Submitted to: Cruise
Submitted by: ICF, National Disability Institute
Authors:
Dominic Modicamore
George Voigt
Danny Clark
Jack Murphy
Elizabeth Layman

Economic Impacts of Removing Transportation Barriers to Employment for Individuals with Disabilities Through Autonomous Vehicle Adoption

December 30, 2022

Table of Contents

I. Introduction

Eliminating barriers to inclusion for people with disabilities has been an ongoing global and domestic effort for many decades. Still, persistently low employment rates and general social exclusion prevent many with disabilities from full participation in society and the economy. A relatively novel potential solution to this problem is seen in the emergence and rapid development of autonomous vehicles (AVs) in the 21st century – particularly in providing more accessible, reliable, and affordable access to transportation for people with disabilities. Available in many different varieties, including on-demand and electric, these AV transportation services for people with disabilities could not only present significant job creation potential for the U.S. economy, but it could also generate additional tax revenue and reduce expenditures surrounding Supplemental Security Income (SSI) and Social Security Disability Insurance (SSDI). Given these potential opportunities, this report projects the impact of AV adoption on the employment and incomes of people with disabilities and on the wider U.S. economy, using existing data about labor force and industry participation by workers with disabilities. Simulations revealed large potential increases in employment among the disability workforce, as well as large gains in the U.S. Gross Domestic Product (GDP).

This report presents a literature review on the status quo of today's disability labor force and outlines the barriers to employment that this population segment faces, presents the methodology and findings of the economic impact analysis of accessible AV transportation for people with disabilities, and concludes with a robust discussion of associated qualitative findings from dozens of interviews with people with disabilities and disability policy leaders on the potential impact of AV transportation, as well as the residual impacts to health, education, and entrepreneurship in an AV future.

II. Literature Review - The Status Quo of Transportation for People with Disabilities

There are 42.5 million people with disabilities living in the United States.[1] The disability community makes up a significant portion of the American workforce.[2] According to the Bureau of Labor Statistics (BLS), almost 6 million individuals with disabilities aged 16 and over are employed, while an additional 669,000 are in the labor force but unemployed.[3] Disability, which increases with age, will continue to impact the U.S. economy as the large baby boomer generation continues to age.[4] However, there is a well-researched[5] [6] [7] trend of low labor force participation rates among people with disabilities, particularly in comparison to individuals without disabilities. According to BLS, only 21% of people aged 16 and over with disabilities participate in the labor force, while 67% of people without disabilities in that age group participate in the labor force. Furthermore, among those in the labor force, 10.1% of people with disabilities are unemployed, double the national unemployment rate when the entire labor force is considered.[7] Workers with disabilities are also more likely to find themselves in contingent and part-time work, precluding them from the benefits of full-time employment, such as pensions and insurance.[8] The issue of lower wages and underemployment is compounded by the higher cost of living associated with having a disability, including higher costs associated with having to hire on-demand transportation or vehicles with accommodations.[9] [10]

Some people with disabilities may face additional barriers to employment due to limited mobility as a result of their disability. Of the 31 million people with disabilities aged 16 and up, over one-third have inadequate access to transportation.[7] Silverman et al.'s 2019 survey identified transportation barriers as a leading obstacle to employment among legally blind Americans, one subset of the people with disabilities population.[11] The Bureau of Transportation Statistics (BTS)

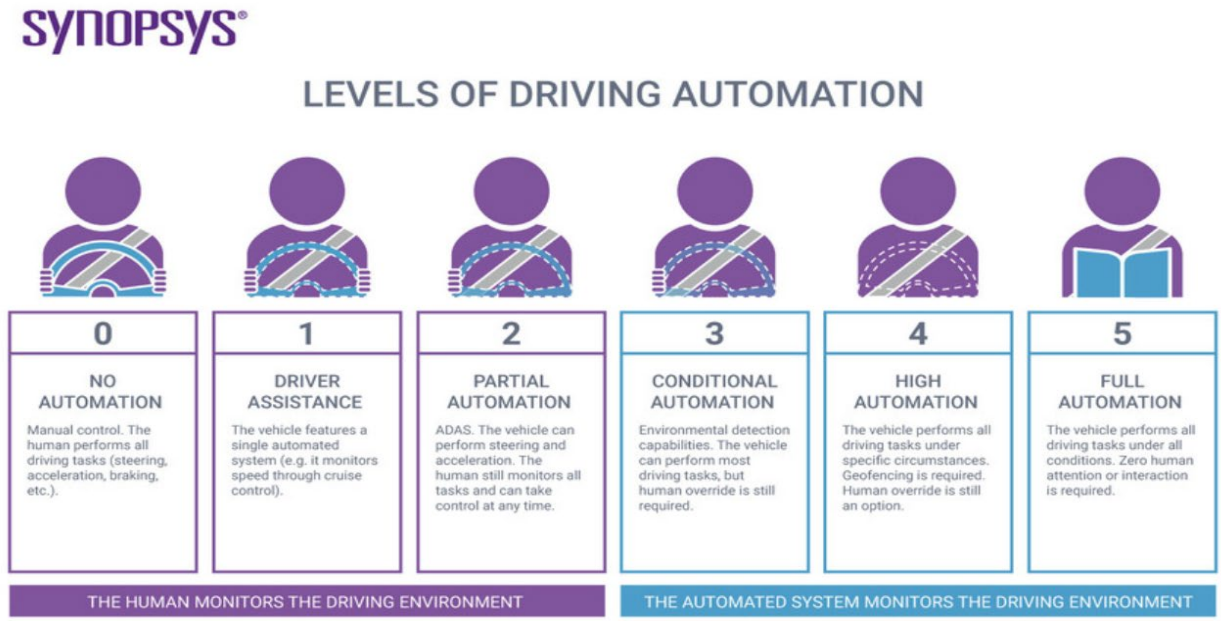
has also identified a long-term trend of low travel among Americans with disabilities; in 2003, BTS found that 560,000 people with disabilities never leave home because of transportation difficulties, but by 2018, the number of non-travelers with disabilities in the U.S. had risen to 3,600,000.[12] [13] These mobility issues can manifest themselves in various ways, including complicating access to public transit systems and limiting usability of conventional automobiles. People with disabilities may simply be unable to afford a conventional automobile or the requisite modifications for use by a person with a disability. Still other people with disabilities are unable to obtain driver's licenses, which are still required to operate highly automated vehicles (see below). In America's car-centric cities and suburbs, those without a car are all but dependent on public transit, which can be inaccessible and unreliable for people with disabilities. Beyond major cities, public transit is scarce, if available at all.[14] [15] Additionally, this group of people may use public transit but be unable to travel to or from the transit stop and their destination.[16]

Ultimately, the limited mobility – both physical and geographic – impacts the health and economic well-being of people with disabilities and their families. For example, people with disabilities were found to compose roughly one-fifth of people living in poverty across several metrics for poverty[17] and were found to experience a lower quality of life across several measures.[18] Lack of accessible, affordable transportation options deprives people with disabilities of full inclusion in society and the economy. Moreover, unemployment, which is more common among the disability community, has negative impacts on mental health among people with disabilities.[19] People with disabilities who have mobility limitations may also be unable to attend needed doctor's appointments or pick-up essential medications, compounding their health problems.[20]

In sum, people with disabilities are more likely to experience unemployment and the accompanying socioeconomic and health problems due, in part, to their limited mobility. Given these obstacles, contemporary research has found that increasing access to transportation is crucial to advance well-being for people with disabilities.[21]

AVs have the potential to remedy these issues by providing people with disabilities an additional means of personal mobility. Over the course of a few decades, AVs have moved from the realm of science fiction onto the highways and byways of contemporary American cities.[22] Within the industry, AV capabilities are broken down taxonomically into five levels, reflecting the Society of Automotive Engineers (SAE) J3016 standard: 1) Cars requiring "Driver Assistance" on "steering, accelerating, or breaking tasks," including cars with "adaptive cruise control and lane keeping assist"; 2) Cars with "partial automation" on "steering and speed under certain conditions"; 3) Cars with "conditional Automation" in which the vehicle can monitor its own environment and a licensed driver is only required when the system notifies the driver; 4) Cars with "high Automation" on steering, pedal control, and most other driving tasks under certain environments without a human driver – and where notably human controls may be absent from the vehicle's design, and 5) "Full Automation" cars able to drive without a driver anytime and anywhere (again, potentially absent human controls).[23] Figure 1 shows how the responsibility of the driver changes across the various levels of AVs.[24] Note that for Levels 0-4, a human operator (either in-person or remote) may still be necessary for certain circumstances. Should this apply to a platform where the fallback is in-vehicle human controls, this technology may not be applicable to individuals without a driver's license, including those with disabilities.

Figure 1. Overview of levels of driving automation



Source: Synopsys (2022). Note: "Human override" can take the form of remote operators in SAE Levels 3-4.

AVs in SAE Levels 1 and 2 are already commercially available and have been deployed on roads around the world. Cars in Levels 3-5, those that require little or no human input, have undergone tens of millions of miles of road-testing as part of development initiatives spearheaded by technology and automobile companies.[22] [25] Level 3 and 4 AVs would also give some people with low vision or physical disabilities, including aging Americans, greater access to point-to-point mobility, and near complete freedom of movement within established geographies (known in the industry as operational design domains (ODDs), while Level 5 AVs would allow anyone to travel freely, regardless of the individual's ability to obtain a driver's license or the severity of their disability. It is generally-accepted that the level of automation available for personally-owned vehicles is SAE Levels 2-3. AV fleet operators are also developing Level 3-4 systems – likely initially to offer service in ridehailing and delivery services given the unit economics of this technology's cost today.

However, development of vehicles in these categories has been limited by a lack of statutory clarity and prohibitive costs.[26] A clear majority of AV industry

leaders and experts surveyed by McKinsey & Co. cited regulation as the primary barrier to AV adoption.[22] Thirty-eight states and the District of Columbia have passed legislation or had executive orders enacted that at least permit AV testing in certain forms,[27] but some of these states still lack legislation or associated regulation to enable commercial deployment of this technology.[28] Moreover, there are concerns among some disability advocates that future AVs will be inaccessible to many in the disability community just like many of the human-piloted vehicles that preceded them if appropriate designs and product features are not developed.[29] Several studies have also recorded lukewarm perceptions among people with disabilities toward use of autonomous vehicles or autonomous public transit.[30] [31] The promise of AVs is great, especially for people with disabilities. But this emergent technology requires legislative support to take root, and it should be designed with accessibility at the fore. AV developers must establish trust with the community of people with disabilities – some of whom are skeptical of this technology – and many of whom have historically negative experience with transit and travel.

While these AV-driven impacts for people with disabilities to the economy and workforce have been well anticipated, they have yet to be quantitatively predicted and forecasted. As of 2022, there is limited literature estimating the quantitative impacts of self-driving vehicles. Claypool et al. 2017 anticipated several billion dollars in health care savings and a decrease in the number of missed medical appointments, along with new employment for 2 million people with disabilities;[32] Harper et al. (2016) estimated an increase of nearly 300 billion Vehicle Miles Traveled (VMT) in an AV future, with most growth among the working age population aged 19-64.[33] However, there has yet to be a sector-by-sector analysis of employment impact caused by the introduction of AVs to the market.

For this analysis, where the goal is to examine the impacts on the entire disability population, we will specifically focus on Level 4 AVs, using remote operators for fallback conditions and Level 5 AVs, which could be used by anyone with any type of disability regardless of whether they hold a driver's license. We will work under the assumption that the fully autonomous AVs are also fully accessible to people with all types of disabilities, including those who use mobility devices like wheelchairs.

III. Economic Impact Analysis

This section outlines the methodology used to develop the economic impact analysis, the economic impact results or findings on the U.S. economy, and the fiscal impact associated with tax revenue generation and savings in SSI and SSDI expenditures by the federal government. The analysis is based on the estimated change in labor force participation by people with disabilities facilitated by an increase in mobility due to AV adoption. Three scenarios of labor force participation are estimated based on existing literature and current labor force characteristics of people with disabilities.

1. Methodology

The process for developing the economic impact scenarios began with understanding the number of individuals with disabilities who may be impacted by AV adoption, then identifying what industries they could be employed in based on current employment characteristics, remote work potential, and a net-income analysis. Scenarios in the future were also examined using wage growth data from the past 10 years and forecasting wage growth in each industry sector.

1.1 Baseline Employment Characteristics of Individuals with Disabilities

BLS collects data annually on the employment characteristics of people with disabilities. In 2021, as shown in Table 1, individuals with disabilities had a significantly lower workforce participation rate compared with individuals without

disabilities and nearly double the unemployment rate of individuals without disabilities.[3]

Table 1. Employment status of the civilian noninstitutional population 16 years and over by disability status, 2021 annual average

Employment Status	With Disabilities	Without Disabilities
Unemployment Rate, 16+	10.1%	5.1%
Labor Force Participation Rate, 16+	21%	67%
Unemployed #, 16+	669,000	7,954,000
Employed #, 16+	5,950,000	146,631,000
Not in Labor Force #, 16+	24,465,000	75,776,000

Source: Bureau of Labor Statistics (2022b).

Individuals with disabilities do not participate in the labor force at the same rate as individuals without disabilities, and the industry of employment also differs by disability status. The proportional industry employment between individuals with and without disabilities was examined using the American Community Survey data from 2020, shown in Table 2. Key differences appear to be in retail trade and public administration where people with disabilities are employed at a greater proportion, and in construction, educational services, health care, and social assistance fields where people with disabilities are employed at a lower proportion.

Table 2. Proportional disability and non-disability individual employment by industry

Industry	Disability Employment	Non-Disability Employment
Agriculture, forestry, fishing and hunting, and mining	2.8%	1.9%
Construction	6.6%	7.4%
Manufacturing	9.7%	9.6%
Wholesale trade	1.9%	2.3%
Retail trade	13.0%	10.5%
Transportation and warehousing, and utilities	6.2%	6.1%
Information	1.3%	1.8%
Finance and insurance, and real estate and rental and leasing	6.6%	7.0%
Professional, scientific, and management, and administrative and waste management services	12.3%	12.7%
Educational services, and health care and social assistance	20.7%	22.8%
Arts, entertainment, and recreation, and accommodation and food services	8.7%	8.3%
Other services (except public administration)	5.0%	4.7%
Public administration	5.3%	4.8%

Source: Bureau of Labor Statistics (2022b).

1.2 Existing Remote Work Adjustment

Several sectors have been able to implement remote work for their employees, which accelerated during the COVID-19 pandemic. Assuming longer-term prevalence of remote work availability for certain sectors, the introduction of AVs may not increase the employment potential as significantly for individuals with disabilities. Table 3 presents the proportion of employees who work remotely by industry.[34] The inverse of those proportions is characterized as the percentage of employees by industry who are required to at least work in a hybrid situation. The

use of AVs by individuals with disabilities would be impacted for those in-person positions – in this analysis, the distribution of increased labor force participation for in-person job requirements follows those proportions, in combination with overall disability employment by industry.

Table 3. Remote work potential by industry

Industry Sector	Percent of Jobs Fully Remote Capable	Percent of Jobs That Required In-Person
Natural resources and mining	2.1%	97.9%
Utilities	11.4%	88.6%
Construction	3.3%	96.7%
Manufacturing	4.9%	95.1%
Wholesale trade	14.6%	85.4%
Retail trade	3.7%	96.3%
Transportation and warehousing	6.0%	94.0%
Information	52.2%	47.8%
Financial activities	27.5%	72.5%
Professional and business services	30.8%	69.2%
Educational services	20.3%	79.7%
Health care and social assistance	7.4%	92.6%
Arts, entertainment, and recreation	6.6%	93.4%
Accommodation and food services	0.7%	99.3%
Other services	13.4%	76.6%

Source: Bureau of Labor Statistics (2022c).

1.3 Potential Impacts on Labor Force Participation from AV adoption

Due to the lack of literature establishing quantitative bounds for the impact that fully autonomous vehicles will have on labor force participation by individuals with disabilities, this analysis establishes three scenarios from which a range of economic impacts are generated, lower and maximum bound scenarios based on

literature regarding the impact of transportation as a barrier to employment, and a moderate scenario that is the mid-point of these two. The impact for the maximum case scenario is based on a range of estimates that are averaged together to result in a 20% increase in labor force participation.[7] [15] [11] The lower bound scenario is based on a conservative estimate from BLS for exclusive transportation impacts of 10%.[vii] The moderate scenario is set at 15% between the two bounds. As an aggregate, these estimates provide a range of impacts from the adoption of AVs from only 50% of individuals who report transportation as a primary barrier to employment entering the labor force to 100% of those individuals participating.

The estimates presented in this report are aggregated across disability categories to facilitate modeling on a national scale given a lack of available data for disability subpopulations within each category by state. The authors acknowledge that the impact of AVs on labor force participation is highly variable by disability category[35] as shown in Table 4.

Table 4. Transportation as a barrier to employment by disability group

Disability	Condition Prevents Working*	Lack of Reliable Transportation
Physical only	74.0%	25.6%
Sensory only	29.3%	36.4%
Psychiatric only	58.3%	30.0%
Multiple disabilities	69.1%	32.6%

Source: Anand & Sevak (2017). Note: All language in this table reflects that of the study to retain fidelity.
* Individuals may have trouble navigating the public transportation system or being independently mobile and attribute that to their own disability/condition without attributing the barrier to transportation specifically.

In addition, this analysis considers the impact of the transition to full-time employment where individuals could comfortably leave behind their benefits and have a net gain in annual income. Because certain industries' median wages are low (such as Accommodation and Food Services), individuals may not be able to work full-time, leave the benefit rolls, and have a net increase in their income. The

authors acknowledge that there are likely situations where part-time employment could be utilized to increase annual income; however, due to the complexity of modeling Supplemental Security Income (SSI), Social Security Disability Insurance (SSDI), Medicare, and Medicaid benefits as income increases, this analysis does not consider those strategic part-time employment options, and low wage industries are excluded from the analysis.

To examine the impacts over time from AV adoption, the analysis made several assumptions regarding the longitudinal characteristics of the labor force. Research by the Federal Reserve Bank of Atlanta found that individuals who switch jobs experience higher wage growth than individuals who stay in their jobs.[36] As a result, this analysis examined the impacts of 0,[i] 5, and 10 years of wage growth among the disability population resulting from AV adoption, while the labor force remains the same size over time.[ii] To determine the impacts on personal income, wages are inflated at 10-year average levels based on data from the Federal Reserve Bank of Atlanta from 2013 to 2022. The results of the 5-year and 10-year scenarios are shown in Appendix A.

1.4 Modeling Economic Impacts

This analysis utilizes IMPLAN, an economic impact model that estimates the impact of employment on the broader economy by mapping the outputs of labor, the spending on disposable income, and the upstream supply chain impacts necessary to support that labor by industry. IMPLAN generates three types of results: direct, indirect, and induced impacts:

[i] The Year 0 impacts refer to the first year in which the full AV adoption scenario is achieved at a national level. For example, if it was 2030 when 15% of individuals with disabilities who are currently not in the labor force participated, that would be Year 0, and 2035 and 2040 would be the 5-year and 10-year estimates, respectively.

[ii] This assumption is based on an equal number of new employable individuals with disabilities who are entering and exiting the labor force each year.

- *Direct impacts* are the jobs that are filled by individuals with disabilities as a result of the value their work generates, the wages they earn, and the taxes they pay on those wages.
- *Indirect impacts* are the upstream jobs and output that are necessary to support the direct jobs, such as the manufacturing jobs necessary to supply education supplies to teachers.
- *Induced impacts* are the downstream jobs and output supported by the direct jobs. These can be grocery store clerks whose job is supported by spending by individuals with disabilities.
- For both the indirect and induced categories, the individual's employment may consist of some contiguous individuals with disabilities, but it is not possible to determine how many additional disability jobs would be filled in those roles. As a result, this analysis will consider the direct impacts as the impacts to the disability community and categorize the indirect and induced impacts as those broader economic impacts but not specifically benefiting the disability community but the economy in general. Additional detail describing the IMPLAN model is provided in Appendix C.

2. Results - Economic Impacts of AV Adoption

The following section outlines the results of the economic impact analysis. Results are presented for the moderate scenario in Year 0 (the first year of impact), and additional scenarios and years are provided in the appendices. An overview of the economic impact to the U.S. is provided first, breaking out direct, indirect, and induced impacts, followed by the industry specific impacts. Federal government savings and revenue are presented with the economic impacts for tax revenue generated from the increased employment and then discussed later in regard to savings related to social security insurance and social security disability insurance

benefits that are not spent because of the increased income for individuals with disabilities who are employed under the various scenarios.

2.1 Findings

The estimated impacts from the adoption of AVs are presented in Table 5. Results are presented across direct, indirect, and induced impacts, and they show employment, GDP value added, output, income, and federal tax revenue. Impacts for the direct impact can be directly attributed to the disability community, while indirect and induced impacts would accrue to the general U.S. population and would include individuals with and without disabilities. Total employment in Year 0 under the moderate scenario, an increase in labor force participation by people with disabilities of 15%, is projected to result in 4.4 million direct jobs for people with disabilities and 9.2 million total jobs across the U.S. The U.S. GDP and output[iii] are projected to increase by $868 billion and $1.6 trillion, respectively. Direct income, those associated with the wages and earnings of people with disabilities, is projected to increase by $160 billion, while total income is projected to increase by almost $417 billion.

The direct, indirect, and induced impacts of AV adoption by individuals with disabilities represent a sizable increase in the U.S. economy. The projected increase in employment represents a 4.1% increase in U.S. employment, while GDP, output, and income in the U.S. increase by 3.8%, 5.7%, and 2.0%, respectively. AV adoption by individuals with disabilities is projected to increase federal tax revenue by 1.8%.

[iii] GDP represents the value added (output minus the intermediate inputs), whereas output is the final value of all products produced in the U.S.

Table 5. National economic impact of AV adoption (moderate scenario Year 0)

Economic Impact Category	Direct	Indirect	Induced	Total*	Estimated Percent of U.S. Total (2021)
Employment (Millions)	4.41	1.93	2.81	**9.15**	**4.1%**
GDP (Billions)	$348.05	$242.22	$277.43	**$867.70**	**3.8%**
Output (Billions)	$639.67	$467.57	$495.74	**$1,602.99**	**5.7%**
Income (Billions)	$160.23	$117.27	$139.42	**$416.92**	**2.0%**
Federal Tax Revenue (Billions)	$36.41	$26.04	$30.51	**$92.96**	**1.8%**

Source: IMPLAN Group LLC, ICF (2022). *Total may not add up due to rounding.

Total federal tax revenue, associated with the increase in direct, indirect, and induced employment is projected to be almost $93 billion, or a 1.8% increase in total federal tax revenue. This equates to an average tax contribution of roughly $7,300 per newly employed individual. The amount of federal tax revenue generated by source is shown in Table 6. There are six major categories of federal tax revenue generated by the IMPLAN model: Personal Income Tax, Social Insurance Tax (both for employees and employers), Taxes on Production and Imports less Subsidies (TOPI) both for Excise Taxes and Custom Duty Taxes, and Other Proprietor Income (OPI) Corporate Profits Tax. These categories comprise most of the tax revenue generated by the IMPLAN model at a national level. The personal income tax, projected to be a cumulative $40.5 billion across direct, indirect, and induced employment, is the greatest revenue generator for the federal government under this scenario, followed by the social insurance tax paid by workers and employers. Together these three federal tax revenue sources comprise roughly 85% of projected total tax revenue. Detailed results from each labor force participation scenario are presented in Appendix A.

Table 6. Federal tax revenue sources (moderate scenario Year 0) – billions $s

Tax Revenue Source	Direct	Indirect	Induced	Total
Personal Income Tax	$15.76	$11.39	$13.39	$40.54
Social Insurance Tax – Employee	$8.25	$6.00	$7.08	$21.33
Social Insurance Tax – Employer	$6.82	$4.99	$5.93	$17.73
TOPI : Excise Tax	$0.841	$0.524	$0.647	$2.01
TOPI: Custom Duty	$0.681	$0.424	$0.525	$1.63
OPI: Corporate Profits Tax	$4.06	$2.72	$2.93	$9.70
Total	**$36.41**	**$26.04**	**$30.51**	**$92.96**

Source: IMPLAN Group LLC and ICF (2022).

Those same results can be disaggregated based on industry sector to better understand how impacts are distributed. Table 7 presents those results for the direct, indirect, and induced impacts with employment, value added, output, and income by each IMPLAN 2-digit industry category. These results reflect the underlying inputs, with a large proportion of impacts accruing to the Retail Trade, Health Care and Social Assistance, Manufacturing, and Finance and Insurance.

Table 7. National economic impact of AV adoption by industry (moderate scenario Year 0)

Industry	Employment	Value Added	Output	Income
Agriculture, Forestry, Fishing and Hunting	253,869	$14,489,205,278	$34,696,651,239	$5,138,824,060
Mining, Quarrying, and Oil and Gas Extraction	49,397	$10,254,478,151	$20,810,068,110	$2,965,637,757
Utilities	180,653	$51,393,936,587	$110,056,629,028	$13,917,414,279
Construction	410,557	$29,482,193,954	$52,952,037,520	$16,313,539,872
Manufacturing	754,701	$80,235,428,640	$257,720,768,842	$40,451,693,170
Wholesale Trade	253,167	$40,730,563,663	$68,785,101,443	$18,468,768,968
Retail Trade	1,036,980	$51,289,318,656	$84,480,336,018	$28,328,307,515
Transportation and Warehousing	455,898	$31,302,416,981	$56,937,425,441	$17,893,712,293

Information	119,348	$31,975,146,496	$60,429,770,702	$11,936,796,398
Finance and Insurance	621,458	$86,257,307,648	$167,897,906,844	$43,864,762,370
Real Estate and Rental and Leasing	421,023	$152,342,307,087	$227,418,615,804	$10,168,025,826
Professional, Scientific, and Technical Services	545,432	$60,739,229,789	$92,906,756,776	$40,672,560,326
Management of Companies and Enterprises	244,764	$25,368,226,059	$40,390,271,344	$22,167,331,617
Administrative Support & Waste Management and Remediation Services	450,557	$24,280,925,871	$41,051,940,919	$17,904,649,346
Educational Services	504,834	$24,684,132,697	$34,876,806,213	$20,028,963,188
Health Care and Social Assistance	990,239	$58,814,713,872	$94,642,068,325	$47,546,605,478
Arts, Entertainment, and Recreation	355,400	$19,983,170,638	$31,638,799,337	$9,469,312,263
Accommodation and Food Services	682,730	$27,910,305,291	$47,526,907,490	$16,446,121,430
Other Services	556,035	$26,971,478,775	$44,534,514,949	$17,993,997,495
Government Enterprises	174,924	$14,390,312,765	$28,424,811,157	$11,456,617,963
Administrative Government	92,900	$4,809,932,560	$4,809,932,560	$3,788,443,246

Source: IMPLAN Group LLC and ICF (2022).

While the IMPLAN model used aggregated impacts at the national level, the authors estimated impacts at the state level by distributing national impacts based

on disability population and industrial employment by state. See Appendix B for the supplemental table of employment and output by state.

IMPLAN also estimates the tax revenue generated by each impact in a given industry. Table 8 presents those estimates for each of the input industries. These federal tax revenue estimates for each industry include the indirect and induced tax revenue impacts resulting from the original direct input. For example, federal revenue generated by indirect activity from manufacturing companies which create farm equipment that is used in the Agriculture, Forestry, Fishing and Hunting sector would be categorized as within the Agriculture, Forestry, Fishing and Hunting sector. Taxes that are included within the federal estimates are: Corporate Profits Taxes, Personal Income Tax, Social Insurance Tax (both Individual and Employer contributions), as well as Taxes on Production and Imports.

Table 8. Federal Tax Revenue of AV adoption by industry impact (moderate scenario Year 0)

Industry	Federal Tax Revenue
Agriculture, Forestry, Fishing and Hunting	$4,340,994,895
Mining, Quarrying, and Oil and Gas Extraction	$1,398,924,677
Utilities	$19,417,017,065
Construction	$12,135,251,724
Manufacturing	$26,785,551,649
Wholesale Trade	$4,613,851,768
Retail Trade	$17,805,113,458
Transportation and Warehousing	$5,080,896,709
Information	$2,510,581,088
Finance and Insurance	$13,655,657,979
Real Estate and Rental and Leasing	$24,167,599,256
Professional, Scientific, and Technical Services	$6,344,767,255
Management of Companies and Enterprises	$5,433,150,207
Educational Services	$10,045,697,824
Health Care and Social Assistance	$12,854,653,612
Arts, Entertainment, and Recreation	$7,012,529,145
Other Services	$6,263,958,228
Government Enterprises	$2,328,533,611
Administrative Government	$1,613,754,149

Source: IMPLAN Group LLC and ICF (2022).

3. Federal Savings from AV Adoption

The benefits to the federal government extend beyond the tax revenue generated from the direct, indirect, and induced jobs, also including the reduced spending on SSI and SSDI benefits. In FY2021, the Social Security Administration's budget for SSI and SSDI was $206.3 billion,[37] which following the increase in individuals with disabilities who are employed across the three scenarios of 9.0%, 13.5%, and 18.0%, respectively, translates to a reduction in federal spending of $18.5 billion for the low employment scenario, $27.8 billion for the moderate employment scenario, and $37.1 billion for the maximum employment scenario (Table 9). In combination with the federal tax revenue, the increase in federal net revenue/savings (tax revenue + savings in SSI and SSDI) is estimated to be approximately $80.5 billion, $120.7 billion, and $161.5 billion under the low, moderate, and maximum employment scenarios, respectively (Table 9). For reference, the Department of Homeland Security has a budget of $80 billion, while $161.5 billion is about 1.5 times greater than the entire budget of the Department of Transportation.[38]

Table 9. Federal savings from AV adoption – billions $s

Savings Type	Low	Moderate	Maximum
Reduction in federal spending	$18.5	$27.8	$37.1
Increase in federal net revenue/savings	$80.5	$120.7	$161.5

Source: IMPLAN Group LLC and ICF (2022).

IV. Qualitative Analysis

Alongside the robust macroeconomic analysis conducted by ICF, the National Disability Institute (NDI) also conducted three sets of semi-structured interviews to build additional context and qualitative understanding of the challenges faced by the disability community around transportation, as well as what value accessible AV mobility could provide.

1. Research Topics

The analysis was structured with one set of 10 interviewees to answer each of the three proposed research questions, for a total of 30 interviews. The research questions were as follows:

1. What are some of the most promising economic/employment impacts and use cases of AVs for people with disabilities?
2. What are some of the most promising public health impacts and use cases of AVs for people with disabilities?
3. What are some of the most promising use cases of AVs for small business owners and entrepreneurs with disabilities?

For these research questions, the interviewer focused on AVs that would be fully autonomous (assumed to be Level 4 with a remote operator and Level 5), fully accessible to all people with disabilities, more affordable than today's rideshare services, electric, and on-demand (app-based requests, which would be accessible to those using assistive technology).

2. Methodology

Interviewees included people living with a range of disabilities, policy makers, disability advocates, disability employment program directors, researchers, futurists, and small business owners and entrepreneurs with disabilities from NDI's Community Navigator project with the U.S. Small Business Administration (SBA). Capitalizing on its longstanding relationships within the disability community, NDI used a snowballing sampling method – beginning with a small set of experts from its network and a few identified in the research literature, who then recommended other experts to interview. These interviews provided an authentic disability voice and vital first-person anecdotal insights to the broader questions posed by the research. In order to address a particular gap in knowledge and research around

the impact of AVs on small business owners and entrepreneurs with disabilities, NDI allotted one-third (10) of all interviews to this group.

NDI also explicitly sought out interviews with leadership of premier national disability organizations, including those dedicated to serving blind and low-vision professionals, students who are Deaf and hard-of-hearing, community members and employees who have intellectual and developmental disabilities, and professionals and travelers who use wheelchairs or other mobility devices.[iv]

An experienced interviewer from NDI who has worked in the disability advocacy space for nearly 10 years conducted all interviews using an interview guide developed by the research team to direct all interviews. For the interview guide and additional participation parameters, see Appendix D. At the end of each interview, the interviewer asked a series of demographic questions that were posed as optional. Of the 30 interviewees, two chose not to answer. The research team drafted these questions after reviewing both external demographic question sets, including health and population surveys from the Centers for Disease Control and Prevention (CDC) and the U.S. Census Bureau, and internal best practices from NDI's Diversity, Equity, Inclusion, and Accessibility (DEIA) curriculum. These demographic questions are listed in Appendix D at the end of the interview guide.

3. Qualitative Analysis Results

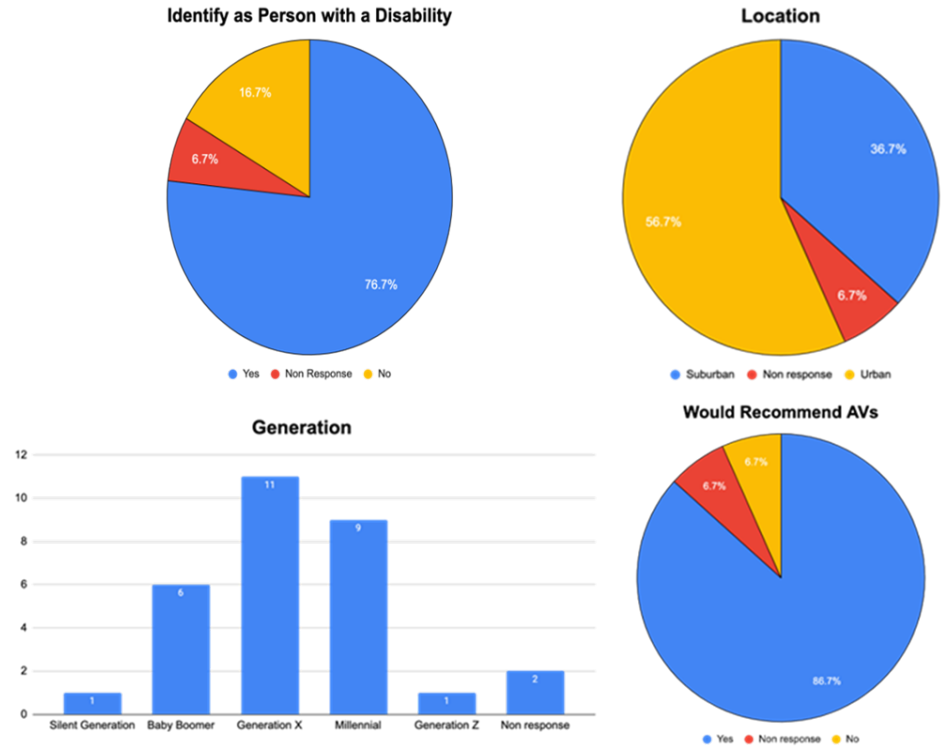
As recommended by the literature, including a recent paper published by Disability Rights Education and Defense Fund,[39] NDI succeeded in reaching a diverse group of interviewees, with a variety of valuable findings and quotes across the disability spectrum and various stakeholders.

[iv] NDI compensated individuals with disabilities for their interviews, but given public employees' ethics considerations, NDI avoided offering compensation to public employees or people in leadership positions at large organizations that receive public funding.

3.1 Demographic Findings

The majority of interviewees identified as having a disability (23 of 30 or about 77%). Those who did not identify as having a disability worked in the disability space and/or had close family members with disabilities. Demographic findings are presented in Figure 2.

Figure 2. Snapshot of participants by "identify as a person with a disability," location, generation, and would recommend AVs to friends/family.



Additionally, there were slightly more interviewees who identified as "woman" (15) than "man" (12), with one identifying as "other." Three of the interviewees identified as LGBTQIA+, which is on par with national representation per the latest Gallup Poll.[40] There were more interviewees who identified as "Black, Indigenous, Latino, Asian, mixed race, or other person of color" (18) than not (10); this may be because NDI researchers emailed interview invitations to NDI's SBA project network, which focuses explicitly on collecting voices from a diverse and intersectional group of small business owners and entrepreneurs with disabilities.

A limitation to these findings is that no participants identified as living in a rural area. This is important to note since individuals with disabilities in rural areas stand to gain as much, if not more, from the use of AVs than their peers in suburban and urban areas who likely have greater access to public transportation and other transportation resources. For further details on participants' characteristics, see Appendix E.

3.2 Existing and AV Future Mobility Findings

Most interviewees reported a high reliance on rides from family or friends, public transportation, living within "walking distance" of important places, rideshare services like Uber and Lyft, traditional taxis, and paratransit. Very few interviewees had a license and/or owned an adaptive vehicle that they could drive independently. Though grateful for existing transportation options, each interviewee discussed at length the limitations of each. Interviewees were excited by the potential time and money savings gained from using AVs when compared to interviewees' current transportation options. The response to AVs was overwhelmingly positive, with 87% of interviewees saying they would recommend AVs to friends, family members, or colleagues if they became available in their hometown tomorrow. Though they admitted they might need a few rides before having full trust in the technology, all interviewees asked when they could try out AVs themselves – a few initially argued with the interviewer because they could not believe AVs were already in full operation in some cities. Upon hearing this, three interviewees said they would plan a trip just to try out an AV themselves, while several other interviewees asked which government officials they should talk to in order to bring on-demand and fully accessible AVs to the places they live, as well.

Five specific themes emerged from the interviews. Interviewees overwhelmingly believed AVs would offer them an increase in 1) employment opportunities, 2) entrepreneurship and small business success, 3) personal safety,

4) independence, and 5) health access. Notable quotes and takeaways from respondents on each of these themes are presented below:

1. Employment opportunities: Interviewees who employed people with disabilities explained that transportation was a main limiting factor to their programs' current success, as well as future growth and hiring possibilities. One interviewee who employs people in the Intellectual & Developmental Disabilities (IDD) community told NDI, "Transportation has been an absolute nightmare for this employment program. I feel like I've been able to overcome every other challenge in this space except this one." His program has cycled through several different transportation options, including taxis, rideshare services, and friends and family carpooling, but each has presented logistical challenges, especially with pandemic considerations in 2020. Similarly, an interviewee who employs people who are blind and low-vision explained, "Transportation is a huge issue for people who are blind. Having access to something like [AVs] would open up the opportunities for them to be able to do different kinds of work. I can say unequivocally that it would open up more career opportunities for people who are blind." Other interviewees explained how requiring a job near accessible public transportation restricted their job searches not only to certain companies and roles but also to certain cities, barring them from accepting otherwise favorable job offers.

2. Entrepreneurship and small business success: Based on NDI's previous research, many people with disabilities choose small business ownership and entrepreneurialism due to the added flexibility when compared to traditional employment options.[41] That said, the interviewees in this group described limited transportation as a key barrier to developing their small businesses. Several interviewees explained that they relied on moving their wares primarily in rolling bags, which proved challenging when their disabilities changed or grew more

severe. One of these entrepreneurs, a person with multiple disabilities, said, "I was doing pop-ups as a vendor at weekend events, and then I had a heart attack. I had all of my stuff in a rolling bag. It was too much strain to take this stuff up the hill, so I couldn't do it anymore. [An AV] would have come in very handy." Many entrepreneurs explained that they rely on friends and family for rides or use rideshare services, the latter of which can become very expensive. In describing her experience, another entrepreneur with multiple disabilities said, "[An AV] would definitely give me a sense of freedom. I love my boyfriend, but I don't like to depend on people. If I don't have support getting [to pop-ups], it's hard. It would be great to not have to spend money on Uber because I do have to do that on days that my boyfriend has other things going on. Then, there are times where I don't even make a profit because Uber eats it all up." Beyond transporting themselves, their wares, and their staff members, interviewees also noted the value in AVs delivering their products directly to customers.

3. Personal safety: The majority of interviewees agreed that AVs were safer than their alternative. One interviewee who uses a wheelchair and receives rides from his children noted, "I mean, it's going to take some time to get used to the idea, but I think I find them safer than a regular driver. With me having four kids, I can tell you that they are definitely safer." Beyond road safety, several interviewees with personal or professional relationships to the IDD community expressed the idea that the lack of a driver might mean added personal safety for vulnerable riders. Perhaps the most commonly cited benefit to an AV in terms of safety is the car's lack of discrimination. Interviewees brought up concerns with rideshare services and taxis denying them passage due to racial/ethnic discrimination, service animal use, and subjectively destination. An interviewee who was blind explained one such experience, saying, "After a work event, I walked over to my Uber ride and told him I was going to Baltimore, and the driver refused. Now, I was standing there in not the

greatest area suddenly alone in the dark, and it was chilly. I had to call two more Ubers before one agreed to take me. I think people forget about the safety element of being stranded. The AVs are going to be a lot more reliable, especially in these sort of late night, early morning situations where safety can be paramount."

4. Independence: One of the interviewees' biggest complaints about existing transportation options is that they do not instill in people with disabilities a feeling of independence; interviewees explained they always felt like they were running on someone else's schedule – be it a transit official, a family member, or a friend. One interviewee who is blind and a wheelchair user was eager for an AV future, saying, "Aside from giving us all more independence, increasing our quality of life, increasing the amount of change we've got at the end of the day because it costs less and lets us have more opportunities, just the concept of being able to independently do anything is huge. It's certainly an ego-boost." This interviewee offered a litany of places they would go in an AV, including work events, social events, and natural places like the beach. Interviewees highlighted that an AV would free them from the limitations of other people's schedules and from the incredible energy-drain involved in intensively planning every trip they take.

5. Health access: The disability population inherently has a complex relationship with health access and medicine. When asked about health access, one interviewee who is blind explained her most recent medical experience, "I just got a new kidney. I'm out on medical leave, but my husband isn't. Being able to go to appointments by myself would ease a lot of strain on our schedule. Right now, we're on a once every two weeks [schedule]. I can only imagine what cancer patients have to go through to meet their chemo treatments or physical therapy. So for us, for people with disabilities, it would be a Godsend to have that [AV], you know, where I could go on my own." Currently, the vast majority of interviewees described going to doctor's

appointments with family or friends or occasionally relying on public transportation in dire situations.

V. Other Impacts of AV Adoption

In addition to the direct economic impact results in Section 3, there is robust literature on the additional impacts AVs could generate for individuals with disabilities. These include increased educational attainment through increased mobility, increased access to health care and reduction in health costs because of fewer missed appointments, and an increased ability for small businesses to succeed from both a patronage and ownership perspective.

1. Additional AV Adoption Economic Impacts

In addition to the direct employment benefits, individuals with disabilities stand to gain educational opportunities in an AV future.[42] In a 2021 comparative BLS labor force analysis, while 40.1% of individuals without any disability held bachelor's degrees or higher, only 20.8% of individuals with disabilities had attained that level of education.[3] The BLS analysis also revealed that people with disabilities who have higher education levels have a higher labor force participation, as well. Adoption of AVs could increase access to education through increased mobility access, which would provide even more lifetime earning potential and quality of life. While this analysis does not directly consider the impacts of increased education and associated economic output and employment for the disability community, the authors acknowledge that those benefits would create additional economic activity and allow individuals with disabilities to be gainfully employed in higher income positions.

2. Potential Health Impacts from AV Adoption

Alongside the estimated economic impacts from the adoption and utilization of AVs by individuals with disabilities, there are potential benefits to physical and mental health because of increased mobility options. In a meta-analysis of transportation

barrier impacts on physical health, over 50% of respondents reported transportation barriers as the reason for missed clinical appointments.[20] Furthermore, research on physiotherapy patients (including those with disabilities) found that missed appointments bear high costs for both the patient and provider.[43] In addition to sunk costs, missed appointments slow recovery time and have a cascading impact on health care system capacity.

Less available transportation can also reduce access to medications and pharmacies, with one study finding patients with disabilities 45%- 65% less likely to miss doses of medication if transportation barriers were addressed.[20] Irregular or infrequent adherence to prescription schedules may also worsen existing health issues or mobility limitations, reinforcing cycles of illness, immobility, and socio-economic exclusion.

Research also has identified the lower income levels of individuals with disabilities as an additive challenge to both transportation access and agency over medication purchases, clinical visits, quality of life, and discretionary expenses[9 17]– all of which impacts the physical and mental health of people with disabilities. Given the projected income increase for people with disabilities following the adoption of AVs (Table 5), one might also expect a higher quality of life for people with disabilities overall from greater access to health care options and insurance protections.

AV enabled movement also promises to decrease social isolation experienced by some people with disabilities and improve mental well-being.[32 19] Decades of research have identified a positive relationship between unemployment and depression, both in the general population and among people with disabilities,[44] with decreasing unemployment being tied to decreased depression. In moderate scenario Year 0, the expected gain of more than 4 million jobs for

people with disabilities could have a measurable impact on the prevalence or severity of depressive symptoms for the disability population.

In sum, AV adoption stands to improve the health of people with disabilities across a number of categories – access to medicine and healthcare, quality of life, and mental wellbeing. All of this reduces health care costs in the long run and improves the wellness of entire communities.[32] [21] Since a large proportion of heath care costs is borne by the federal government through Medicare and Medicaid expenditures, savings in health care costs among people with disabilities would be realized by federal authorities, as well as individuals, in addition to SSI and SSDI savings.

3. Potential Impacts to Small Businesses from AV Adoption

While there is limited specific research on small business owners with disabilities and the challenges they face related to mobility and transportation, it is a growing area of interest for both policymakers and academics. Heuristically, observed difficulty with travel and public transit for people with disabilities comports to the challenges faced by disability-owned business enterprises (DOBEs) – including reliance on public transit.[13] [15] Like other entrepreneurs, DOBEs need access to storefronts, warehouses, production lines, and other places of operation beyond the home. AVs could help provide that needed access to mobility (for both entrepreneurs and goods shipment). For example, new businesses of a certain sector often emerge in one clustered area – like Silicon Valley – which, according to Stuart and Sorensen (2003), indicates the value of geographic access to a network of employees and like-minded entrepreneurs to the success of new ventures.[45] However, given the transit challenges faced by people with disabilities, even entrepreneurs with disabilities living in small business hubs may miss out on the important networking opportunities associated with geographic closeness that

were observed, while AV access could open the door to a wider network of fellow entrepreneurs and investors.

Moreover, small and growing businesses (DOBEs and non-DOBEs alike) need to hire the best talent available. However, these employees must also be capable of traveling to the workplace. Adoption of Level 4 AVs with remote operators and Level 5 AVs would open a wider pool of potential employees from which small businesses owners may hire.[32] Increased access to education in an AV future may result in a more skilled workforce overall. As shown by the diversity of industries in which individuals with disabilities work (Table 2), the mobility impacts on employment will touch every sector of the economy. Finally, small businesses with storefronts may incidentally benefit from increased patronage by customers with mobility limitations in an AV future – particularly sectors like Retail Trade that are also poised to see high increases in employment.[33]

VI. Policy Implications and Considerations

This report estimated economic impacts of AV adoption for people with disabilities on the basis that existing transportation barriers are a leading factor in low workforce participation rates among the disability population of the U.S. Bolstered by additional qualitative research with people with disabilities themselves, an AV future seems to hold promise for this population's economic/employment opportunities, public health, and small business and entrepreneurial development. The estimates presented in this report broadly represent the impacts of individuals with disabilities joining the labor force, with the primary driver presented being the adoption of AVs. Even in a moderate scenario with adoption of Level 4 AVs with remote operators and Level 5 AVs, people with disabilities stand to gain employment opportunities and raise their socio-economic status. As AVs continue to evolve into different varieties, including on-demand and electric, these impacts are likely just the starting point. That said, reaching this level of AV adoption would

certainly be aided by legislative support[46] at the national and state level to permit testing and deployment, as well as to provide a ramp for achieving commercial scale – a major federal barrier for AVs without human controls.

There were several policy developments in 2022, such as the creation of the bipartisan Congressional Autonomous Vehicle Caucus,[47] [48] some state-specific driverless deployment permits,[49] and sessions specifically dedicated to AVs and people with disabilities at the fall 2022 National Highway Traffic Safety Administration (NHTSA) Safety Research Portfolio Public Meeting. However, there is still more that can be done in this realm. From the researchers' initial findings, it seems that lifting the federal cap on the number of exempted AVs that can be manufactured would be one efficient way to allow the industry to scale and get people with disabilities and the country as a whole on the road to achieving the economic and employment, public health, and small business benefits discovered by this report.

VII. Appendix A: Intertemporal Scenario Results

Appendix A Table 1 shows the economic impact results by year and scenario. Results are divided between the year, the labor force participation scenario, and the impact type (direct or indirect/induced). Direct employment increases for the three scenarios are 2.2 million for the low scenario, 4.4 million for the moderate scenario, and 9.8 million for the maximum scenario. For contextual reference, the three scenarios (low, moderate, and maximum) represent a direct increase in national employment of 1.1%, 2.3%, and 5.0%, respectively. Output and tax revenue are significant, ranging for output from $319 billion to $639 billion and $24 billion to $73 billion for tax revenue. In the context of national output and tax revenue, these values are consistent with the employment estimates ranging across the three scenarios from national increases of 1.5%, 2.3%, and 3.0% for output and 0.5%, 0.75%, and 1.0% for federal tax revenue. The indirect and induced impacts are similarly sized with direct employment estimates for the three scenarios and are 2.3 million, 3.5 million, and 4.7 million for the low, moderate, and maximum scenarios respectively. These correspond to roughly 1.2%, 1.8%, and 2.4% increases in national employment. Output for indirect and induced impacts are $481 billion, $722 billion, and $963 billion for the three scenarios, respectively. These represent approximately 2.3%, 3.4%, and 4.6% increases in national output. The federal tax revenue for the three scenarios is $37 billion, $56 billion, and $75 billion, which correspond to 0.8%, 1.1%, and 1.5% increases in federal tax revenue, respectively.

Comparing those estimates to the Year 5 and Year 10 estimates, the magnitudes are similar across the years however output, and federal taxes increase for direct impacts due to the wage growth of individuals over time. For the indirect and induced impacts, growth is larger due to the increased spending power of the direct jobs, and the national proportions reflect that with Year 10 output being $675

billion, $1.0 trillion, and $1.4 trillion across the three scenarios, which translates to 3.2%, 4.8% and 7.0% increases, respectively.

Across both direct, indirect, and induced impacts the magnitude of the impact of autonomous vehicle adoption by individuals with disabilities is a sizeable increase in the U.S. economy with estimates for the Year 0 impacts on employment being 2.3%, 4.1%, and 7.5% increase in national employment. Output and federal taxes are a similar story with increases to the national figures by 3.8%, 5.7%, and 7.6%, respectively for outputs and 1.2%, 1.8%, and 2.5% for federal tax revenue.

Appendix A Table 1: National Economic Impact of AV Adoption by Year and Scenario

Year	Scenario	Impact Type	Employment	Output	Federal Taxes
0	Low	Direct	2,209,913	$319,836,356,602	$24,271,899,422
0	Moderate	Direct	4,418,838	$479,754,534,903	$36,407,849,134
0	Maximum	Direct	9,842,986	$639,672,713,205	$48,543,798,845
0	Low	Indirect/ Induced	2,368,020	$481,657,703,432	$37,701,186,077
0	Moderate	Indirect/ Induced	3,552,030	$722,486,555,148	$56,551,779,116
0	Maximum	Indirect/ Induced	4,736,041	$963,315,406,864	$75,402,372,154
5	Low	Direct	2,209,913	$378,880,130,264	$28,661,566,506
5	Moderate	Direct	4,418,838	$568,320,195,396	$42,992,349,759
5	Maximum	Direct	9,842,986	$969,201,080,558	$67,700,898,640
5	Low	Indirect/ Induced	2,802,092	$570,186,826,895	$44,625,488,588
5	Moderate	Indirect/ Induced	4,203,139	$855,280,240,343	$66,938,232,883

5	Maximum	Indirect/ Induced	6,632,302	$1,350,136,839,520	$105,665,998,523
10	Low	Direct	2,209,913	$448,875,481,836	$33,850,449,320
10	Moderate	Direct	4,419,836	$673,313,222,754	$50,775,673,980
10	Maximum	Direct	9,842,986	$897,750,963,672	$73,551,210,367
10	Low	Indirect/ Induced	3,316,151	$675,068,419,760	$52,827,999,262
10	Moderate	Indirect/ Induced	4,974,226	$1,012,602,629,640	$79,241,998,892
10	Maximum	Indirect/ Induced	7,175,819	$1,459,568,798,205	$114,246,018,410

Source: IMPLAN Group LLC (2022).

VIII. Appendix B: State Specific Results – Year 0 Moderate Impacts

State	Employment	Value Added	Output	Employee Income
Alabama	123,605	$11,715,321,896	$21,642,756,044	$5,629,076,635
Alaska	19,954	$1,891,268,151	$3,493,907,855	$908,732,466
Arizona	187,666	$17,787,106,124	$32,859,703,046	$8,546,498,711
Arkansas	76,437	$7,244,706,338	$13,383,790,328	$3,480,997,580
California	1,087,811	$103,103,389,773	$190,472,061,464	$49,539,985,968
Colorado	171,399	$16,245,272,721	$30,011,337,077	$7,805,665,599
Connecticut	105,501	$9,999,447,580	$18,472,868,818	$4,804,618,877
Delaware	26,644	$2,525,313,384	$4,665,236,003	$1,213,383,865

District of Columbia	22,289	$2,112,589,525	$3,902,774,514	$1,015,074,826
Florida	564,955	$53,546,723,825	$98,921,625,119	$25,728,581,308
Georgia	286,547	$27,159,057,715	$50,173,342,717	$13,049,613,025
Hawaii	39,327	$3,727,397,852	$6,885,953,549	$1,790,971,545
Idaho	47,688	$4,519,939,207	$8,350,085,679	$2,171,778,497
Illinois	364,088	$34,508,463,602	$63,750,553,835	$16,580,917,528
Indiana	187,752	$17,795,212,608	$32,874,678,875	$8,550,393,783
Iowa	93,972	$8,906,712,293	$16,454,161,741	$4,279,572,214
Kansas	84,238	$7,984,163,475	$14,749,855,262	$3,836,298,180
Kentucky	116,300	$11,023,018,211	$20,363,801,877	$5,296,432,723
Louisiana	117,990	$11,183,170,972	$20,659,666,315	$5,373,384,272
Maine	39,398	$3,734,212,158	$6,898,542,223	$1,794,245,740
Maryland	179,417	$17,005,205,910	$31,415,229,241	$8,170,804,704
Massachusetts	210,957	$19,994,670,731	$36,937,933,475	$9,607,207,965
Michigan	271,771	$25,758,651,536	$47,586,247,837	$12,376,734,058
Minnesota	172,678	$16,366,555,222	$30,235,393,027	$7,863,940,437
Mississippi	72,460	$6,867,810,047	$12,687,516,290	$3,299,903,273
Missouri	171,163	$16,222,891,536	$29,969,990,323	$7,794,911,698

Montana	30,317	$2,873,422,821	$5,308,329,525	$1,380,646,422
Nebraska	58,322	$5,527,777,295	$10,211,954,612	$2,656,033,039
Nevada	83,106	$7,876,807,781	$14,551,527,541	$3,784,715,011
New Hampshire	42,599	$4,037,548,180	$7,458,921,833	$1,939,995,189
New Jersey	258,312	$24,482,951,578	$45,229,533,849	$11,763,774,986
New Mexico	51,829	$4,912,380,289	$9,075,076,992	$2,360,341,897
New York	550,513	$52,177,937,352	$96,392,944,134	$25,070,895,244
North Carolina	281,969	$26,725,184,106	$49,371,809,412	$12,841,141,775
North Dakota	23,422	$2,219,956,263	$4,101,122,637	$1,066,663,301
Ohio	326,977	$30,991,044,674	$57,252,513,025	$14,890,838,426
Oklahoma	103,791	$9,837,411,773	$18,173,525,662	$4,726,762,547
Oregon	117,589	$11,145,178,730	$20,589,479,868	$5,355,129,440
Pennsylvania	362,131	$34,323,025,017	$63,407,976,643	$16,491,816,433
Rhode Island	31,257	$2,962,588,624	$5,473,053,444	$1,423,489,559
South Carolina	134,882	$12,784,151,889	$23,617,300,748	$6,142,637,081
South Dakota	26,107	$2,474,449,061	$4,571,269,817	$1,188,944,147
Tennessee	183,785	$17,419,227,468	$32,180,088,087	$8,369,737,273
Texas	785,668	$74,466,025,217	$137,567,711,046	$35,780,063,609

Utah	89,693	$8,501,134,069	$15,704,901,017	$4,084,696,569
Vermont	19,153	$1,815,333,366	$3,353,626,775	$872,246,681
Virginia	243,813	$23,108,698,198	$42,690,753,361	$11,103,462,136
Washington	213,593	$20,244,480,765	$37,399,429,767	$9,727,238,796
West Virginia	43,384	$4,111,958,857	$7,596,387,294	$1,975,748,659
Wisconsin	174,096	$16,500,947,255	$30,483,667,381	$7,928,514,254
Wyoming	16,750	$1,587,534,536	$2,932,793,736	$762,791,978
Puerto Rico	59,815	$5,669,303,918	$10,473,409,328	$2,724,034,943

Source: IMPLAN Group LLC (2022).

IX. Appendix C: IMPLAN Background and Limitations

1. IMPLAN Background

ICF utilized the IMPLAN model (version 6.6)[v] to assess the direct, indirect, and induced economic impacts of the increased adoption of autonomous vehicles on disability populations. Using IMPLAN enables ICF to model the economic impact through the inclusion of employment growth resulting from fewer hurdles to labor force participation and employment. Results are presented in terms of income generation, job creation, tax revenue, and gross domestic product, consistent with best practices for economic impact analysis. ICF discusses results at the national level due to availability of data.

The IMPLAN model, created and maintained by the Minnesota IMPLAN Group, is the economic impact modeling system that can be used to measure the

[v] IMPLAN Group LLC. (2022). IMPLAN® model, 2022 Data, using inputs provided by the user. IMPLAN System (data and software). 16905 Northcross Dr., Suite 120, Huntersville, NC 28078. www.IMPLAN.com.

macroeconomic impacts of changes to a local economy. IMPLAN is widely used and recognized in the field of economic impact analysis. Because of IMPLAN's wide use, the result of this analysis can be easily compared to other studies across the county. Although IMPLAN is a static model, it is possible to estimate long-term impacts by aggregating years; however, this does introduce uncertainties around long-term results. For the purpose of this analysis, a single static year is estimated, and results are presented as per year estimates.

The modeling framework in IMPLAN consists of two components – the descriptive model and the predictive model. The descriptive model defines the economy in the specified modeling region (for this project, the United States of America) and includes accounting tables that trace the "flow of dollars from purchasers to producers within the region."[vi] It also includes the trade flows that describe the movement of goods and services, both within and outside of the modeling region (i.e. regional exports and imports with the outside world). In addition, it includes the Social Accounting Matrices (SAM) that trace the flow of money between institutions, such as transfer payments from governments to businesses and households, as well as taxes paid by households and businesses to governments. The predictive model consists of a set of "local-level multipliers" that can then be used to analyze the changes in final demand and their ripple effects throughout the local economy. These multipliers are thus coefficients that "describe the response of the [local] economy to a stimulus (a change in demand or production)."[vii] Three types of multipliers are used in IMPLAN:

- **Direct Effect** – represents the impacts generated from spending that results in final demand changes, such as employee income resulting from the ability to participate in the labor force.

[vi] IMPLAN PRO User Guide.
[vii] *Ibid.*

- **Indirect Effect** – represents the impact generated in secondary industries due to spending in the direct industries. For example, the jobs supported by the entrepreneurial individuals with disabilities hiring employees.

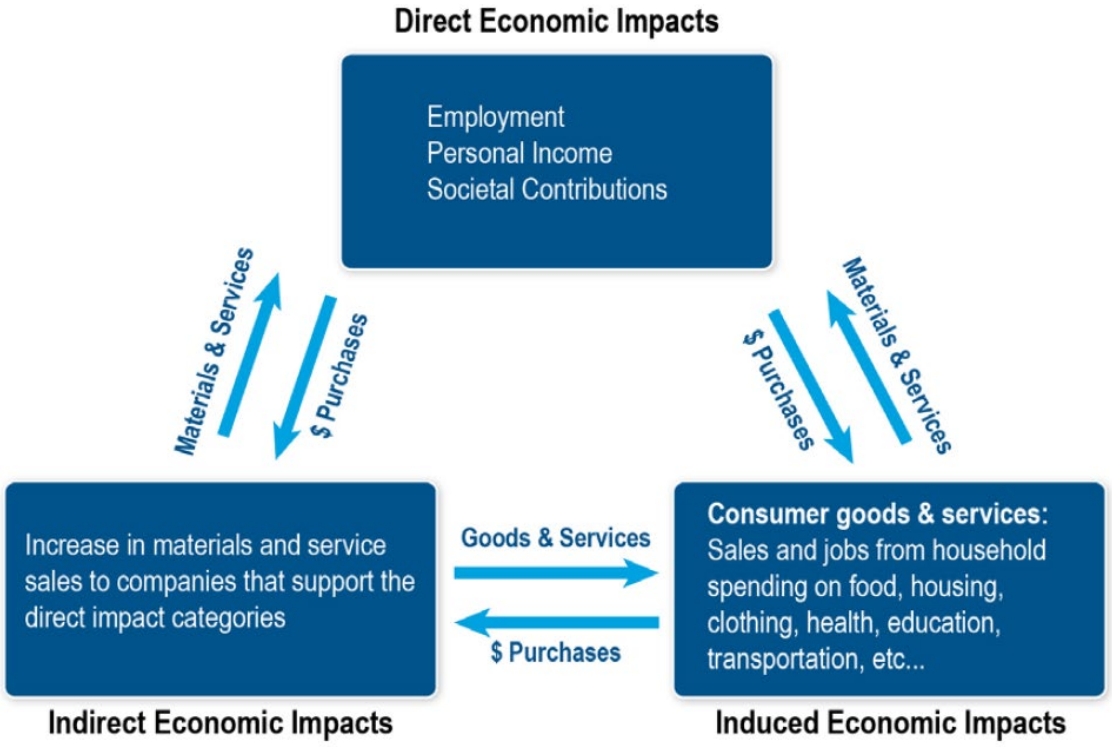
- **Induced Effect** – represents the impact created in all local industries due to expenditures arising from the new household incomes generated by the direct and indirect effects. For example, all the grocery store workers whose jobs are supported by the purchases of workers in the direct and indirect categories.

IMPLAN provides detailed industry information for 546 sectors roughly aligned with 4-digit NAICS (North American Industry Classification System) industry codes. This level of detail allows the analysis to be tailored in terms of allowing for granular industries to be included as inputs (which drive the multipliers).[viii]

Appendix C Exhibit 1 depicts the conceptual relationship between direct, indirect, and induced impacts in the IMPLAN model and shows the flow of dollars between direct expenditures and broader macro-economic impacts.

[viii] Bureau of Labor Statistics. (2022a). Employment Projections. Available from: https://www.bls.gov/emp/tables/industry-employment-and-output.htm. Accessed: October 2022.

Appendix C Exhibit 1. Economic Impact Model Concept Diagram



2. IMPLAN Limitations

The modeling itself introduces uncertainties in the economic impacts. For one, the IMPLAN model is not a general equilibrium model. It always assumes there is sufficient slack in the economy to provide workers, industry output, and intermediate inputs required. As a result, all estimates are presented as a net increase to the macroeconomy when in reality there is likely some tradeoff. For example, an individual may be providing some form of home care to a family member and by taking a job, will then have to employ another individual to provide that same care, reducing the overall benefit the individual gains by entering the workforce. The IMPLAN model is also a static model. It does not consider price effects from increasing the supply of labor to the workforce. It also does not consider how different economic factors may evolve over time; the model does not

allow for work productivity to change over time and assumes a fixed relationship between capital and labor.

X. Appendix D: Interview Guide

Additional methodology explained: The interviewer asked broad open-ended questions designed to allow the interviewees to explain what an AV future might mean for their financial health. The interviewer also asked more specific questions to identify each interviewee's current transportation barriers and how these barriers affect the interviewee's economic/employment opportunities, public health, and/or small business/entrepreneurial development. The interviews were audio recorded and transcribed. All transcribed interviews passed through NVivo qualitative analysis software where researchers identified and consolidated the main themes expressed by the interviewees.

Introduction for interview: Thanks so much for agreeing to talk with me today. I'm going to start by giving you a little background. National Disability Institute (NDI) is a national nonprofit focused on advancing economic opportunity and financial health for people with disabilities. We have a new research project that is investigating the ways autonomous vehicles (or AVs for short) might impact people with disabilities/entrepreneurs and small business owners with disabilities *(choose one).* For this interview, I'd like for you to imagine there is an autonomous vehicle taxi company available in your town. The fleet is made up of self-driving cars that are completely accessible, and you can call a car at any time. Each car can transport up to six people at a time for a price similar to the price of Lyft and Uber. It can also transport goods for an even lower price. There is no driver, so this autonomous vehicle (AV) literally drives itself.

Economic/employment questions:

1. What is your current role and how does it interact with people with disabilities in the workforce/workplace?
2. How do you/your colleagues get to work every day? Can you explain any existing challenges?
3. AVs could allow for both spontaneous travel and pre-planned travel. Could you think of instances when either of these purposes might be useful to you or your colleagues?
4. (If another question is needed for probing) Could you think of instances when AVs might be helpful to you or people with disabilities generally when accessing work or employment opportunities and/or being more financially independent overall?
5. Knowing what you now know about fully accessible AVs, would you recommend them to your friends, colleagues, or clients?

Public health questions:

1. How might AVs impact you or your family's/employees' access to work/employment?
2. How might AVs impact your or your family's/employees' access to education?
3. How might AVs impact your or your family's/employee's access to health care?
4. How might AVs impact your access to your neighborhood?
5. How might AVs impact your access to your community or social network?
6. People with disabilities often use paratransit. AVs could offer an alternative. Are there differences you could imagine? (e.g. What's wrong with paratransit? How would AVs compare?)
7. AVs could allow for both spontaneous travel and pre-planned travel. Could you think of instances when either of these purposes might be useful to you or your loved ones?

8. Knowing what you now know about fully accessible AVs, would you recommend them to your friends, colleagues, or clients?

Small business/entrepreneur questions:

1. What is your current role and how does it interact with people with disabilities in the workforce/workplace?
2. (If another question is needed for probing) Tell me a little more about yourself and your business:
    - What kind of business is it?
    - How long have you been running the business? (number of months, years)
    - Are you producing a good or providing a service? If so, what kind?
    - Is this (or do you envision this to be) a one-person business or do you have employees?
    - Do you have another job or is this business your main income? Do you envision it to be your main source of income at some point?
    - Has COVID impacted you/your business, especially around transportation?
3. How do you and/or your employees typically get to work every day (if you don't work from home)? For your business, have there been any challenges around transportation of people or goods? If so, describe those challenges.
4. AVs could allow for both human transportation and delivery of cargo/goods. Could you think of instances when either of these purposes might be useful to you or your colleagues?
5. Do you feel like you have faced barriers that are different than you would have faced if you did not have a disability, especially in the realm of transportation? Please describe those challenges.
6. AVs could allow for both spontaneous travel and pre-planned travel. Could you think of instances when either of these purposes might be useful to you or your colleagues?

7. Knowing what you now know about fully accessible AVs, would you recommend them to your friends, colleagues, or clients?

Demographic questions: We hope to talk to a diverse group of people to get diverse thoughts on this topic. You can decline to state answers for any of the following questions. All answers will be presented in a collective, anonymous format.

- Do you consider the place you live to be urban, suburban, or rural? (choose one)
- Do you identify as a person with a disability? (y/n)
- Do you identify as a man, a woman, or other? (choose one)
- Do you identify as a person who is Black, Indigenous, Latino, Asian, mixed race, or other person of color? (y/n)
- Do you identify as a person who is LGBTQIA+? (y/n)
- Which generation do you most identify with? (choose one)
    - Silent Generation 1928-1945
    - Baby Boomers (aka Baby Boom Generation)1946-1964
    - Generation X(aka 13th Generation)1965-1980
    - Millennials (aka Millennial Generation)1981-1996
    - Generation Z (aka Homeland Generation)1997-2012
    - Generation Alpha 2013-2025
- Is there anything else you'd like to tell me about yourself?

XI. Appendix E: Characteristics of Interviewees (n=30)

Characteristic	Yes	No	No Answer
Location	--	--	2
Urban	17	--	--
Suburban	11	--	--
Rural	0	--	--
Disability	23	5	2
Gender	--	--	2
Man	12	--	--
Woman	15	--	--
Other	1	--	--
BIPOC*	18	10	2
LGBTQIA+	3	25	2
Generation	--	--	2
Silent Generation	1	--	--
Baby Boomer	6	--	--
GenX	11	--	--
Millennial Generation	9	--	--
GenZ	1	--	--
Gen Alpha	0	--	--

*In this table, BIPOC stands for Black, Indigenous, Latino, Asian, mixed race, or other person of color.

XII. References

[1] United States Census Bureau. (2021). Disability Characteristics. *The American Community Survey 1-Year Estimate Tables*, S1810, https://data.census.gov/cedsci/table?q=disability&tid=ACSST1Y2021.S1810.

[2] Hogan, A., Kyaw-Myint, S. M., Harris, D., & Denroden, H. (2012). Workforce participation barriers for people with disabilities. *International Journal of Disability Management*, 7, 1-9. doi.org/10.1017/idm.2012.1.

[3] Bureau of Labor Statistics. (2022b). *Persons With a Disability: Labor Force Characteristics – 2021.* Available from: https://www.bls.gov/news.release/pdf/disabl.pdf. Accessed: August 2022.

[4] Kim, S., & Ulfarsson, G. F. (2013). Transportation in an Aging Society: Linkage between transportation and quality of life. *Transportation Research Record*, (2357), 109-115. doi.org/10.314/2357-13.

[5] Stern, S. (1989, July). Measuring the effect of disability on labor force participation. *Journal of Human Resources*, 24(89), 361-396. Social Science Premium Collection.

[6] Rigg, J. (2005). Labour market disadvantage amongst disabled people: A longitudinal perspective. *Center for Analysis of Social Exclusion*, 103, 1-33.

[7] Bureau of Labor Statistics. (2021, October). *America's Recover: Labor Market Characteristics of People with a Disability*. Retrieved from Department of Labor.

[8] Schur, L. (2003). Barriers or Opportunities? The cause of contingent and part-time work among people with disabilities. *Industrial Relations*, 42(4), 589-623.

[9] Cullinan, J., Gannon, B., & Lyons, S. (2011). Estimating the extra cost of living for people with disabilities. *Health Economics*, 20, 582-599. doi.org/10.1002/hec.1619.

[10] Morris, Z., McGarity, S., Goodman, N., & Zaidi, A. (2020). *The extra costs associated with living with a disability in the United States* [Working Paper].

[11] Silverman, A., Bell, E., & Mendez, M. A. (2019). Understanding the Employment Experiences of Americans who are Legally Blind. *The Journal of Rehabilitation*, 85(1), 44-52.

[12] Bureau of Transportation Statistics. (2003, April). *Transportation difficulties keep over half a million disabled at home* (Issue 3) [Issue Brief].

[13] Brumbaugh, S. (2018, September). *Travel patterns of Americans with Disabilities* [Issue Brief]. Bureau of Transportation Statistics.

[14] Ramey, C. (2015). America's Unfair Rules of the Road. *Slate Magazine*.

[15] Kassens-Noor, E., Cai, M., Kotval-Karamchandani, Z., & Decaminada, T. (2021). Autonomous vehicles and mobility for people with special needs. *Transportation Research*, A(150), 385-397. doi.org/10.1016/j.tra.2021.06.014.

[16] Darcy, S., & Burke, P. F. (2017). On the road again: The barriers and benefits of auto-mobility for people with disabilities. *Transportation Research*, A(107), 229-245. doi.org/10.1016/j.tra.2017.11.002.

[17] Brucker, D. L., Mitra, S., Chaitoo, N., & Mauro, J. (2015, March). More Likely to Be Poor Whatever the Measure: Working-age Persons with Disabilities in the United States. *Social Science Quarterly*, 96(1), 273-297. doi.org/10.1111/ssqu.12098.

[18] Anand, P., Roope, L. S. J., Culyer, A. J., & Smith, R. (2020). Disability and multidimensional quality of life: A capability approach to health status assessment. *Health Economics*, 29, 748-765. doi.org/10.1002/hec.4017.

[19] Milner, A., LaMontagne, A. D., Aitken, Z., Bentley, R., & Kavanagh, A. M. (2014). Employment status and mental health among persons with and without a disability: evidence from an Australian cohort study. *Journal of Epidemiology and Community Health*, 68(11), 1064–1071. https://doi.org/10.1136/jech-2014-204147.

[20] Syed, S., Gerber, B., & Sharp, L. (2013). Traveling Towards Disease: Transportation barriers to health care access. *Journal of Community Health*, 38(5), 976-993. NIH Public Access. doi.org/10.1007/s10900-013-9681-1.

[21] Blais, D. (2014). *Better living through mobility: The relationship between access to transportation, well-being and disability* [Paper submitted for presentation and publication at the 93rd Transportation Research Board Annual Meeting].

[22] Heineke, K., Heuss, R., Kelkar, A., & Kellner, M. (2021, December). *What's next for autonomous vehicles?* McKinsey & Company.

[23] Society of Automotive Engineers. (2021). *Taxonomy and Definitions for Terms Related to Driving Automation Systems for On-Road Motor Vehicles J3016_*202104. Available from: https://www.sae.org/standards/content/j3016_202104/. Accessed: December 2022.

[24] Synopsys. (2022). *The 6 Levels of Vehicle Autonomy Explained*. Available from: https://www.synopsys.com/automotive/autonomous-driving-levels.html Accessed: December 2022.

[25] Henderson, S., & Golden, M. (2015). *Self-Driving Cars: Mapping Access to a Technology Revolution*.

[26] Reardon, C. (2021, December 20). *Disabled passengers were promised autonomous vehicles – they're still waiting*. The Verge.

[27] National Conference of State Legislatures (2022). Autonomous Vehicles State Bill Tracking Database. Available from: https://www.ncsl.org/research/transportation/autonomous-vehicles-legislative-database.aspx. Accessed: December 2022.

[28] Governor's Advisory Council on Connected and Autonomous Vehicles. (2018). *Executive Report*.

[29] Carlson, T. (2014, May 28). *Accessible taxis: A civil right or a nice bonus of a city?* HuffPost.

[30] Kassens-Noor, E., Kotval-Karamchandani, Z., & Cai, M. (2020). Willingness to ride and perceptions of autonomous public transit. *Transportation Research*, *A*(138), 92-104. doi.org/10.1016/j.tra.2020.05.010.

[31] Bennett, R., Vijaygopal, R., & Kottasz, R. (2019). Attitudes towards autonomous vehicles among people with physical disabilities. *Transportation Research*, *A*(127), 1-17. doi.org/10.1016/j.tra.2019.07.002.

[32] Claypool, H., Bin-Nun, A., Gerlach, J., & Kopić, K. (2017, January). *Self-Driving Cars: The Impact on People with Disability* [White Paper]. Ruderman Family Foundation.

[33] Harper, C. D. (2016). Estimating potential increases in travel with autonomous vehicles for the non-driving, elderly and people with travel-restrictive medical conditions. *Transportation Research*, *C*(72), 1-9. doi.org/10.1016/j.trc.2016.09.003.

[34] Bureau of Labor Statistics. (2022c). Telework during the COVID-19 pandemic: estimates using the 2021 Business Response Survey. Available from:

https://www.bls.gov/opub/mlr/2022/article/telework-during-the-covid-19-pandemic.htm. Accessed: October 2022.

[35] Anand, P., & Sevak, P. (2017). The role of workplace accommodations in the employment of people with disabilities. *IZA Journal of Labor Policy*, 6(1). https://doi.org/10.1186/s40173-017-0090-4

[36] Federal Reserve Bank of Atlanta. (2022). Wage Growth Tracker. Available from: https://www.atlantafed.org/chcs/wage-growth-tracker Accessed: October 2022.

[37] United States Social Security Administration. (2021). A Message From The Commissioner. Accessed: November 2022. Available from: https://www.ssa.gov/budget/FY21Files/2021BO.pdf

[38] Fiscal Data.Treasury.gov. (2022). How much has the U.S. government spent this year? Available from: https://fiscaldata.treasury.gov/americas-finance-guide/federal-spending/#deficit-vs-debt. Accessed: December 2022.

[39] Moura, I., & Tyson, C. ed. (2022). Addressing Disability & Ableist Bias in Autonomous Vehicles:
Ensuring Safety, Equity & Accessibility in Detection, Collision Algorithms & Data Collection. Disability Rights Education & Defense Fund. Available from: https://dredf.org/wp-content/uploads/2022/11/DREDF-Moura-AV-AI-Brief-Nov-2022-Final.pdf. Accessed: November 2022.

[40] Jones, J. M. (2022). What Percentage of Americans are LGBT? Gallup. Available from: https://news.gallup.com/poll/332522/percentage-americans-lgbt.aspx.

[41] National Disability Institute. (2022). *Small Business Ownership by People with Disabilities Challenges and Opportunities.* Available from: https://www.nationaldisabilityinstitute.org/wp-content/uploads/2022/07/ndi-small-business-research-report.pdf . Accessed: August 2022.

[42] Vermeulen, B., Kesselhut, J., Pyka, A., Saviotti, P.P. (2018). The Impact of Automation on Employment: Just the Usual Structural Change? *Sustainability*, 10-1661. Available from: https://www.mdpi.com/2071-1050/10/5/1661 . Accessed: August 2022.

[43] Mbada, C. E., Nonvignon, J., Ajayi, O., Dada, O. O., Awotidebe, T. O., Johnson, O. E., & Olarinde, A. (2013). Impact of missed appointments for out-patient physiotherapy on cost,

efficiency, and patients' recovery. *Hong Kong Physiotherapy Journal*, 31(1), 30–35. https://doi.org/10.1016/j.hkpj.2012.12.001

[44] Jiménez-Solomon, O., Primrose, R., Moon, I., Wall, M., Galfalvy, H., Méndez-Bustos, P., Cruz, A. G., Swarbrick, M., Laing, T., Vite, L., Kelley, M., Jennings, E., & Lewis-Fernández, R. (2022). Financial Hardship, Hope, and Life Satisfaction Among Un/Underemployed Individuals With Psychiatric Diagnoses: A Mediation Analysis. Frontiers in Psychiatry, 13(867421). https://doi.org/10.3389/fpsyt.2022.867421.

[45] Stuart, T & Sorenson, O. (2003). The geography of opportunity: spatial heterogeneity in founding rates and performance of biotechnology firms. *Research Policy, vol. 32*(2), pp. 229-253.

[46] DiCianno, B., Sundaram, S. A., Sivakanthan, S., Satpute, S., Kulich, H., Powers, E., Deepak, N., Russell, R., Cooper, R., & Cooper, R. A. (2021). Systematic review: Automated vehicles and services for people with disabilities. *Neuroscience Letters*, 761, 1-18. doi.org/10.1016/j.neulet.2021.136103.

[47] Dingell, D. (2022a). Press Releases: Dingell, Latta Shift into Drive the Bipartisan Autonomous Vehicle Causuc. Available from: https://debbiedingell.house.gov/news/documentsingle.aspx?DocumentID=3556.

[48] Dingell, D. (2022b). Press Releases: Dingell, Latta Host Bipartisan Autonomous Vehicle Caucus Launch Event. Available from: https://debbiedingell.house.gov/news/documentsingle.aspx?DocumentID=3655.

[49] California Public Utilities Commission (2022). CPUC Issues First Driverless Autonomous Vehicle Passenger Service Deployment Permit. Available from: https://www.cpuc.ca.gov/news-and-updates/all-news/cpuc-issues-first-driverless-autonomous-vehicle-passenger-service-deployment-permit.