100,000 USD per employer or property manager per fiscal year.

INDIVIDUAL BENEFITS & CARPOOL MOTIVATORS

Studies suggest that carpooling is a flexible solution that is used by many user groups. Although research is limited, carpooling participants frequently benefit from carpooling in a number of ways. Common individual carpooling benefits and motivators include:

- Enhanced accessibility and economic opportunity for low-income households;
- Cost savings associated with shared travel costs; and
- Increased convenience and reduced stress from shared driving responsibilities and travel-time savings associated with HOV lane access.

Each of these topics are discussed in greater detail in the sections that follow.

WHO USES CARPOOLING

Carpooling is a flexible solution that is used by many users. A number of studies have found that casual carpooling participants are more likely to be single or married without children. Teal (1987) found that carpool participants were more likely to have lower incomes and be the second worker in a household. Another study of casual carpooling users between the ages of 25 and 34 in Houston found that they were more likely to make commute trips (96%) versus non-commute trips (80%) (Burris and Winn, 2006). This study also found that HOV lane users tended to belong to larger households with over 60% of carpools comprising family members.

ENHANCING ACCESSIBILITY AND ECONOMIC OPPORTUNITY FOR LOW-INCOME AND MINORITY HOUSEHOLDS

In the nation's largest metropolitan areas, 7.5 million predominantly lower-income households do not have access to an automobile (Tomer, 2016). Only 40% of these public transit dependent households can access metro-wide jobs with a commute of 90-minutes or less (Tomer, 2016). Long commutes and limited job access via public transportation in most metropolitan regions leaves many jobs out of reach for carless households.

Some studies have shown that carpooling can provide job access to households with lower incomes and households with more workers than vehicles (Teal, 1987). More recent data from the National Household Travel Survey and the American Community Survey show that ridesharing users tend to have lower incomes, and Hispanics and African Americans

carpool more than other racial and ethnic groups. These surveys and other studies indicate that ridesharing may serve an important role in enhancing mobility in low-income, immigrant, and nonwhite communities where travelers are more likely to be unable to afford personal automobiles and obtain drivers' licenses (Liu and Painter, 2012).

COST SAVINGS

A number of studies have shown that some carpooling users can have longer commute distances and therefore have higher commute costs (Teal 1987). As such, carpooling can be an important cost saving travel strategy for commuters. For example, in the San Francisco Bay Area, commuters often use casual carpooling to get from the East Bay to downtown San Francisco during the morning commute. Carpooling, which uses the HOV lanes of the San Francisco-Oakland Bay Bridge, allows travelers to take advantage of a toll discount and shorter waits at the toll plaza. According to a 1998 survey, approximately 9,000 commuters (6,000 riders and 3,000 drivers) used casual carpooling each morning (Metropolitan Transportation Commission, 1999).

CONVENIENCE

Commuters who participate in carpooling frequently have access to preferential parking and HOV lanes, contributing to carpooling's convenience and time savings. Several casual carpooling studies have documented travel time savings, cost savings, and convenience as key motivators to share a ride (Maltzman, 1987; Reno et al., 1989; Beroldo, 1990, 1999; Burris and Winn, 2006). One study of casual carpooling in the San Francisco Bay Area found that convenience, time savings, and monetary savings, were key motivators to carpool (Shaheen, Chan, and Gaynor, 2016).

Another study of casual carpooling in Washington D.C. and Northern Virginia found that driver departure flexibility was a primary reason for driving instead of riding as a carpool participant. The study also found that the top reason for choosing to be a rider was the desire to save on the cost of gasoline, followed by a preference to do other things during the drive (Oliphant, 2008). This study found that 60% of casual carpooling participants in Washington D.C. and Northern Virginia only participated as passengers; 12% only participated as drivers; and 28% participated as both passengers and drivers.

The inability to have access to a private vehicle during the work day is often cited as a common drawback associated with traditional carpooling and ridematching programs. However, on-demand app-based carpooling and a variety of shared modes are converging to help overcome this challenge. Today an increasing number of shared mobility options, such as carsharing, bikesharing, scooter sharing, and others are providing carpooling users innovative options for getting around during the workday. On-demand app-based carpooling services are also providing increased flexibility. App-based carpooling options can help address potential inconveniences associated with traditional carpooling by allowing carpoolers to have different morning and evening carpool matches. This allows travelers to share a ride who may not have been able to previously due to variable or irregular work schedules.

SUMMARY

Carpooling can provide numerous societal, employer, and individual benefits including:

- Reducing VMT[1], fuel consumption, and GHG emissions;
- Cost savings for public agencies and employers;
- Serving environmental justice communities by reducing the adverse impacts of air pollution and increasing accessibility and mobility for low-income and minority households;
- Reducing the need for employer parking;
- Increasing the productivity and morale of employees;
- Providing financial and tax benefits for employers;
- Reducing commute times, lowering commuter stress, and increasing convenience by sharing driving tasks, accessing HOV lanes, and using preferential parking;
- Enhancing access, mobility, and economic opportunities for low-income and minority communities who may be unable to afford a vehicle; and
- Providing cost savings, tax benefits, and other incentives for travelers that carpool.

1 Shaheen et al. (2016) found that 75% of casual carpool users were former public transit riders compared to approximately 10% that previously drove alone. Casual carpooling competes with public transit due to reduced travel times (HOV lane access) and costs (typically much less expensive than comparable trips on public transit). Due to the potential for reduced travel times and costs, carpooling could encourage more people to drive, a phenomenon known as induced demand (Shewmake, 2018).

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INNOVATIONS AND TRENDS IN MOBILITY

INNOVATIONS AND TRENDS IN MOBILITY

In recent years, socio-economic forces—coupled with advancements in technology, social networking, location-based services, wireless services, and cloud technologies—are contributing to the growth of shared and on-demand mobility, such as app-based carpooling. Carpooling's potential to reduce congestion, emissions, and fossil fuel dependency is becoming a frequent topic of discussion. This chapter discusses both innovations and trends impacting mobility as well as other considerations, such as the growth of megaregions, the role of telework, attitudes toward driving, Millennials and mobility, and suburbanization.

INNOVATIONS AND TRENDS

Technological, mobility, social, and demographic trends are also changing the way people travel and carpool (Shaheen et al., 2017; Martin et al., 2016). These include technology, mobility, and demographic trends.

TECHNOLOGICAL TRENDS

- The growth of cloud computing, location-based navigation services, and mobile technologies;
- The expansion of data availability, collection, sharing, aggregation, and re-dissemination through crowd-sourced private- and public-sector sources facilitated through public-private partnerships, application programing interfaces (APIs), and other tools; and
- The commodification of passenger services supporting app-based and on-demand transportation options.

MOBILITY TRENDS

- Increasing demand and urban congestion, reduced transportation funding, and the critical need to maximize existing infrastructure capacity;
- Growing popularity of shared and higher occupancy modes, such as microtransit, app-based carpooling, and others; and
- Increasing consumer interest in on-demand transportation options.

SOCIAL TRENDS

- Heightened environmental awareness about emissions and carbon footprints;
- Growth of megaregions as economic centers and transportation corridors (Lang and Dhavale, 2005);
- Urbanization and reduced reliance on private vehicle ownership; and
- Hyper-demand and the need for instant gratification driven in part by growing expectations for immediate results—enabled and magnified by the mobile Internet and smartphone apps—that create increasing consumer desire for on-demand goods and services, including mobility.

DEMOGRAPHIC TRENDS

- Demographic changes, such as rising life expectancies, people working longer, and Millennials entering the workforce;
- Persons with disabilities comprise nearly 20% of the U.S. population;
- In 30 years, the U.S. population is expected to grow by approximately 70 million people;
- By 2045, the number of Americans over the age of 65 will increase by 77%;
- People are delaying life milestones, such as getting married and having children that could have an impact on automobile ownership and use. For example, the average age of marriage for men and women has increased from 23.2 and 20.8, respectively in 1970 to 29.2 and 27.1, respectively in 2015 (U.S. Census Bureau, 2016); and
- A number of studies have documented that Millennials are increasingly embracing apps and other technologies (Shaheen et al., 2016); Transportation Cooperative Research Program 2013; Transportation Research Board 2016; Dutzik et al., 2014).

WHAT'S CHANGING, WHAT'S NOT

This section discusses other trends that could impact the future of carpooling, including:

- Growth of Megaregions
- Role of Telework and Telecommuting
- Attitudes Toward Driving
- Millennials and Mobility
- Suburbanization.

These trends could have a notable impact on carpooling in the future (Martin, Shaheen, and Zohdy, 2016; Shaheen and Cohen, 2018b). For example, the growth of megaregions could lead to the growth of "super commuters" who works in one metropolitan area and resides outside that urban area. Similarly, the growth of telework and telecommuting could change how travelers carpool. Rather than using pre-arranged ridematching

with the same carpool partner on a routine basis, flexible work schedules and part-time telecommuting could result in a growing number of flexible and on-demand carpoolers. Finally attitudes toward driving, mobility, and suburbanization among Millennials and the broader workforce has notable implications on residential location choice and key travel behavior indicators, such as vehicle ownership and use. Continued suburban growth could reinforce automobile dependency in many metropolitan regions. Each of the following sections discuss the ways in which these trends could impact the future of carpooling.

DEVELOPMENT OF MEGAREGIONS

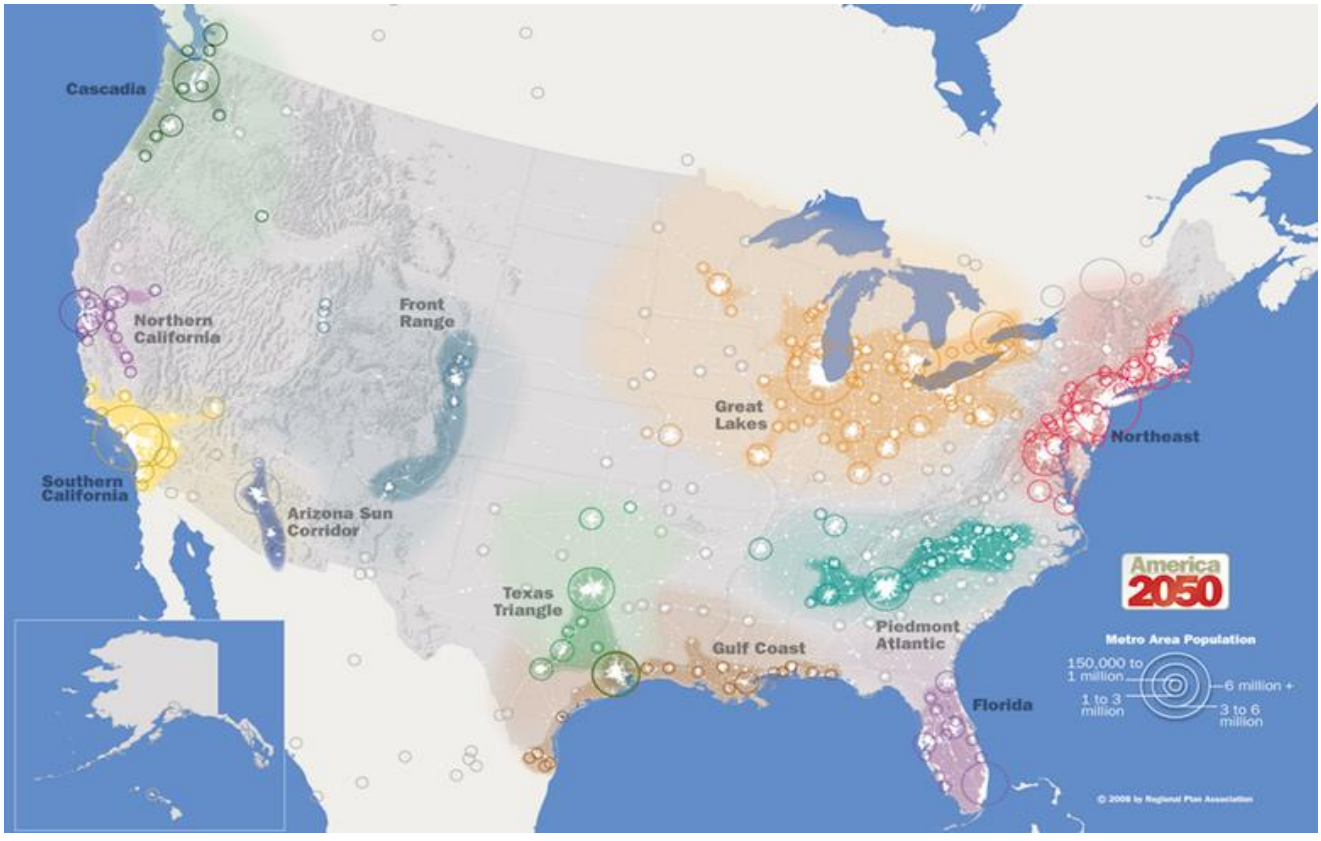
Interstate corridors have given rise to "megaregions," which could contribute to the growth of "super commuters" who work in one metropolitan area and reside outside that urban area. Megaregions are large metropolitan areas that connect various separate urban, suburban, and rural areas through shared economic, social, and cultural ties (Figure 2.1) (America, 2050). In some cases, a megaregion may be comprised of several growth centers of growth that are more closely interlinked to each other than they are to other regions of the United States. Lang and Dhavale (2005) estimate that ten regions in the U.S. will have populations exceeding 10 million residents by 2040. The Federal Highway Administration (FHWA) estimates that megaregions will comprise 75% of the United States' population by 2050 (Martin et al., 2016). For policymakers, the challenge with megaregions is that the areas are larger than the jurisdiction of metropolitan planning organizations (MPOs) and generally span multiple states.

ROLE OF TELEWORK AND TELECOMMUTING

Telecommuting is a work arrangement where employees do not commute to a workplace (i.e., an office building) and instead work remotely from an alternative location (e.g., home, café, library, or other public or shared workspaces) (Shaheen and Cohen, 2018b). Telecommuting frequency (i.e., working remotely intermittently or regularly) and location (i.e., working from home or elsewhere) can vary. However, documenting the impacts of telecommuting policies on travel behavior is empirically difficult to measure and compare because employers often do not monitor or survey their employees (Nilles, 1988; Mokhtarian, 1991).

American Community Survey (ACS) data indicate that there has been an increase in the share of people commuting via telework between 2005 and 2013 based

FIGURE 2.1 MEGAREGIONS IN THE UNITED STATES



Source: America 2050

on US Census Journey to Work data. While studies on the impacts of telecommuting on carpooling are limited, anecdotal evidence suggests that the growth of part-time telecommuting coupled with variable and non-traditional employee work schedules, support the growth of flexible and on-demand carpooling over traditional ridematching approaches, which emphasize pairing employees for carpooling trips on a regular and ongoing basis.

ATTITUDES TOWARD DRIVING

There is some evidence to suggest that attitudes among Americans toward driving could be changing (Shaheen and Cohen, 2018b). Handy et al. (2005) conclude that Americans may be driving out of necessity due to limited modal choices, urban sprawl, and the value proposition of driving (travel time and flexibility compared to other modal options). Millennials (those born between 1981 and 1996) are now the largest age group in the United States and are often cited as the generation beginning to reject car ownership. The percentage of high school seniors with driver's licenses decreased from 85% to 73% between 1996 and 2010 (Dutzik et al., 2014). However, more research is needed to determine, if Millennials have different attitudes and perceptions toward auto ownership or are becoming "late" car owners due to other factors, such as the Great Recession, living at home longer and starting families later in life than prior generations.

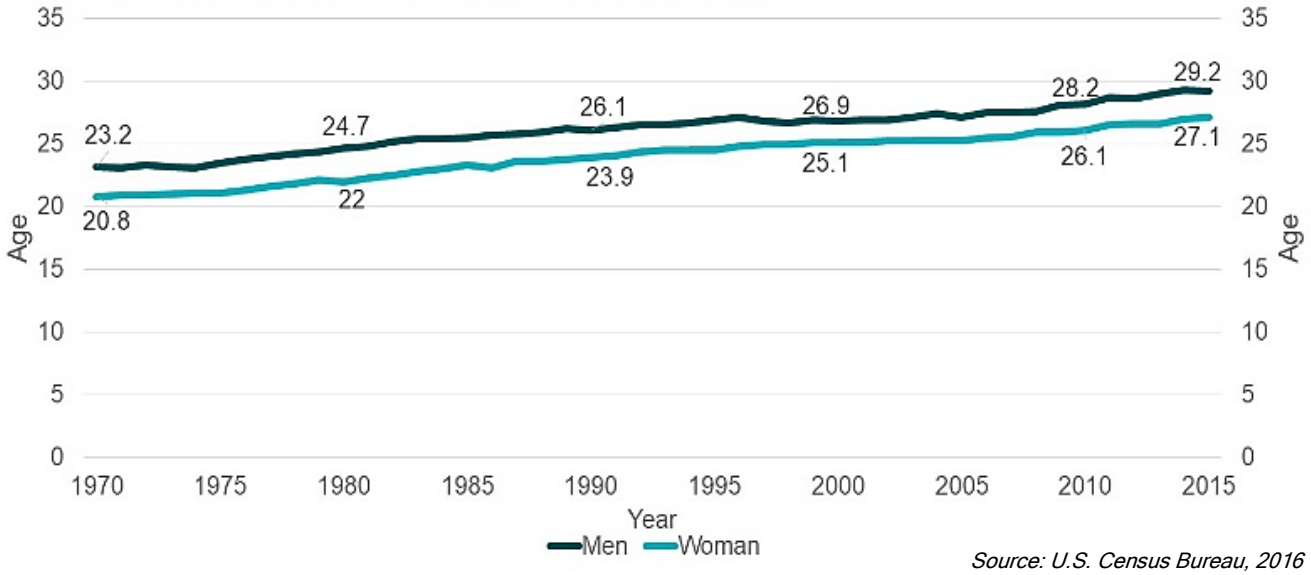
MILLENNIALS AND MOBILITY

One early study of Millennials and mobility concluded that Millennial car owners are living downtown, are parents of kids under 18, and are using cars as one mode in a mix of options. The study also found that the public transit industry may have an opportunity to better promote the use of public transit and other transportation options to Millennials in conjunction with driving. The study also found that Millennials are motivated by cost, reliability, convenience, and active lifestyles with environmental considerations as an added perk. The study also found that the ability to multi-task while commuting is a key motivator when selecting transportation options.

It is widely accepted that Millennials are embracing information and communication technology (ICT), which contributes to growth in mobile Internet connectivity, the growth of smartphone apps, and wearable devices among this cohort. However, research about the impact of ICT on travel behavior is limited (Dutzik et al., 2014). Another study by Blumenberg et al. (2012) found no correlation between ICT usage and a reduction of driving among Millennials. Mans et al. (2012) concluded it will be difficult to model the impacts of ICT due to the many and complex ways ICT could impact traveler behavior (e.g., an online purchase may replace a shopping trip with a delivery trip or create induced demand). However, both the ability to multi-task while commuting coupled with the attraction of ICT and app-based services suggest that app-based carpooling could be an attractive travel option for Millennials.

One trend not commonly discussed is the rising average age of first marriage. Since 1970, the average age of first marriage has steadily risen from 23.2 and 20.8 for men and women, respectively compared to 29.2 and 27.1 in 2015 for men and women, respectively (Figure 2.2). This indicator suggests that Millennials are delaying life

FIGURE 2.2 ESTIMATED MEDIAN AGE OF FIRST MARRIAGE BY GENDER: 1970 TO 2015



Source: U.S. Census Bureau, 2016

milestones, such as getting married and having children, which could impact overall mobility decisions (e.g., modal choice and vehicle ownership).

Early indicators suggest Millennials could be purchasing single family suburban homes similar to Generation X and the Baby Boomers. A recent study of Millennials and home ownership found that many Millennials are bypassing the starter-home market in favor of a more expensive "forever home" (Davidson, 2018). The study concluded that by renting or living with their parents for years, many Millennials in their mid-30s can now afford pricier houses because they have saved more money and moved up to better jobs. According to recent statistics from the National Association of Realtors, 30% of Millennials bought homes priced at $300,000 USD or above this year, up from 14% in 2013 (Davidson, 2018). Additionally, the U.S. Census Bureau found that almost a third of home buyers aged 33 to 37 purchased four-bedroom homes from 2012 to 2016, compared to about 24% in 1980, 1990, and 2000. If Millennials suburbanize as they marry and have children, there could be renewed interest in carpooling among this generational group.

MILLENNIALS MAY CONTINUE TO SUBURBANIZE AS THEY RECOVER FROM THE GREAT RECESSION AND ATTAIN LIFE MILESTONES, SUCH AS GETTING MARRIED AND HAVING CHILDREN.

SUBURBANIZATION

Contrary to popular belief that urban centers are growing faster than the suburbs, the U.S. population is still suburbanizing (Martin et al., 2016; Shaheen and Cohen, 2018b). More than eight in 10 Americans live in metropolitan areas. Sixty-five percent live in large metropolitan areas with over a half million people. Forty-five percent of the U.S. population resides in the suburbs of these large metropolitan areas, and 75% of U.S. households reside in single-family or mobile homes (Frey, 2012).

BETWEEN 1990 TO 2010, SUBURBS GENERALLY GREW FASTER THAN URBAN CORES.

Recent studies indicate that America continues to become more suburban. In the nation's largest metropolitan regions, seven in 10 residents now live in the suburbs. Within each U.S. region, the suburban portion of the population continued to rise in the 2000s (Frey, 2012). Over this decade, suburban growth exceeded urban growth in 81 of the largest 100 U.S. metros.

Additionally, job centers are growing outside of urban cores and in various suburban nodes, such as "edge cities" (suburbs with high concentrations of employment density, such as office parks) (Kneebone, 2016). This study found that employment notably decentralized between 1996 and 2006 with 95 out of 98 metro areas decreasing the share of jobs located within three miles of downtown. Kneebone (2016) concluded that only 21% of employees in the top 98 metro areas work were within three miles of downtown, while over twice that share (45%) worked more than 10 miles away from the city center. Because of more limited transportation options in many suburbs, anecdotal evidence suggests that carpooling can enhance suburban mobility by offering additional transportation choices in a relatively auto-dependent built environment.

FIGURE 2.3 FIVE COMMON BUILT ENVIRONMENTS IN THE U.S.

Source: Shaheen et al. 2017

SUMMARY

Many technological changes and demographics trends are contributing to the growth of shared and on-demand mobility, such as app-based carpooling. Key trends include:

- Increasing availability of location-based mobile services;
- Growth and commodification of on-demand passenger travel;
- Increasing urban congestion;
- Growth of megaregions;
- Demographic shifts, such as rising life expectancies, an aging population, and Millennials delaying life milestones, such as marriage;
- A growing number of telecommuters;
- Potential changing attitudes toward driving and vehicle ownership; and
- Continued growth and expansion of many suburbs.

While longer-term attitudes toward driving and suburbanization are less definitive, the need for transportation solutions that reduce traveler stress, overcome congestion, and increase overall commuter productivity are clear. In the future, these trends could create new demand for carpooling and provide additional mobility options for new potential carpoolers.

3

HOW GOVERNMENT AND EMPLOYERS CAN SUPPORT CARPOOLING

HOW GOVERNMENT AND EMPLOYERS CAN SUPPORT CARPOOLING

A variety of stakeholders play a crucial role in supporting carpooling. One of the most important methods employers, local and regional governments, state agencies, and the federal government can employ to support carpooling is incentives. Employers and public agencies at all levels of government can also support carpooling in a variety of ways, ranging from specific programs at the employer and local government level to broader policy support at the state and federal levels of government. Each of the following sections discuss ways in which key stakeholders can support carpooling.

ROLE OF INCENTIVES AND DISINCENTIVES

Carpool incentive programs may incorporate a variety of means to encourage employees to carpool. Common incentives include direct cash incentives, reduced cost or free parking, preferred parking, or reward programs (such as prize drawings) (U.S. Environmental Protection Agency, 2005).

A number of studies have tried to document the role of incentives and disincentives. A study by Shoup (1997b) found that parking cash out programs where employers are required to give their employees a choice to either keep their employer-paid parking space at work or to accept a cash payment and give up the parking space, increased carpooling by 64%, while decreasing single occupant vehicle (SOV)-travel by 17%.

A study of Georgia's Cash for Commuters program in which new carpoolers were offered a $3 USD per day incentive for 90-days to try carpooling found that 57% continued to carpool 18 to 21 months after the initial incentive period (Georgia Department of Transportation 2009). This study highlights the role that short-term incentives can have in encouraging longer-term modal shift.

Additionally, multiple studies have examined the impacts of additional fees on solo driving with varied findings. Jacobson and King (2009) found that if driving costs of $1 USD are added to each vehicle trip, the maximum rational value of time for travelers to choose ridesharing approximately doubles. However, Baldassare et al. (1998) and Koppelman et al. (1993) found that few drivers are willing to reduce single occupant travel as a result of pricing. In particular, Koppelman et al. (1993) found that solo drivers were more likely to be influenced to carpool through an incentive (e.g., weekly lotteries for supermarket and movie vouchers) than by increases in driving costs (e.g., parking, fuel, etc.).

EMPLOYER SUPPORT

Employers can enjoy several benefits from carpooling. Common employer benefits include: 1) reducing parking demand (to lower parking costs or to make a parking space available for facility expansion); 2) reducing congestion; 3) satisfying local zoning or air pollution requirements; and 4) increasing employee productivity and morale by reducing commute costs, time, and stress.

Employers looking to encourage carpooling can draw upon a number of strategies to encourage shared rides and discourage SOV commutes. Employer support for carpooling commonly includes a combination of administrative support and financial support strategies:

Administrative Support Strategies:

- Providing tools that make it easier for employees to find a match, such as commute planning resources and matching or referral services to help employees locate others nearby with similar schedules;
- Offering marketing and outreach to encourage carpooling; and
- Committing in-kind administrative support or direct funding contributions to carpool programs.

Financial Support Strategies:

- Allowing parking cash out programs where an employer offers employees the option to accept taxable cash income instead of a free or subsidized parking space at work (Shoup, 1997b);
- Implementing 100% commuter choice where employers provide all employees an equal tax-free transportation allowance equal to or less than what an employer charges for parking (Lew Pratsch, unpublished paper, 2017).
- Implementing carpool incentive programs that incorporate a variety of strategies to encourage employees to carpool. Common incentives include: preferred parking for carpoolers; parking cash-out programs;100% commuter choice; discounted parking for carpools (if it is paid); and reward programs, such as prize drawings.
- Leveraging gamification (e.g., the use of game design elements in a non-game context) to encourage carpooling competition among fellow employees.
- Providing services that make carpooling more convenient, such as public transit passes and guaranteed ride home programs.

- Renting cars for carpools (similar to renting vans for vanpools) to provide an option for two to five passengers who want to carpool but may not have a suitable vehicle.

A number of studies in the 1990s documented the cost effectiveness of transportation demand management (TDM) approaches for reducing vehicle travel and emissions (Kuzmyak et al., 2010). Schreffler (1996) found that the annual cost per an employee ranged from $8 to $57 USD with an average of $24 USD (Schreffler, 1996). A 1993 Federal Highway Administration report sampling 22 employer programs found the direct cost per daily one-way vehicle trip reduced averaged $1.22 USD compared to an average cost savings of $1.94 USD per trip reduced (Comsis Corporation, 1993).

Studies on the effectiveness of individual employer carpooling programs are more limited. One study in the Cornell University implementation of a carpooling program in the 1990s found that the TDM program succeeded in reducing the need to construct additional parking spaces. Cornell University increased its parking fees to disincentivize single occupant vehicles. The university estimates its commuter benefits program results in 2,400 fewer daily vehicle trips and a savings of $36 million USD during the first ten years of program implementation (U.S. Environmental Protection Agency 2005).

Collectively these studies found that employer TDM programs that incorporate financial incentives and disincentives are generally the most effective in reducing vehicle trips and have the lowest cost per employee and per trip reduced (Kuzmyak et al., 2010).

LOCAL AND REGIONAL SUPPORT

Local and regional governments can support carpooling in a number of ways. First, local and regional governments can partner with private sector employers and carpooling providers to support local and regional ridematching efforts. Additionally, they can provide incentives and sponsor guaranteed ride home programs for carpooling. In addition to these policies, local and regional governments can:

- Implement parking reforms, such as pricing parking, eliminating parking minimums, instituting 100% commuter choice, and implementing parking cash-out programs;
- Institute road and curb pricing strategies, such as road tolls, congestion fees, and other charges;
- Implement trip reduction and TDM ordinances; and
- Fund carpooling infrastructure and support high occupancy vehicle priority through HOV lanes, park-and-ride facilities, encourage the inclusion of carpooling parking at new and existing facilities, and implement signal prioritization for higher occupancy vehicles.

Each of these topics are discussed in greater detail below.

PARKING: ZONING, PRICING, 100% COMMUTER CHOICE, AND PARKING CASH-OUT

In most U.S. cities, parking is typically free. The oversupply of free parking can distort the transportation marketplace and individual mode choice. Many cities have implemented minimum parking requirements requiring new buildings to include a fixed number of off-street parking spaces based on an assumed demand for parking generated by the buildings' use (Shoup, 2011). A common criticism of minimum parking requirements is that they assume a building's users will travel by car providing a one-size fits all approach mandating parking supply, often requiring sufficient supply for a building's peak (e.g., minimum parking at a shopping center based on the number of shoppers during the holiday season). Minimum parking requirements are often attributed to an over supply of underpriced parking subsidizes low-occupancy private vehicle use (Shoup, 2005).

Nationally, employers provide 85 million free parking spaces for commuters (Shoup and Breinholt, 1997). Typically, the capital costs of parking range from approximately $10,000 to $75,000 USD per parking space (surface versus structured parking, respectively) and $300 to $700 USD for operations and maintenance per parking space annually. With minimum parking requirements, cities require developers to increase parking supply by as much as a new development increases parking demand assuming that the parking is free (Shoup, 2011). As such, minimum parking requirements provide subsidies for driving that inflate parking demand. By severing the cost of providing parking and the price drivers pay for it, the true cost of parking is not passed onto the driver and therefore fails to influence travel decisions about vehicle ownership and use (Shoup, 2011).

Shoup (1995) found that when commuters paid for parking, they drove an average of 53 vehicles to work per 100 employees. However, when commuters parked free, they drove an average of 72 cars per 100

employees, stimulating a 36% increase in the number of cars driven to work (Shoup, 1995).

Eliminating minimum parking requirements and pricing existing parking are two strategies that can reduce oversupplies of parking and single occupant vehicle use. If parking were less plentiful and priced, people would be more prudent about when and where they drove (Shoup, 2011).

Another strategy, 100% commuter choice involves employers providing all employees an equal tax-free transportation allowance equal to or less than what an employer charges for parking. If a commuter needs to drive alone to work, they use the 100% commuter choice allowance provided by the employer to pay for parking. Other employees might choose to move closer to work walk, use public transit, cycle, carpool, or vanpool to work (Lew Pratsch, unpublished paper, 2017). Studies show that 10-20% of the commuters who drive alone to work and park free would choose another mode if required to pay for parking. A FHWA report documents a 10-15% decrease in VMT can reduce traffic congestion over 50% (Louis Berger Group, Inc 2008; Lew Pratsch, unpublished paper, 2017).

Finally, parking cash-out, can also reduce single occupant vehicle travel. Parking cash-out, which can be implemented by employers or through local or state mandates, is an employer-funded program in which an employer offers a cash allowance to an employee equivalent to the parking subsidy that an employer would otherwise pay to provide the employee with a parking space. For example, in 1992 California enacted legislation that converted employer-paid parking from a matching grant for driving to a block grant for commuting (Shoup, 1997a). The law requires employers that subsidize commuter parking to offer a parking cash-out program. Although implemented on a statewide scale, parking cash-out can be required by local and regional governments or voluntarily offered by individual employers. By offering commuters the option to elect free parking or its cash value makes it clear that free parking has a cost. Parking cash-out can encourage commuters that drive to work alone and park for free to carpool.

ROAD AND CURB PRICING

In addition to pricing parking, road and curb pricing are also strategies that can encourage higher occupancy modes (Forscher et al., 2018). Road and curb pricing are direct charges that are levied for the use of roads and curb frontage, such as road tolls, distance or time-based fees, congestion charges, and fees designed to discourage certain vehicles or behaviors, such as higher polluting vehicles and lower occupancy vehicles, respectively.

In the context of pooling, pricing can be applied to discourage single occupant vehicle travel. For example, in the San Francisco Bay Area, the Bay Area Toll Authority responsible for administering regional bridge tolls provides discounts for carpools during commute times (Bay Area Toll Authority, 2018). Toll discounts for carpoolers vary from approximately 30% to 60% depending on the bridge and if electronic toll collection is used (Bay Area Toll Authority, 2018).

FIGURE 3.1 BAY AREA TOLL AUTHORITY RATES FOR SINGLE-OCCUPANT AND CARPOOL VEHICLES

Bridge	Toll Rates During Commute Times*		Commute Hours Monday - Friday	
	Regular	Carpool	Morning	Afternoon
Golden Gate Regular Toll With FasTrak	$8.00 $7.00	$5.00	5 am –9 am	4 pm – 6 pm
San Francisco – Oakland Bay	$6.00	$2.50	5 am –10 am	3 pm – 7 pm
Antioch	$5.00	$2.50	5 am – 10 am	3 pm – 7 pm
Benicia – Martinez				
Carquinez				
Dumbarton				
Richmond – San Rafael				
San Mateo – Hayward				

Source: Bay Area Toll Authority 2018

In addition to road pricing, pricing can also be used to manage curb space demand. Charging pricing based on vehicle occupancy is one way to discourage lower occupancy vehicles and encourage carpooling in urban centers (Goffman, 2018). Pricing curb access for lower occupancy vehicles can reduce the amount of curb space needed to meet demand, reduce total vehicle traffic, and increase revenue.

In an automated future, road and curb pricing will be an important component in mitigating some of the potential negative externalities of automated vehicles on congestion, the environment, and equity (Stocker and Shaheen, 2018; Moavenzadeh and Lang, 2018). If automated vehicles (privately owned and shared) are appropriately priced based on their usage, higher-occupancy transportation modes, such as carpooling (Shaheen and Cohen, 2018a), may become more attractive and gain higher ridership than would be the case absent of any road pricing regulations. A simulation by Moavenzadeh and Lang (2018) estimates a 15.5% travel time improvement attributable to road pricing in an automated future (Moavenzadeh and Lang, 2018). A combination of pooling incentives with various pricing policies and rights-of-way access policies, tailored to city

and regional travel patterns, will be necessary to mitigate the potential negative impacts of an automated vehicle future (Stocker and Shaheen, 2018).

TRIP REDUCTION AND TRANSPORTATION DEMAND MANAGEMENT (TDM) ORDINANCES

Local and regional support for carpooling can also include establishing TDM or trip reduction ordinances. These policy approaches offer a combination of "carrot" and "stick" approaches that require a reduction in single occupant vehicle trips, while also encouraging the inclusion of carpooling into residential, commercial, and mixed-use projects.

Air quality districts failing to meet federal standards began implementing these ordinances in the 1980s. One of the largest mandated trip reduction programs was implemented in 1988 by the South Coast Air Quality Management District (SCAQMD) requiring employers to meet a minimum average vehicle ridership (AVR) of 1.5 for most of the urbanized region (Dill, 1998). AVR is the current number of employees scheduled to report to work during a given timespan (i.e., the morning commute) divided by the number of vehicles arriving at the worksite during the same window. When the regulation was implemented, the trip reduction mandate affected over 2.26 million employees or 40% of SCAQMD's 5.4 million workers (Giuliano et al., 1993; Dill, 1998). This regulation has since been amended, establishing varying AVRs ranging from 1.3 to 1.75 based on one of three zones.

Seattle's Municipal Code requires that employers implement at least two trip reduction programs, which can include ridematching services for employees, subsidies for carpool participation, and preferential parking and reduced parking fees for carpool and vanpool vehicles. The Seattle Department of Transportation (SDOT) estimates over 250 employers with over 139,000 daily commuters participate in the city's trip reduction program. SDOT estimates that its program has contributed to an 11% reduction in single occupant vehicle (SOV) trips with an additional 10% estimated for 2017 (results are currently being tabulated). A number of other Washington municipalities have implemented trip reduction programs, including some paired with monetary incentives. The City of Redmond offers a monthly gift card lottery for taking alternative modes at least four days per month and the City of Bellevue offers a perks program where commuters can earn monthly coupons to local retailers and be entered to win one of 25 monthly gift card drawings.

Like Washington, numerous Arizona localities have implemented similar trip reduction ordinances. For example, Maricopa County (Phoenix metro) requires major employers with 50 or more employees to implement eligible trip reduction measures including but not limited to ridematching services, carpooling subsidies, and preferential parking for carpooling. In 2011, 2,993 Maricopa County employers participated in the local Trip Reduction Program. Similarly, Pima County (Tucson metro) has also implemented a trip reduction ordinance similar to the Arizona and Washington laws. Pima County's law requires major employers with 100 or more employees to implement eligible trip reduction measures, such as ridematching services, carpooling subsidies, and preferential carpooling parking.

In addition to mandating trip reductions, local and regional governments can implement policies that encourage carpooling by integrating provisions within building codes. For example, in April 2016, the City of Indianapolis revised its zoning and subdivisions ordinance to permit developers a cumulative reduction in required parking up to 35% for the inclusion of TDM measures. One of the measures that help developers qualify for this parking reduction is the inclusion of carpool and vanpool parking spaces. Indianapolis allows developers to reduce off-street parking by four spaces for each carpooling parking spot in addition to allowing each carpool parking spot to count toward the minimum number of required spaces.

In summary, trip reduction and transportation demand management ordinances can be implemented by local and regional public and quasi-public agencies (e.g., MPOs, air quality districts, cities, etc.). Implementation of trip reduction and demand management ordinances vary widely and can include imposing AVR standards, implementing employer programs (e.g., preferential parking for carpools, monetary incentives, etc.), and minimum parking reduction incentives for developers. Table 3.1 summarizes examples from a selection of local governments across the U.S.

TABLE 3.1 EXAMPLES OF LOCAL TRIP REDUCTION AND TRANSPORTATION DEMAND MANAGEMENT ORDINANCES

Jurisdiction	Key Policy Components
Bellevue, WA	• Key Component: Earned Incentives and Lotteries • Applicability: Commuters can earn coupons and enter drawings for additional rewards
Indianapolis, IN	• Key Component: Minimum parking reductions for developers for the inclusion of carpooling and other infrastructure supportive of alternative modes • Applicability: Developers can earn a 35% cumulative minimum parking reduction for the inclusion of TDM measures, such as carpooling parking in a new development
Maricopa County, AZ	• Key Component: Mandated employer commute trip reduction program • Applicability: Employers with 50 or more employees are required to implement trip reduction measures, such as ridematching, carpooling subsidies, and preferential parking for carpooling
Pima County, AZ	• Key Component: Mandated employer commute trip reduction program • Applicability: Employers with 100 or more employees are required to implement trip reduction measures, such as ridematching, carpooling subsidies, and preferential parking for carpooling
Redmond, WA	• Key Component: Lotteries • Applicability: Commuters taking alternative modes can enter a lottery for gift cards
Seattle, WA	• Key Component: Mandated employer commute trip reduction program • Applicability: Employers with 100 or more employees are required to implement trip reduction measures, such as ridematching, carpooling subsidies, and preferential parking for carpooling
South Coast Air Quality Management District (SCAQMD)	• Key Component: Average vehicle ridership (AVR) • Applicability: Worksites with 250 or more employees must implement an annual commute trip reduction program that that achieves an average vehicle ridership performance requirement of 1.3 to 1.75 depending on the geographic zone

CARPOOLING INFRASTRUCTURE AND HIGH OCCUPANCY VEHICLE (HOV) PRIORITY

A number of carpooling infrastructure and priority policies can be implemented individually or collectively to provide priority to higher occupancy vehicles, such as carpools. Carpooling infrastructure typically includes:

- High occupancy vehicle (HOV) highway and arterial lanes that provide carpoolers a network of HOV lanes on highways and high-volume corridors and surface streets; and
- Park-and-ride facilities that provide parking for travelers to leave their vehicles and transfer to a carpool or public transportation for the remainder of their journey.

The availability of HOV lanes and park-and-ride facilities are a critical component of promoting carpooling within a region. A study in the San Francisco Bay Area found that 59% of park-and-ride commuters formed prearranged and casual carpools at facilities that were near HOV lanes or inadequately served by public transit (Shirgaokar and Deakin, 2005). Turnbull et al. (2006) found that HOV lanes are most effective at reducing single occupant vehicle use on congested highways to large employment centers in large urban areas with high frequency bus service during peak periods, where public transit provides time savings of at least five to 10 minutes per trip (Victoria Transport Policy Institute 2014). Turnbull (2001) provides implementation guidelines for HOV facilities emphasizing effectiveness in major urban areas with large employment centers, heavy congestion, and supportive TDM policies. Best practices for implementing effective HOV facilities include:

- A minimum threshold of approximately one million people in a metropolitan region;
- High levels of traffic congestion along a corridor;
- Access to an employment center with more than 100,000 workers;
- Supportive TDM programs and policies with ongoing marketing;
- Visible HOV or automated HOV enforcement; and
- Institutional, local, and regional support for carpooling.

HOV lanes can be implemented by adding new road capacity designated for HOVs or converting an existing lane to HOV use. HOV lanes have a number of varying design and operational characteristics, such as:

- Separation from regular traffic using signs, markings, painted buffers, or physical barriers; and
- Operational hours varying from peak hours only to 24 hours. Some facilities may use reversible lanes for areas with high levels of directional traffic.

Studies indicate that HOV lanes can reduce vehicle trips by 4% to 30% (Comsis Corporation, 1993; Turnbull et al. 2006; Victoria Transport Policy Institute 2014). Another study estimates that HOV lanes can reduce peak period vehicle trips by two to 10%, and up to 30% on congested corridors, if HOV lanes are separated by a barrier (Ewing, 1986). Apogee (1994) concluded that HOV lanes can regionally reduce VMT by 1.4% and vehicle trips up to 0.6% (Victoria Transport Policy Institute 2014).

HOV FACILITIES ARE MOST APPROPRIATE ON CONGESTED HIGHWAYS WHERE HOV USE CAN RESULT IN NOTABLE TRAVEL TIME SAVINGS FOR CARPOOLERS.

Park-and-ride facilities are parking lots that allow commuters to park their vehicles and carpool or take public transit to their destination. Park-and-ride facilities are typically located in the suburbs or outskirts of metropolitan areas (Turnbull et al., 2004). The average park-and-ride typically contains between 30 and 250 parking spaces; however, some facilities can have more than 2,000 parking spaces.

While research on the impacts of park-and-ride lots are limited, anecdotal evidence indicates that these facilities support carpooling because they provide a safe, convenient meeting location for travelers to form a match. Studies suggest that one carpool is formed for approximately every 1.5 vehicles parking in these facilities (Turnbull et al., 2004; Victoria Transport Policy Institute 2014). Additionally, these facilities can shift parking and congestion out of existing urban areas to lower density, less congested areas (Turnbull et al., 2004; Victoria Transport Policy Institute 2014).

In addition to HOV lanes and park-and-ride facilities, a number of policies can prioritize carpooling and encourage sharing a ride through travel time savings. These policies include:

- Queue jumping where HOV lanes can by-pass ramp metering and enter immediately, while SOV lanes must wait for the ramp meters;
- Signal prioritization for HOV lanes on surface streets; and
- Preferred parking space locations or parking fee discounts for carpooling vehicles.

Each of these policies can help reduce travel times for higher occupancy vehicles. HOV priority effectiveness will typically depend on maintaining notable travel time savings over single occupant vehicle trips. As such, this policy should target corridors with congested general purpose lanes where maximum travel time savings could be achieved (Victoria Transport Policy Institute 2014).

In summary, signal prioritization for HOVs, HOV ramp metering priority, a network of HOV lanes, park-and-ride facilities, and preferred parking for carpooling can create a synergy that supports and encourages carpooling usage.

STATE AND FEDERAL SUPPORT

The state and federal levels of government can support carpooling in a number of ways. Three key ways that state and federal agencies can support carpooling include:

- State and federal agencies can provide tax incentives and commuter tax benefits for carpooling;
- State and federal agencies can implement clear, concise carpooling definitions;
- State and federal agencies could implement performance-based contracts that allow contractors to receive performance bonuses for verifiable reductions in traffic or VMT (Lew Pratsch, unpublished paper, 2017); and
- State agencies can implement statewide trip reduction laws (similar to local trip reduction ordinances).

Each of these support strategies are discussed in greater detail below.

TAX INCENTIVES AND COMMUTER TAX BENEFITS FOR CARPOOLING

Section 132(f) of the U.S. Internal Revenue Code provides a way for employers to provide parking, public transit, vanpool, and bicycle expenses on a tax-free basis. This can be done on a pre-tax basis, through employer subsidies, or both of these approaches.

- With pre-tax public transit benefits, employees can elect to withhold funding from their paycheck. Those funds are used to purchase fares for public transit or vanpools. The employee is not taxed on the funding withheld, and the employer does not pay employment taxes on those funds.
- Through subsidies, employers can provide public transit or vanpool fares in addition to salary. With subsidies, neither the employee is not taxed on the value of these funds nor does the employer pay employment taxes on those funds.
- Employers can subsidize a portion of an employee's commute expenses, and the employee can withhold an additional amount based on need on a pre-tax basis (Internal Revenue Service, 2018).

Previously, employers could deduct the subsidy portion of a commuter's expenses that were paid for by the employer. This tax benefit was eliminated with the

passage of the Tax Cuts and Jobs Act of 2017. While employers can still subsidize these expenses, employers can no longer deduct the subsidized portion of their commuters' expenses (WageWorks, 2018).

THE FEDERAL GOVERNMENT COULD EXPAND SUPPORT FOR CARPOOLING BY EXPANDING SECTION 132(F) OF THE INTERNAL REVENUE CODE TO INCLUDE CARPOOLING AND SIMPLIFYING THE TAX CODE.

Historically, there have been ambiguities in the IRS tax code pertaining to cash reimbursements received by carpool and vanpool drivers. Cash reimbursements received by carpool and vanpool drivers are difficult to track due to the cash nature and size of the transactions. The federal government could expand its support for carpooling by simplifying the tax code by exempting reimbursements received by drivers of commuter driven vehicles carrying up to 15 commuters from taxable income and making them ineligible as business deductions (Lew Pratsch, unpublished paper, 2017). This would simplify the tax code, eliminate difficult to enforce regulations, and negate the need for carpool and vanpool drivers to keep tedious records (Lew Pratsch, unpublished paper, 2017).

A number of states have implemented tax incentives and commuter tax benefits for carpooling. For example, Maryland offers an employer tax credit of 50% of the eligible costs of providing commuter benefits to employees. The tax credit is applicable to an array of commuting expenses, including vanpooling, guaranteed ride home, and parking cash-out programs (Comptroller of Maryland, 2018). The State of Washington offers a Commute Trip Reduction Tax Credit for all employers and property managers "who are taxable and provide financial incentives to their employees for ridesharing, carsharing, public transportation, and non-motorized commuting." This credit is valued at up to $60 USD per employee per a fiscal year, up to $100,000 USD per an employer/property manager annually (Revised Code of Washington 82.70.010 et seq.). Georgia offers a similar tax credit of $25 USD for each employee that uses a federal qualified transportation fringe benefit at least 10 days per a month. This credit is available to employers that provide carpool or vanpool parking on or near the workplace (Georgia Code 48-7-29.3 et seq.).

In summary, tax incentives and commuter tax benefits for carpooling are a key way the federal and state government can support carpooling. Table 3.2 compares key tax incentives and commuter tax benefits from the states of Maryland, Georgia, and Washington.

TABLE 3.2 EXAMPLES OF STATE-LEVEL TAX INCENTIVES AND CREDITS FOR CARPOOLING

State	Incentive Beneficiary	Incentive Amount
Maryland	Employer	50% of the eligible costs of providing commuter benefits to employees.
Georgia	Employer	$25 for each employee using a federal qualified transportation fringe benefit at least 10 days per a month.
Washington	Employer and Property Managers	$60 per employee per a year, up to $100,000 per an employer/property manager annually

CLEAR AND CONCISE DEFINITIONS OF CARPOOLING

Increasingly, differing terms and definitions can be confusing for the public and policymakers. Developing clear, consistent, and precise definitions can encourage the growth of carpooling by providing policy and decisionmakers with a greater understanding of the types of pooled services available and their associated impacts (Shaheen et al. 2016). Clear and consistent definitions can help to clear confusion about modes and service models.

As noted by SAE International, a global standards organization for mobility engineering, certain terms such as "ridesharing" are sometimes used inconsistently or confusingly. SAE Standard J3163, states "a for-hire vehicle service with one paid driver and one paid passenger is not considered ridesharing (or carpooling). While some ridesourcing services offer shared rides for more than one traveler, these services are referred to as "ridesplitting," "pooling," and "taxi sharing," the latter used to describe sharing a taxi cab (SAE International 2018).

PERFORMANCE-BASED CONTRACTS FOR CONGESTION MITIGATION

State and federal agencies could implement performance-based contracts for congestion mitigation (Lew Pratsch, unpublished paper, 2017). The FAST Act and MAP-21 encourage performance and outcome-based programs to achieve reductions in congestion and improvements in system reliability of the transportation network. One strategy for reducing congestion is for state and federal agencies (perhaps through Congestion Mitigation and Air Quality (CMAQ) funds) to initiate performance-based contracts that provide contractors performance bonuses that reduce traffic or VMT. Contractors could develop plans to decrease traffic congestion, develop a verification procedure, and upon

successfully demonstrating performance, be awarded a contract bonus for congestion reduction. Incentives could be based on a portion of the annualized cost of adding additional roadway capacity along a congested corridor or urban area. Measures could include carpool marketing, the use of apps that reduce congestion, conversion of HOV lanes to high occupancy toll (HOT) lanes, HOV/HOT lane additions, parking and congestion pricing, and other initiatives (Lew Pratsch, unpublished paper, 2017).

STATEWIDE TRIP REDUCTION LAWS

Similar to local trip reduction ordinances, states can pass legislation or issue regulatory mandates requiring commute trip reduction benchmarks. For example, the State of Washington has implemented a state-wide Commute Trip Reduction Law applying to all employers with 100 or more full-time employees at a single worksite who are scheduled to begin their workdays between 6:00 and 9:00 a.m. weekdays and are located in counties or urban growth areas with populations exceeding 150,000. As part of this law, employers are required to develop their own trip reduction plans and submit them for approval (Washington Code 468-63-010 et seq.; Revised Code of Washington 70.94.521 et seq.) (Interagency Commute Trip Reduction Board 2011). Many local municipalities have adopted similar local ordinances mimicking this state law. Similarly, Arizona State requires all major employers to develop, implement, and maintain a travel reduction program to reduce traffic impacts on air pollution and emissions (Arizona Code 49-581 et seq.).

In Massachusetts, the Department of Environmental Protection (MassDEP) has implemented a statewide ridesharing regulation that requires facilities to develop plans and set goals for reducing employee and student drive-alone commute trips by 25%. This regulation applies to business that employ 250 or more daytime employees and educational institutions with 1,000 or more applicable commuters. MassDEP's regulation requires facilities to conduct carpool matching using a designated coordinator or using a carpool-matching service and set aside preferential spaces for carpools (Massachusetts Code 310 CMR 7.00 et seq.).

Similar to MassDEP, Oregon's Department of Environmental Quality has implemented an Employee Commute Options Program requiring that employers with more than 100 employees at a single worksite must provide commute options to employees designed to reduce the number of cars driven to work in Portland and surrounding areas. These employers must provide incentives for employee use of commute options, like taking the bus or carpooling (Oregon Administrative Rules 340-242-0010 et seq.).

Trip reduction laws are one common way state governments encourage the implementation of carpooling programs at the employer level. Table 3.3 summarizes state trip reduction laws in Arizona, Massachusetts, Oregon, and Washington.

TABLE 3.3 EXAMPLES OF STATE TRIP REDUCTION LAWS

State	Key Policy Components
Arizona	• Requirements: Major employers must provide employees with information on alternative commute options, participate in a mode choice and VMT survey, designate a transportation coordinator, and implement trip reduction measures such as: providing ridematching and vanpooling services, subsidizing carpooling and vanpooling, allowing the usage of company vehicles for carpooling, and offering preferential parking for carpooling among other applicable measures • Applicability: All major employers with 100 or more full-time employees (50 or more employees in select areas) working at or reporting to a single work site during any 24 hours period for at least three days per week during at least six months of the year
Massachusetts	• Requirements: Facilities must offer carpool matching using a designated coordinator or carpool-matching service and set aside preferential spaces for carpools • Applicability: Businesses that employ 250 or more daytime employees and educational institutions with 1,000 or more applicable commuters
Oregon	• Requirements: Employers must offer commute options to employees designed to reduce single-occupant vehicle commute trips; incentives must have the potential to reduce commute trips by 10% from an established baseline • Applicability: Employers with 100 or more employees at a single worksite
Washington	• Requirements: Employers must develop their own trip reduction plans and submit them for approval • Applicability: All employers with 100 or more full-time employees at a single worksite with a scheduled start between 6-9:00 AM on weekdays; employers located in urban growth areas or counties with populations exceeding 150,000

SUMMARY

Employers, local and regional governments, and the federal government can play an important role in supporting carpooling. The primary ways employers can support carpooling include:

- Helping employees form carpools by providing matching or referral services to help locate matches with similar schedules;
- Providing tools that make carpooling more convenient, such as commute planning resources, public transit passes, and guaranteed ride home programs; and
- Implementing 100% commuter choice, parking cash-out, and other carpool incentive programs.

The primary ways local and regional governments can encourage carpooling include:

- Partnering with private sector employers and carpooling providers to support local and regional ridematching efforts;
- Considering parking reforms, such as pricing parking, eliminating parking minimums, and implementing 100% commuter choice and parking cash-out programs;
- Considering pricing policies that incentivize higher occupancy and disincentivize low-occupancy modes;
- Implementing trip reduction and TDM ordinances; and
- Supporting HOV infrastructure (e.g., HOV lanes and park-and-ride facilities) and signal prioritization that encourages carpooling.

State and federal governments can support carpooling by:

- Employing tax credits and commuter tax benefits for carpooling. In particular, the federal government can encourage carpooling by expanding commuter tax benefits to carpooling and simplifying the tax code pertaining to cash reimbursements received by carpool and vanpool drivers;
- Developing clear, concise, and consistent definitions of carpooling;
- Implementing performance-based contracts for contractors that successfully reduce congestion (Lew Pratsch, unpublished paper, 2017); and
- Implementing state-level trip reduction laws.

4

CONCLUSION

KEY TAKEAWAYS

Carpooling allows travelers to share a ride to a common destination and can include several forms of sharing a ride, such as casual carpooling and real-time carpooling. Today, carpooling is the second most common travel mode in the United States after driving alone—although percentages have continued to decline in recent decades. More policy support is needed to reverse this trend and increase carpooling mode share, particularly in an automated vehicle future.

CARPOOLING IMPACTS AND MOTIVATORS

Carpooling is often associated with numerous societal, employer, and individual benefits.

SOCIETAL BENEFITS

- Reduced vehicle miles traveled;
- Reductions in fuel consumption and GHG emissions;
- Reductions in adverse air pollution impacts on low-income, minority, and other environmental justice populations; and
- Cost savings for public agencies and employers.

EMPLOYER BENEFITS

- Reduced need for parking;
- Increased morale and productivity of employees; and
- Financial and tax benefits for employers.

INDIVIDUAL CARPOOLING BENEFITS AND MOTIVATORS

- Enhanced accessibility and economic opportunity for low-income households;
- Cost savings associated with shared travel costs; and
- Increased convenience and reduced stress from shared driving responsibilities and travel-time savings associated with HOV lane access.

INNOVATIONS AND TRENDS IN MOBILITY

Socio-economic forces, coupled with technological innovations, are encouraging shared and pooled services. Key technological, mobility, social, and demographic trends changing the way people travel include:

TECHNOLOGICAL TRENDS

- Growth of cloud computing, location-based navigation services, data sharing, and mobile technologies; and
- Commodification of passenger services supporting app-based and on-demand transportation options.

MOBILITY TRENDS

- Increasing demand and urban congestion, reduced transportation funding, and the critical need to maximize existing infrastructure capacity; and
- Growing popularity of shared and higher occupancy modes, such as microtransit, app-based carpooling, and others; and
- Increasing consumer interest in on-demand transportation options.

SOCIAL TRENDS

- Heightened environmental awareness about emissions and carbon footprint, and
- Growth of megaregions.

DEMOGRAPHIC TRENDS

- Demographic changes, such as rising life expectancies, people working longer, and Millennials entering the workforce;
- People delaying life milestones, such as getting married and having children that could have an impact on automobile ownership and use; and
- Millennials increasingly embracing apps and other technologies.

OTHER TRENDS

- Growing number of telecommuters,
- Possible changing attitudes toward driving and vehicle ownership, and
- Continued growth and expansion of many suburbs.

HOW GOVERNMENT AND EMPLOYERS CAN SUPPORT CARPOOLING

A variety of public and private stakeholders play a crucial role in supporting carpooling. Below are key ways each of these stakeholders can support carpooling.

EMPLOYER SUPPORT

Employers can support carpooling by:

- Allowing parking cash out programs and 100% commuter choice (Shoup, 1997b; Lew Pratsch, unpublished paper, 2017).
- Providing tools that make it easier for employees to find a match, such as commute planning resources and matching or referral services to help employees locate others nearby with similar schedules;
- Providing marketing and outreach to encourage carpooling;
- Committing in-kind administrative support or direct funding contributions to carpool programs;
- Implementing carpool incentive programs, such as: reduced or free parking; preferred parking for carpoolers; parking cash-out programs; discounted parking for carpools (if it is paid); and reward programs, such as prize drawings;
- Incorporating game design elements (e.g., gamification) to encourage carpooling competition among fellow employees; and
- Providing services that make carpooling more convenient, such as public transit passes and guaranteed ride home programs.

LOCAL AND REGIONAL GOVERNMENT SUPPORT

Local and regional governments can support carpooling by:

- Implementing parking reforms, such as pricing parking, eliminating parking minimums, and implementing 100% commuter choice and parking cash-out programs;
- Instituting road and curb pricing strategies, such as road tolls, congestion fees, and other charges;
- Implementing trip reduction TDM ordinances; and
- Funding carpooling infrastructure and supporting high occupancy vehicle priority through HOV lanes, park-and-ride facilities, and other measures, such as signal prioritization.

STATE AND FEDERAL GOVERNMENT SUPPORT

States and the federal government can support carpooling by:

- Providing tax incentives and commuter tax benefits for carpooling;
- Simplifying the tax code by exempting reimbursements received by drivers of commuter driven vehicles carrying up to 15 commuters from taxable income and making them ineligible as business deductions (Lew Pratsch, unpublished paper, 2017);
- Implementing clear, concise carpooling definitions;
- Implementing performance-based contracts for contractors that successfully reduce congestion (Lew Pratsch, unpublished paper, 2017); and
- Developing statewide trip reduction laws (similar to local trip reduction ordinances).

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