GRAND CANYON INSTITUTE

Automation in Arizona's Transportation Sector

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Executive Summary

The emergence of Arizona as a world leader in the automated vehicle sector provides the state with a unique opportunity to capitalize on the nascent status of the industry through targeted investments, embedding the sector within the regional economy in which it operates. Failure to do so will result in economic hardship in the coming years as automation displaces tens of thousands of transportation sector workers.

Summary of Findings

This report looks at the effect that automation will have on the state's transportation sector. The key findings of this report include:

- 130,000 of the state's 242,000 transportation-sector jobs are at a high risk of automation (described in Figure 1), meaning that greater than 70% of the tasks for that occupation have the potential to be automated.
- 85% of those in high-risk jobs have no college degree (described in Figure 2).
- Transportation workers in high-risk jobs have a similar median pay to transportation workers in medium-risk jobs but far lower pay than those in low-risk jobs.
- The lack of a higher education will make it much more difficult for those displaced by automation to find new jobs, placing downward pressure on wages of other low-skill transportation jobs.

Figure 1

Automation Risk for Arizona's Transportation Jobs

Figure 2

Percentage of Workers in Transportation Sector Jobs with No College Degree
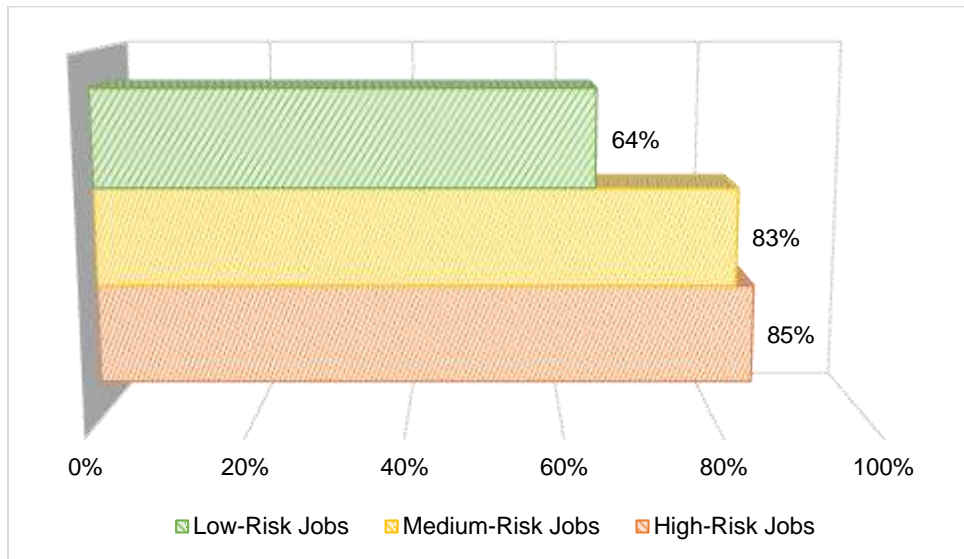
While the effect that the COVID-19 pandemic will have on the development of automation technology is unclear, it will likely not change the broader trajectory of the industry. Though there does exist a degree of uncertainty due to the coronavirus, any negative impact on research and development is likely to be short-term.

The state can transform the potential economic hardship faced by those in high-risk jobs into opportunities for upward mobility by investing in the creation of new career pathways. These pathways can provide those in high-risk jobs with the training and education that they need to move into the present and future high-skill, low-risk jobs resulting from automation.

Summary of Recommendations
A summary of policy recommendations is provided below:
- The Arizona Commerce Authority's Institute of Automated Mobility (IAM) should consider expanding its mission beyond infrastructure to look at the human capital needs of the transportation sector as it adopts automation technology and should seek involvement from leadership from Arizona's community college districts and labor unions.
- The legislature should fully fund the state's community colleges to the amounts that state statute dictates and should make targeted investments to create formal pathway programs.
  - The State of Arizona only appropriated $2 million of the statutorily required $10.6 million to Maricopa County Community College District (MCCCD) and Pima County Community College District's (PCCCD) based on its STEM and Workforce Programs State Aid formula; it additionally does not fund the Operating State Aid formula for these districts.
- MCCCD should consider partnering with one of the many autonomous-vehicle companies to develop programs that could make available training to work with autonomous systems for the 188,000 workers in the county who hold transportation jobs.
  - This would be similar to the PCCCD partnership with TuSimple, resulting in their "autonomous vehicle driver and operations specialist" certificate program.

The organization responsible for ensuring that Arizona is prepared to adopt automotive technologies in its transportation sector is IAM. But IAM currently only focuses on infrastructure needs. IAM should expand its mission to focus on the human capital needs that the transportation sector will have as automotive technologies proliferate. Additionally, while IAM features the presidents of Arizona's three universities, it does not include any representatives from Arizona's community college districts. Leaders from these districts should be invited to collaborate at IAM so that they can bring their expertise in workforce development to bear. Additionally, IAM should invite labor union leaders so

that the perspectives of the workers in high-risk positions can be included in strategic planning.

The Arizona legislature must also fund community colleges to the amounts that state statute dictates. In FY21, it only appropriated $2 million of the required $10.6 million to MCCCD and PCCCD based on the STEM and Workforce Programs State Aid formula and does not currently fund the Operating State Aid formula for these districts. The legislature has funded several economic development-linked projects in the past, such as the $33 million provided to universities for their New Economy Initiative, the $5.8 million to expand MCCCD's health care specialty programs, and the $15 million for PCCCD's aviation program. The legislature should provide targeted funding for Arizona's community colleges to develop programs to address the human capital needs resulting from automation.

One such pathway currently being offered is through PCCCD. Through a partnership with the autonomous-trucking company TuSimple, the PCCCD developed an Autonomous Vehicle Driver and Operations Specialist certificate program aimed at current truck drivers. Upon completion of the program, drivers are eligible for a number of automation-related jobs at TuSimple.

With 180,000 workers in the automation sector located in Maricopa County, along with several autonomous vehicle companies, if a similar program were to be offered by MCCCD it would immediately have a significant target market. By creating partnerships with these companies or other transportation/warehousing companies in the county, the district can develop a number of programs that provide those currently working in high-risk jobs with the skills that these companies are looking for, creating pathways to the high-skill, low-risk jobs offered by autonomous-vehicle businesses.

Should the state fail to act, the result will be economic hardship for tens of thousands of transportation workers. Coordinated strategy and investment would benefit not just those in high-risk jobs but the economy as a whole. Arizona has the opportunity to cement its position as a leader in the autonomous-vehicle sector, but this requires an education system capable of producing workers with the skills needed to succeed in the jobs that this industry will generate.

Introduction

Visitors to the East Valley of Maricopa County find themselves surrounded by something out of science fiction that residents have long since become accustomed to: a car with what looks like a black, pill-shaped instrument on top. East Valley residents have only shared the road with these cars for three years, but their ubiquity results in an apathetic recognition by the residents in the communities where they operate.

Waymo, Uber, General Motors, Ford, Kroger, Ryder, and TuSimple have raced to the East Valley in the 21st century equivalent of the gold rush that is getting the first self-driving car to market[1]. In 2015, Governor Doug Ducey waved a checkered flag by signing an executive order that created a framework for self-driving car regulations[2]. Waymo, owned by Google's parent company Alphabet, made Arizona its home in 2016[3]. Uber was lured to Arizona in 2017 by Governor Ducey after their veritable eviction from California[4]. Since then more companies have arrived, attracted by Arizona's regulations on testing self-driving cars being among the friendliest in the country.

This expansion stalled in 2018 when an Uber vehicle operating in autonomous mode hit and killed a pedestrian[5]. Governor Ducey suspended Uber's ability to test their self-driving cars, leading Uber to move its testing out of the state. Despite 21 of its vehicles being assaulted by pedestrians, Waymo not only stayed in Arizona but expanded its operations[1]. In 2018, a taxi service called Waymo One was launched, allowing Valley residents to download an app and request rides from Waymo's autonomous fleet.

Waymo recently announced that it would be doubling its operations in the area, adding to the hundreds of vehicles already roaming the streets of Arizona. Waymo also announced recent partnerships with the City of Chandler to utilize self-driving cars for city business[6], and with Lyft to use their platform to further expand ride-sharing operations[7].

Waymo also waded into the self-driving truck business. It began testing self-driving trucks in Arizona in 2017, stopped later that year, and announced in 2019 that testing would resume[8]. These will not be the only autonomous trucks on Arizona roads; the U.S. Postal Service recently unveiled a partnership with TuSimple to test long-distance drives by autonomous trucks between Phoenix and Dallas[9]. Other companies including Ryder, DHL, and NFI are also implementing driverless technologies operating in the Phoenix area.[10]

However, Arizona's dominance in the self-driving car market masks a huge vulnerability in the state's transportation section. The hundreds of jobs created by the activity discussed above are only a very small part of the 228,000 jobs that make up Arizona's

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[1] Wiles, 2019

[2] Office of the Governor Doug Ducey, 2018

[3] Randazzo & Collom, 2019

[4] The Republic, 2017

[5] Randazzo, 2019

[6] Associated Press, 2019

[7] KTAR.com, 2019

[8] Korosec, 2019

[9] Wiles, 2019

[10] Ronan, 2020

transportation sector. Tens of thousands of people in the industry will eventually find themselves in jobs that a computer can do better and cheaper. Those in transportation jobs at the highest risk of being eliminated due to automation have low levels of education, making it harder for them to find jobs elsewhere as their occupation ceases to exist.

Arizona has undoubtedly distinguished itself as a magnet for self-driving car operations. What Arizona lacks, however, is preparation for the waves of disruption that automation will make on its economy. Self-driving cars are the future of the transportation sector, but the 242,000 Arizonans who work in this industry are vulnerable to the changes that such automation will bring[11].

Automation in the Transportation Sector

While there is much disagreement among researchers about the timeline of automation in transportation, most agree that the sector is among the most vulnerable to the process. This is due to many of the tasks associated with occupations in the transportation sector that are able to be automated and because workers in those occupations have low levels of educational attainment.

Determining the Risk of Automation

When researchers look at how vulnerable occupations are to automation, they tend to break down the tasks associated with that job and study the likelihood that those tasks will be automated. Research articles generally classify occupations as "low-risk" if less than 30% of tasks in that occupation can potentially be automated in the near future, "medium risk" for 30% to 70% automation potential, and "high risk" if there is a greater than 70% automation potential. The more tasks that can be automated, the less of a demand there will be for human workers to fill that position.

A 2019 report by Muro, Maxim, and Whiton concluded that there is a 58% potential for automation for the transportation and warehousing industry, ranking it third among occupation groups most at risk of automation behind the accommodation industry and food services and manufacturing industry[12]. Transportation is so susceptible because many of the tasks involve physical activities that occur in a predictable environment, making them much easier to automate, which is a big reason why warehousing has seen such gains in automation. Jobs in transportation and material moving also generally require less than a bachelor's degree, resulting in workers who are less capable to recover from employment disruption. Men will experience substantially more disruption than women, as they make up over 80% of transportation occupations. Black, Hispanic,

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[11] Bureau of Labor Statistics, 2020a

[12] Muro, Maxim, & Whiton, 2019

and Native American workers will also be disproportionately affected by the negative effects of automation, as a greater proportion of them work in occupations with higher automation potential.

A study by Frey and Osborne (2013) estimated the probability of automation for 702 detailed occupations and predicted that transportation and logistics workers along with office and administrative support workers and labor in production occupations are at risk[13]. The estimates created by Frey and Osborne are used in the data analyses of this report. Details of this usage are available in the methodology section.

While Frey and Osborne argued that 47% of jobs in the United States are at high risk of automation, a report by the Organisation for Economic Co-operation and Development (OECD) features a much more conservative estimate that only 9% of U.S. jobs are at risk[14]. The report argues that there is a larger variability between tasks within occupations, leading to less overall automation risk. However, the OECD still finds that transportation jobs are highly automatable and are therefore at the greatest risk.

One study that stands in contrast to the others comes from Yankelevich, Rikard, Kadylak, Hall, Mack, and Verboncoeur et al. (2018)[15]. The report argues that only a few hundred thousand jobs in the U.S., at most, will be displaced out of the 3.5 million jobs in the U.S. transportation sector. The authors find that the jobs most at risk are drivers of taxis and chauffeured vehicles. Trucking jobs, on the other hand, will not be significantly impacted by automation in the coming decade, according to Yankelevich, et al. This is because of the need for a person to oversee the loading/unloading of a truck when it arrives at its destination, whereas no such presence is needed for passenger transportation.

Yet this finding about trucking jobs is contradicted by the analyses of similar reports. Frey and Osborn (2013) find that light truck or delivery services drivers and heavy and tractor-trailer truck jobs have a 69% and 79% respective probability of automation.[16] Muro, Maxim, and Whiton (2019) have a similar finding that light truck or delivery services drivers face a 78% automation potential.[17] A study by Austin, Bucknor, Cashman, and Rockeymoore (2017) found that 77% of workers in driving occupations are delivery drivers and heavy truck drivers, 15% are bus drivers, and 8% are taxi drivers and chauffeurs.[18] The high potential for automation of occupations that contain the vast majority of drivers foreshadows the significant disruption that automation will create within the industry.

[13] Frey & Osborn, 2013

[14] Nedelkoska & Quintini, 2018

[15] Yankelevich, Rikard, Kadylak, Hall, Verboncoeur, & Cotton, 2018

[16] Frey & Osborn, 2013

[17] Muro, Maxim, & Whiton, 2019

[18] Austin, Bucknor, Cashman, & Rockeymoore, 2017

Timeframe for Automation

The debate seems to be not if transportation jobs such as truck drivers will be replaced, but when. A report by Manyika, Chui, Miremadi, Bughin, George, and Willmott et al. (2017) argues that less than 5% of jobs are at risk of full automation at the present day, but also finds that automation will bring substantial disruption in the near future[19]. The authors rank the transportation and warehousing sector as the third most at-risk sector for automation at a 60% automation potential. The full adoption of automated vehicles by the sector is estimated to be after 2025 at the earliest and after 2065 at the latest.

The large variance in this estimate comes from the unpredictable nature of both the technology surrounding automation and the economies of scale for adoption that will follow. A report by Viscelli (2018) argues that automation will likely first replace long-haul trucking jobs including full truckload jobs (moving goods from factories to distribution centers), less-than-full-time jobs, and parcel jobs (such as drivers for USPS)[20]. Driving on highways is much easier to automate than driving on local streets. The testing of long-haul trucks between Dallas and Phoenix by USPS and TuSimple illustrates the industry's move towards this reality.[21] Viscelli estimates that 294,000 of these trucking jobs are at high risk for automation.

Once the technology is available to automate occupations, companies face the barrier of the cost of integrating automation into their operations. Manyika et al. (2017) point out that this cost of automating is much higher for the transportation sector than for other sectors that rely more on software-based solutions to automate their operations.[22] In his report on automation, Atkinson (2018) points out that old technologies are generally kept until their value is significantly depreciated.[23] Even if affordable self-driving trucks were to emerge, Atkinson argues that the trucking industry would not suddenly replace their capital-intensive fleets.

Yet study after study claim that the data show transportation will be among the first sectors significantly impacted by automation. Frey and Osborn (2013) assert that automation will come in two waves, separated by a technological barrier. The first wave will substitute most workers in transportation and logistics occupations with computer capital, along with office and administrative support workers and labor in production occupations.[24] The second, meanwhile, will displace jobs that rely on creativity and social intelligence, which are much harder to automate. Manyika et al.'s (2017) model shows the transportation

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[19] Manyika et al., 2017

[20] Viscelli, 2018

[21] Wiles, 2019

[22] Viscelli, 2018

[23] Atkinson, 2018

[24] Frey & Osborn, 2013

sector as one of the first affected by automation, along with manufacturing, retail, health care, accommodation, and food services.[25]

Though the timeline of automation is unclear for the transportation sector, the data show that there exists a high potential for automation. Many workers in the transportation sector do not have a post-secondary degree, and less-educated workers are more likely to be negatively impacted by automation.[26] While automation leads to the creation of higher-paying jobs,[27] workers in the transportation sector are unlikely to transition to these jobs. As the transportation sector automates, downward pressure will be put on worker earnings, such as short-distance truck drivers.[28]   Many of the low-skill workers who stay in the transportation industry will do so at a lower pay, while others will be forced to search for jobs elsewhere.

While the effect that the COVID-19 pandemic will have on the development of automation technology is unclear, it will likely not change the broader trajectory of the industry. Some companies are cutting back significantly on development efforts, such as Uber Advanced Technologies Group, which announced in August that 3,500 jobs would be cut.[29] Others have resumed operations, such as Waymo which suspended testing at the beginning of the pandemic but resumed its research and development in May.[30] Some industry experts postulate that the pandemic could hasten the adoption of automation technology due to the skyrocketing demand for contactless delivery and transportation.[31]   Though there does exist a degree of uncertainty due to the coronavirus, any negative impact on research and development is likely to be minimal and short-term.

Transportation Industry in Arizona

While self-driving cars may be one of the most notable aspects of the transportation industry, they only make up a small part of the sector. Transportation is Arizona's fourth-largest occupation group, with almost 242,000 Arizonans currently employed in transportation occupations.[32]   Table 1 summarizes the top five occupation groups in Arizona and the median wages associated with those occupations.

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[25] Viscelli, 2018

[26] Muro, Maxim, & Whiton, 2019

[27] Manyika et al., 2017

[28] Atkinson, 2018

[29] Hall, 2020

[30] Randazzo, 2020

[31] Wiggers, 2020

[32] Bureau of Labor Statistics, 2020a

Table 1

Largest Occupation Groups in Arizona—2019[33]

Occupation Group	Total Employment	Median Annual Income
Office and Administrative Support	427,540	$37,810
Sales and Related Occupations	267,880	$31,190
Transportation and Material Moving	**241,750**	**$32,900**
Food Preparation and Serving Related	241,100	$26,830
Business and Financial O perations	179,470	$64,700
All Occupations	2,835,110	$40,260

While transportation occupations are only the third most numerous in the state, they pay better than sales and related occupations and food preparation and serving related occupations. To understand why this is significant, we must look at the percentage of workers in those occupations with no college degree. Table 2 compares the mean annual incomes for those occupations in Arizona with the national data of workers in those occupations with no college degree.[34]

Table 2

Percentage of Workers with No College Degree[35,36]

Occupation Group	Median Annual Income	Percentage with No College Degree
Office and Administrative Support	$36,540	62%
Sales and Related Occupations	$28,890	60%
Transportation and Material Moving Occupations	**$31,320**	**82%**
Food Preparation and Serving Related Occupations	$25,510	80%
Business and Financial Operations	$64,700	25%

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[33] Bureau of Labor Statistics, 2020a

[34] Bureau of Labor Statistics, 2020b

[35] Bureau of Labor Statistics, 2020a

[36] Bureau of Labor Statistics, 2020b

More than half of all workers in Arizona's top four occupation groups have no college degree. The high pay and low education requirements make transportation jobs an attractive option. While the median annual income for office and administrative support occupations is slightly higher than transportation occupations, workers are more likely to hold a college degree. Less than one out of five transportation workers hold a college degree, yet they make more than many other workers with similar levels of education. The fifth-highest occupation group, management, is much less likely to employ workers with no college degree.

Individuals without a college degree make up a large percentage of Arizona's labor force. As of 2018, 54% of Arizona adults aged 25-64 have no postsecondary degree or certificate.[37] In 2016, the average pay for Arizona workers with just a high school diploma was just $27,947 (see Figure 3).[38] Compare this to $32,900, the median annual income of   Arizonans in transportation occupations. Individuals with only a high school diploma can make 18% more than the state average by working in a transportation occupation. This makes transportation jobs much more attractive than occupations with similar educational attainment requirements.

Figure 3

Annual Income for Arizona Workers
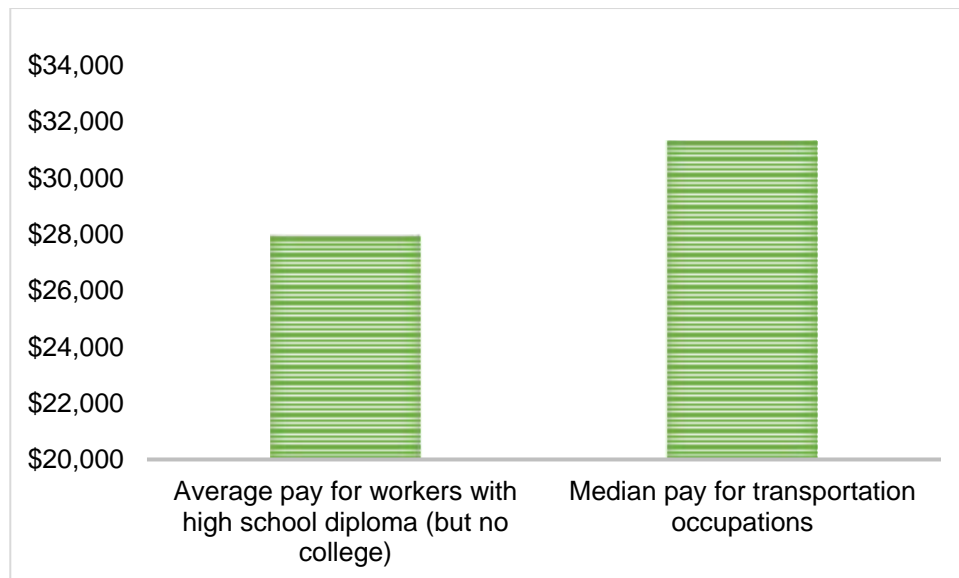
[37] AZ Big Media, 2020
[38] Wiles, 2016

There also exists income variance within the largest transportation occupations. Heavy and tractor-trailer truck drivers earn on average over $47,000 annually, 29% more than light-truck drivers, the next highest-paid occupation, and 54% more than laborers and freight, stock, and material movers which employ the largest number of people in the transportation sector. The higher pay and lower education requirements make heavy and tractor-trailer truck driving jobs appealing. While these jobs are more likely to require a commercial driver's license (CDL), many long-haul trucking companies assist in the cost of acquiring this certification. Table 3 provides an overview of the income and education statistics for the top transportation occupations.

Table 3

Income and Education for Top Transportation Occupations[39,40]

Occupation	Total Employment	Median Annual Income	Percentage with No College Degree
Laborers and Freight, Stock, and Material Movers, Hand	57,860	$30,580	86%
Stockers and Order Fillers	51,380	$29,830	81%
Heavy and Tractor-Trailer Truck Drivers	30,830	$47,040	86%
Light Truck Drivers	17,610	$36,390	86%
Passenger Vehicle Drivers (Except Transit and Intercity Bus Drivers)	11,180	$30,790	74%
Industrial Truck and Tractor Operators	10,910	$36,820	91%

The appeal for transportation jobs is further explained by Shearer and Shah (2018), who found that the industry accounts for a disproportionate share of both good jobs (those with middle-class wages and benefits) and promising jobs (entry-level positions which can lead to good jobs in 10 years) for those with less than a four-year college degree.[41] 15 % of jobs for these workers are good, and 14% are promising.

Shearer and Shah also found that over 75% of transportation workers in pathways to good jobs are projected to switch careers in 10 years. So, upward mobility for workers in the transportation sector exists mainly for those who find other jobs outside of the industry. Workers who remain in the transportation industry are left to compete for the 15% of good jobs available.

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[39] Bureau of Labor Statistics, 2020a
[40] Bureau of Labor Statistics, 2020b
[41] Shearer & Shah, 2018

The incentive for individuals with low levels of education to seek jobs in the transportation sector becomes a problem when automation comes into play. As transportation jobs become automated, workers in pathways to good jobs are likely to transition out of the sector. Those who remain in the sector will face downward pressure   on wages with little prospect of upward mobility. Workers in Arizona are drawn to transportation jobs as an option to earn higher-than-average wages for their education level, but these jobs face significant risks of automation.

Transportation Jobs at Risk of Automation

Findings
The data show that, of the 241,750 transportation jobs in Arizona, 130,180 (54%) are at high risk of automation, with more than 70% of the tasks associated with those jobs being automatable. There are 91,510 jobs (38%) at a medium risk of automation, with between 30% to 70% of the tasks associated with those jobs being automatable. Figure 4 shows the distribution of high-, medium-, and low-risk jobs in the transportation sector.

Workers in jobs with higher risks of automation are also less likely to have a college degree; 85% of workers in high-risk positions have no college degree. Medium-   risk occupations are no better off, with 83% of their workforce holding no college degree. Workers in low-risk occupations are only 64% likely to have no college degree.

Figure 4

Automation Risk for Arizona Transportation Jobs

Workers in jobs with higher risks of automation are also less likely to have a college degree; 85% of workers in high-risk positions have no college degree. Medium-   risk occupations are no better off, with 82% of their workforce holding no college degree. Workers in low-risk occupations are only 62% likely to have no college degree. These statistics are displayed in Figure 4.

Figure 5

Percentage of Workers with No College Degree
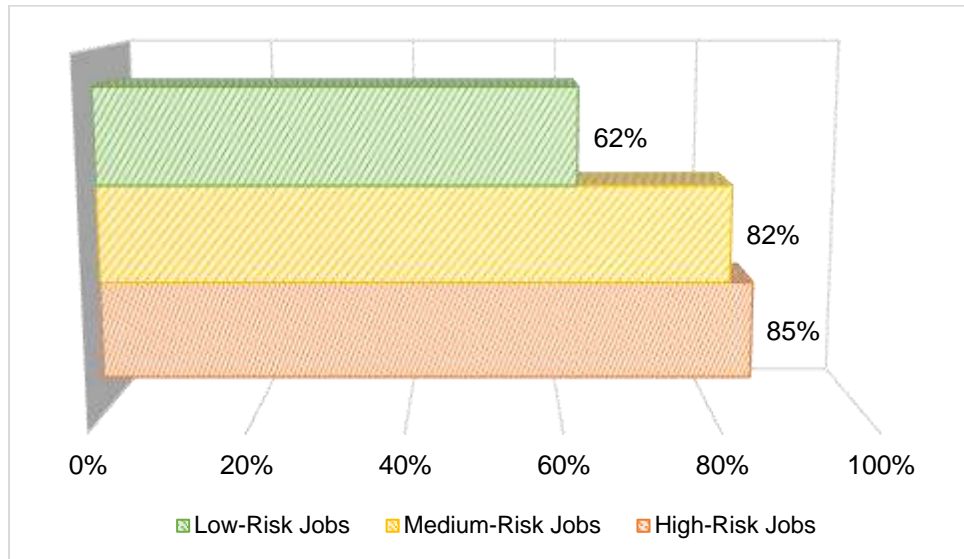
Less than one-fifth of workers in high-risk jobs have any kind of college degree. Most workers with no college degree have at least a high-school diploma (69%), with 22% having taken at least some college courses. Sixteen percent of workers in high-risk jobs have less than a high-school diploma. The average education levels are displayed in Figure 5.

Figure 6

Average Education Levels for Transportation Workers
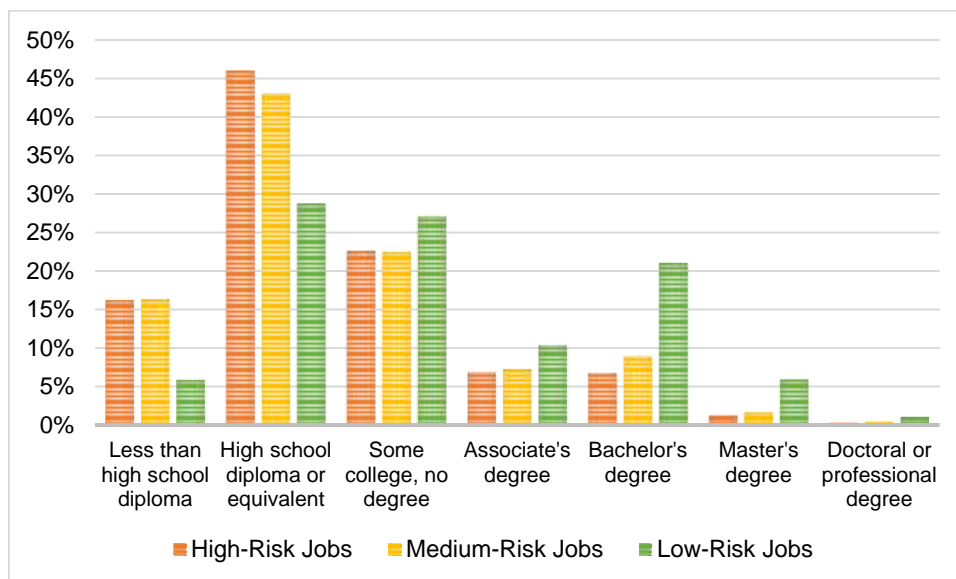
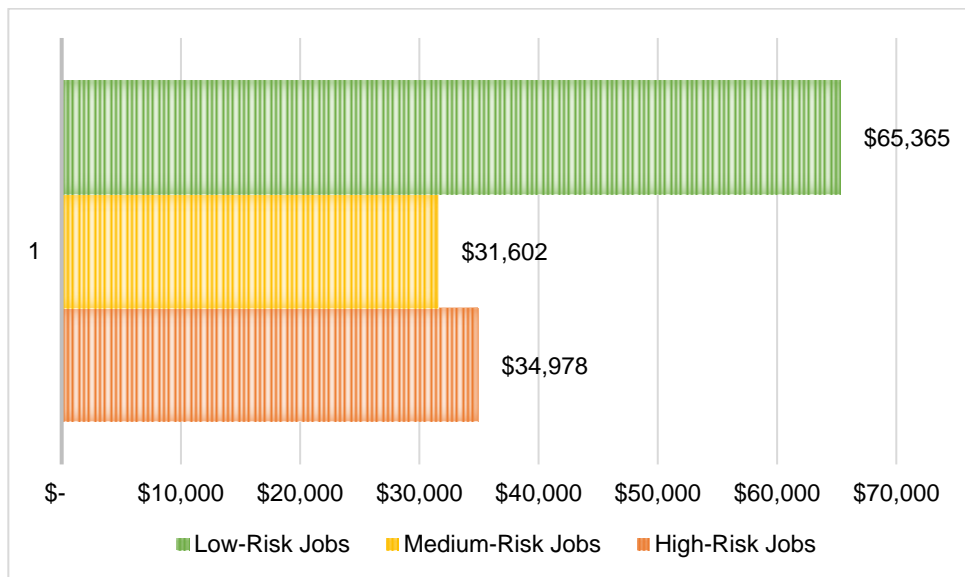High-risk and medium-risk transportation occupations also have lower median pay than low-risk transportation jobs. The high-risk occupations have an average median pay of $34,978, medium-risk occupations earn $31,602, and low-risk occupations earn $65,365. The median pay for each category is shown in Figure 6.

Figure 7

Average Occupational Median Pay for Arizona Transportation Workers

To summarize, in Arizona 130,180 transportation workers are in jobs that are at a high risk of automation. Workers in high-risk jobs are more likely to have low levels of educational attainment with 85% having no college degree. High-risk and medium-risk occupations also have much lower median pay than low-risk transportation occupations, with low-risk workers earning 87% more in median wages than workers in higher-risk positions.

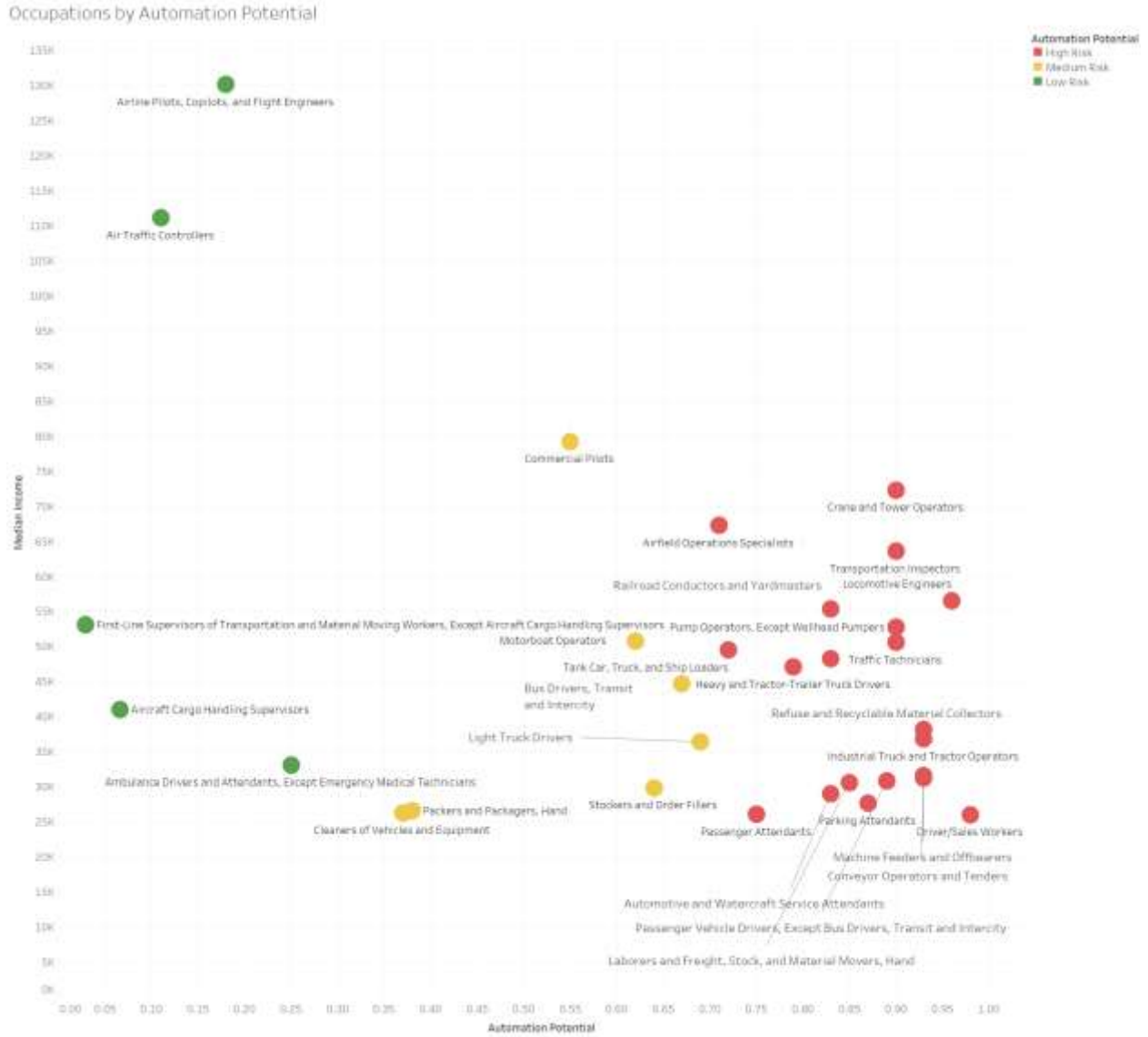Figures 7 and 8 provide a look at the distribution of transportation occupations by employment numbers, income, and automation potential.

The methodology for this paper can be found in Appendix A. Additional occupation-level data can be found in Appendix B.
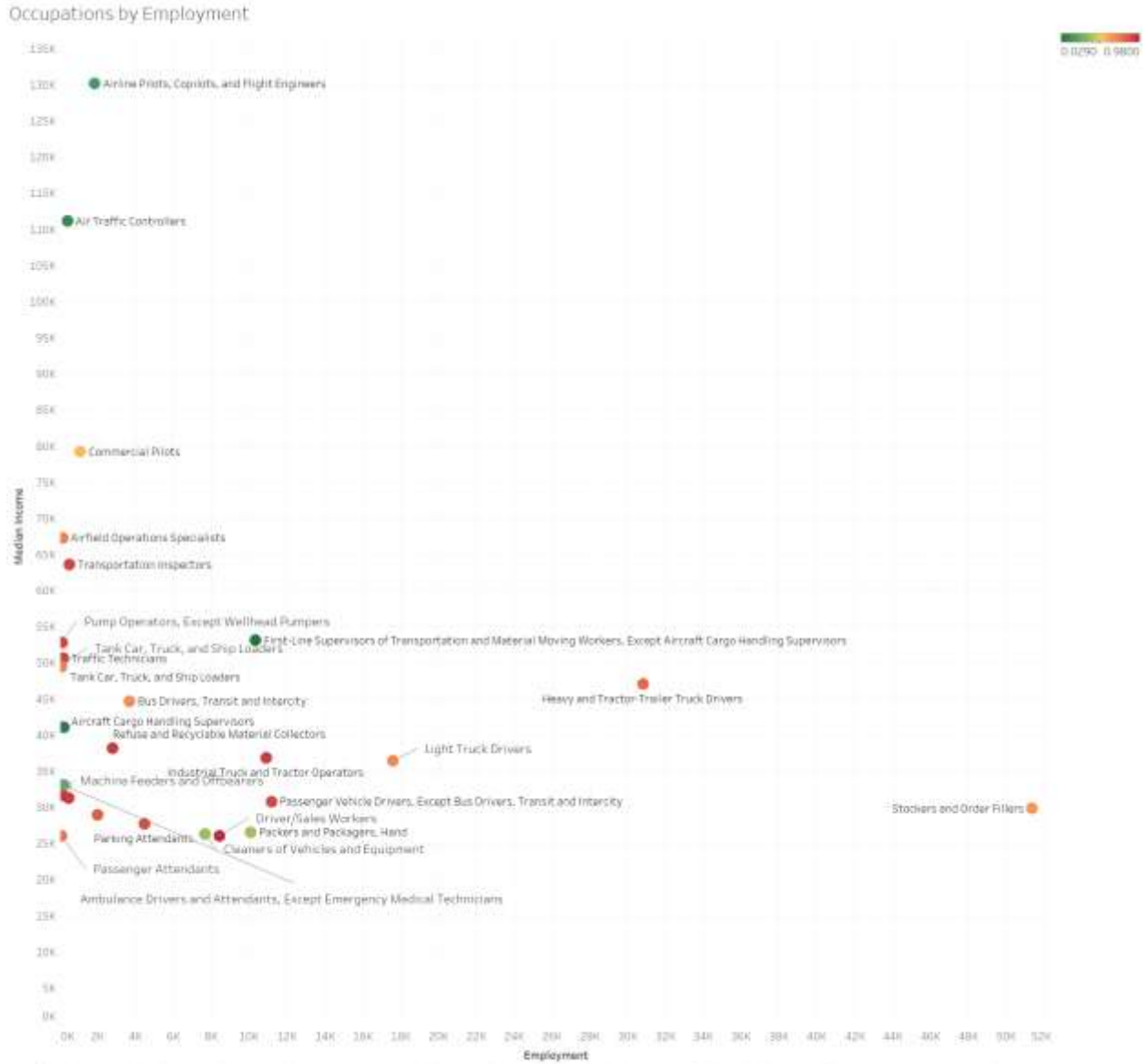
Figure 8

Occupations by Automation Potential

Occupations by Automation Potential

Figure 9

Occupations by Employment Numbers

Occupations by Employment

Policy Recommendation

In the near future, there will be continued demand for transportation workers, even for jobs at high risk of automation. In order to ensure that those who occupy these jobs, both presently and in the future, benefit from automation rather than suffer, pathways must be created from medium- and high-risk jobs to current and emerging low-risk jobs.

Arizona has, thus far, done well in developing this nascent industry. Ensuring that the state will continue to be a leader in this sector requires proactive planning and investment. The state's current answer to this challenge is the Arizona Commerce Authority's (ACA) Institute of Automated Mobility (IAM). While this coalition of policy, business, and education leaders has worked to prepare Arizona for expansion in this sector through the research and deployment of advanced infrastructure, they do not address how the state should ensure that it has sufficient human capital to meet the expansive needs that automation will usher in. As this body is responsible for developing the public policy necessary for the growth of this sector, this organization is ideally placed to   take a leadership role for both infrastructure and human capital.

Additionally, very few formal pathways exist for those wishing to move from high-risk jobs to high-skill, low-risk jobs in the transportation sector. Instead, workers who wish to prepare for such a transition must determine themselves what skills and experiences they need. If left alone, this lack of formal pathways will result in the displacement of most workers in high-risk positions, placing downward pressure on other transportation occupations as those who lost their employment search for similar work.

This policy recommendation section is divided into two three subsections:
1. IAM should play a larger role in the promotion of human capital that will support the automation sector.
2. Community colleges are an important solution in the development of these pathways. Pima County Community College District (PCCCD) has successfully piloted such a program, and Maricopa County Community College District (MCCCD) would be wise to do so.
3. The state   should fully fund community colleges in accordance with the formula defined in state statute   and make additional investments so that these colleges can better serve as the workforce development centers needed to prepare our economy for the transition that automation will bring.

Expansion of the Institute of Automated Mobility into Human Capital

   IAM is a working group housed within the   ACA.[42] Created by an executive order from Governor Doug Ducey, IAM "provides technical guidance and coordination to ensure the prudent implementation of automated mobility." IAM seeks to ensure the development and deployment of safe and efficient automated mobility in Arizona by developing

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[42] Arizona Commerce Authority, n.d.

roadway infrastructure as a service, allowing roadways to broadcast data to automated vehicles. Primarily, IAM does this through various research and analysis projects.

IAM is an impressive effort, distinguishing Arizona as a leader in the field. Yet, without a larger scope, Arizona risks its workforce being unprepared for the advanced, multifaceted labor needs of automation companies. In addition to researching infrastructure technologies, it should research what skills will be needed in this quickly evolving industry. With this information, career pathways can then be identified, created, and implemented. Recommendations can also be made regarding where public investment is needed to ensure that this is done quickly and effectively.

These pathways will require the collaboration of several education stakeholders. While the three presidents of Arizona's public universities sit on the leadership team of IAM, community colleges are not represented. Community colleges work with many of those most at risk of being disrupted due to the economic effects caused by automation. Their leadership are experts in workforce development and can offer a unique perspective into the policies needed for this sector to be successful. Additionally, IAM should invite labor union leaders so that the perspectives of the workers in high-risk positions can be included in strategic planning.

<u>Community Colleges as a Solution for Workforce Development</u>
While traditional education provides resiliency against economic disruptions, including automation, specialized training programs must be developed in order to meet the need of this emerging sector. These programs will be most successful when they are developed in conjunction with autonomous vehicle businesses so that the specific needs of the industry can be identified and addressed.

Community colleges are best situated to create and house such programs thanks to their expertise in industry collaboration along with their ability to target and recruit those who the program intends to benefit. While each community college district in Arizona would benefit from these programs, piloting should be done in areas that have access to both autonomous vehicle companies along with large numbers of transportation workers.

This report recommends the creation of an autonomous program at Maricopa County Community College District. Maricopa County is home to numerous autonomous vehicle companies, along with 188,000 transportation workers. The following section outlines what such a program would look like.[43]

More generally, Arizona should be considering robust investments in the state's education system, including pre-K, K–12, postsecondary education, and workforce training and development in order to ensure that the state has a workforce that is prepared for

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[43] Bureau of Labor Statistics, 2020c

automation. This will require large sums of money allocated as soon as possible to Arizona's education system in order to prepare the next generation for an economy that places high values on intellectual capital along with the ability to retrain and reskill as new technologies become available. Additionally, continual, targeted investments should be made to provide Arizona's workforce with the ability to benefit, rather than suffer from, the introduction of new automation technologies.

Should Arizona invest in creating formal pathways, the threat of automation could become an opportunity for growth and prosperity. While this section focuses on policy recommendations specifically for the transportation sector, the formation of these pathways within and throughout sectors could transform our labor-intensive economy into that of a knowledge economy, where automation benefits, rather than harms, those in occupations which it impacts. A recent National Bureau of Economic Research paper found that 30 million workers in the U.S. without four-year degrees have the skills to earn 70% more.[44] The absence of pathways prevents these transitions from taking place.

Workers who lack a higher education could continue to find economic opportunity through transportation sector jobs that are at medium- and high-risk of being automated. While working in these positions, they could partake in programs that train them in the skills needed to advance to high-skill, low-risk jobs. Instead of tens of thousands of workers being displaced, automation could advance their careers in ways that before they did not view as possible. As recognition of these potential pathways grows, the supply of workers will increase, benefitting the many transportation companies that currently suffer from significant shortages of workers.

This scenario is not hypothetical, it is already taking place in Tucson, Arizona through a program offered by Pima County Community College District (PCCCD), created in conjunction with the autonomous truck company TuSimple. The program forms a pathway between high-risk heavy and tractor-trailer driver jobs and high-skill, low-risk autonomous vehicle operator positions. This program is explored in greater detail in this section, along with a proposal for the creation of a similar program by Maricopa County Community College District (MCCCD) using funding provided by the State of Arizona.

PCCCD Autonomous Vehicle Driver & Operations Specialist Certificate Program

In the fall of 2019, PCCCD began enrolling students for their Autonomous Vehicle Driver & Operations Specialist Certificate (AVDOSC) program.[45] The program, developed in partnership with the autonomous trucking company TuSimple, prepares truck drivers for how to interact with autonomous vehicles. Students are required to have a Class A

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[44] Blair, Castagnino, Groshen, Debroy, Auguste, Ahmed et al., 2020
[45] Pima County Community College District, 2019

commercial driver's license (CDL) prior to enrollment. The program consists of five courses, listed in Table 4. Only one of the AVDOSC courses, "Introduction to Autonomous Vehicles", is new.

Table 4

PCCCD Autonomous Vehicle Driver & Operations Specialist Certificate Program Courses[46]

Course Name	Credits
Industrial Safety	1 credit
Electrical Systems I	3 credits
Introduction to Autonomous Vehicles	2 credits
Computer Hardware Components	3 credits
Transportation and Traffic Management	3 credits
Total	**12 credits**

According to PCCCD program manager Missy Blair, the first cohort completed the program in the winter of 2020. Job opportunities with TuSimple will be available immediately upon completion.[47] Job opportunities include "test drivers to help train the autonomous system, experts to monitor autonomous vehicles remotely from a command center, and drivers to operate the autonomous vehicle when self-driving isn't suitable."[48] TuSimple autonomous trucks are currently operated by a CDL driver and an engineer, but it plans to eventually remove the engineer and leave only the driver. Because of this, TuSimple needs its drivers to have experience with autonomous technologies.

One significant barrier which may prevent interested workers from enrolling in the AVDOSC program is the cost. Tuition is estimated by Blair to be $700-$1,800 for in-state students, depending on assistance from state Workforce Innovation and Opportunity Act funds, and $4,100 for out-of-state students. Because the program is less than 16 credits students are not able to use federal aid, including Pell grants and federal student loans.[49] Students must pay using cash or private student loans, which can be especially challenging for those in high-risk jobs.

Overall, the program successfully creates a pathway between high-risk jobs and high-skill, low-risk jobs that are emerging due to automation. Those students who are able to pay for and complete the program will benefit, rather than suffer, from the economic shifts that will occur from automation. However, this program only has the capacity and reach

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[46] Pima County Community College District, n.d.a
[47] Pima County Community College District, n.d.b
[48] Pima County Community College District, n.d.b
[49] Pima County Community College District, n.d.a

to train a small number of those in high-risk jobs. In order for a majority of such workers to benefit from automation, more pathways must be created.

Creation of an MCCCD Autonomous Program

There exists great potential within Maricopa County for the development of pathways to jobs that will benefit from the introduction of autonomous vehicles. A majority of Waymo's 600 autonomous vehicles reside in the valley,[50] along with such vehicles owned by General Motors, Ford, Kroger, and Ryder.[51] Yet there exist no formal educational programs to provide the training needed for the 188,000 workers who currently hold transportation jobs in Maricopa County to take part in the emerging autonomous vehicle industry.

While such programs could take many different forms, the most accessible would be one offered by MCCCD. MCCCD programs are widely accessible and affordable. As of Fall 2019, MCCCD enrolled 115,000 students and charged $85 per credit hour.[52] Given that 40% of its students   have no prior higher education and 53% of its students   are first-generation students, the District shows that it is capable of working with populations who have little-to-no exposure to the higher education system.

As MCCCD currently has no autonomous vehicle program, one would need to be developed from the ground up. The best way to do this would be by developing a partnership with an autonomous vehicle business to determine the skills and experience needed for current and future jobs relating to automation. MCCCD could then develop one or more educational programs to meet the needs of its corporate partner. This could be done in conjunction with PCCCD, which stated previously that it is willing to help other colleges develop similar programs.[53]

The primary focus in the development of these programs should be to upskill workers who are most likely to be displaced by automation. This could include freight, by partnering with other trucking companies implementing driverless technology such as Ryder, DHL, or NFI.[54] Another option is warehousing, with companies such as Kroger taking significant steps to create automated delivery centers.[55] Additional partnerships with employers of workers in high-risk jobs, such as personal transit, delivery, or other such companies, could provide a steady stream of students along with the possibility of subsidized tuition as an employment benefit.

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[50] Niedermeyer, 2019

[51] Wiles, 2019

[52] Maricopa County Community College District, 2019b

[53] Pima County Community College District, 2019

[54] Ronan, 2020

[55] Brown, 2018

<u>Increasing the Funding of Arizona's Community College Districts</u>
In order to prepare the state for the economic reality that is to come, the Legislature must both fully fund the state's community colleges up to the level that statute requires and invest in the development of this sector by providing funding for the development and expansion of such educational programs offered by PCCCD.

The state's investment in its community college districts, especially MCCCD and PCCCD, has been minimal, and in the case of those two colleges, below the statutory requirements. From 2016 to 2019, the state contributed $0 to MCCCD, down from $82.6 million real dollars in 2008.[56] While the state did provide $1.6 million to MCCCD and $0.4 million to PCCCD for three fiscal years starting in FY19, it was far short of the $10.6 million called for by the STEM and Workforce Programs State Aid formula in FY21.[57] This remained the case in the recently adopted FY22 budget.[58] The state also failed to fund the Operating Aid formula for these districts.

While the state has shown little interest in adhering to statutory funding requirements, it has invested in several programs for both districts. The FY20 budget provided MCCCD with $5.8 million to expand its health care specialty programs, along with $15 million for PCCCD's aviation program.[59]

Funding should also be provided for community colleges to provide financial assistance and academic support services to those who wish to participate in programs yet lack the financial capability to do so. Considering that those in positions at high risk of automation receive lower wages and have less education than those at low risk, it is likely that they will need additional support to both afford and succeed in these programs. Additionally, shorter programs similar to the one offered by PCCCD may not be eligible for students to receive federal loans because they do not meet the 16 credit requirement. Consequentially, it will be harder for students with fewer means to access such programs.

To ensure the creation of the pathways needed to address the increase of automation and the demand for skilled labor, the state must fully fund these formulas, along with providing an additional appropriation for the development of this program. Without state investment, any program without dedicated funding developed by MCCCD could run into budgetary limitations.

As shown by its investments in the health care specialty and aviation programs, along with its $33 million in one-time university funding as a part of the Arizona Board of Regents' New Economy Initiative, the Arizona legislature has shown that it has an

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[56] Diaz, 2018

[57] Joint Legislative Budget Committee, 2020

[58] JLBC Staff, 2021

[59] Maricopa Community College District, 2019c

appetite for funding higher education programs that promise to move Arizona's economy forward.[60] Targeted investment into higher education programs that will prepare workers for the future needs that automation falls into this category, and therefore has a feasible path to legislative approval.

Funding such a program could result in significant economic growth by attracting to Arizona additional investments in autonomous vehicle research. Nationally from (fill in year) through 2023, $61 billion was expected to be spent on autonomous vehicle research—an unknown portion of which has and will go to Arizona. According to a report by economist Jim Rounds, each $1 billion invested in autonomous-vehicle research and development would lead to over 12,295 new jobs in Arizona by 2026.[61] This growth would lead to over $41 million to $57 million in taxes collected in 2026 from the autonomous vehicle sector alone.

Such a large investment would not be necessary for the development of an autonomous education program by MCCCD. PCCCD's program only required the creation of a single course. According to Blair, much of the cost of developing this program came from a federal transportation grant. State funding could be one of many sources to develop such a program, with other potential revenue streams coming from similar federal grants and investments by business partners.

The creation of an autonomous education program by MCCCD, in partnership with PCCCD and other autonomous-vehicle actors and with funding by the state of Arizona, would lead to the creation of new pathways between high-risk jobs and high-skill, low-risk jobs. These pathways would improve economic mobility for those trained and improve the growth of the autonomous vehicle sector in the state. Failing to do so would instead stymie the sector's growth and result in the eventual displacement of 130,000 workers in high-risk jobs, harming the transportation industry as a whole.

Conclusion
Arizona is faced with two potential economic futures for its transportation sector, one bright, the other bleak. In the first future, the state invests significantly in the development of new pathways from high-risk jobs to high-skill, low-risk jobs relating to automation. Consequentially, it experiences significant economic growth and upward mobility for tens of thousands of workers. But in the other future, the state fails to act, resulting in the disruption of 130,180 workers in high-risk jobs. Because 85% of these workers have no college degree, they will struggle to recover from such disruption, placing downward pressure on wages for other low-skilled occupations, both in the transportation sector and elsewhere.

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[60] Aleshire, 2021
[61] Rounds Consulting Group, 2020

Arizona successfully developed one of the world's largest regional autonomous-vehicle sectors. Starting with the arrival of Uber, the sector has since expanded to include hundreds of autonomous vehicles crawling the streets of the East Valley from such companies as Waymo, TuSimple, General Motors, Kroger, and Ryder. However, the state has failed to transform its education system to meet the growing need for high-skilled workers to support the expansion of this industry.

The transportation industry is among the most vulnerable to the economic forces resulting from automation. While the timeline regarding the integration of automation into the transportation sector is uncertain, with the coronavirus making the future of the sector murkier, there exists an overall agreement in the literature that the disruption will be significant. Certain occupations, such as heavy and tractor-trailer truck and personal transit jobs, will likely become automated earlier, placing downward pressure on other high-risk, low-skill transportation jobs.

Transportation is Arizona's fourth-largest occupation group, with over 241,750 Arizonans currently employed in transportation occupations. Transportation jobs offer an opportunity for upward mobility to workers without college degrees, paying more than most other occupations with similar educational requirements. Individuals with only a high school diploma can make 18% more than the state average by working in a transportation occupation. The prospect of good-paying, stable jobs attracts workers without college degrees to the sector, yet these same jobs face significant risks of automation.

Out of the 227,680 transportation jobs in Arizona, 130,180 (or 54%) are at a high risk of automation, with more than 70% of the tasks associated with those jobs being automatable. There are 91,510 jobs (38%) at a medium risk of automation, with between 30% to 70% of the tasks associated with those jobs being automatable. Eighty-five percent of workers in high-risk positions have no college degree, while 83% of workers in medium-risk jobs hold no college degree. High-risk jobs and medium-risk jobs also have lower median pay than low-risk jobs. The combination of low levels of education with lower pay makes these workers especially vulnerable to economic hardship should their job be disrupted by automation.

These workers could benefit, rather than suffer, from automation if formal pathways from high-risk jobs to high-skill, low-risk jobs become available. ACA's IAM should expand its mission to also examine the human capital needs that the sector will have as it further adopts automation technology and should include voices from Arizona's community colleges to determine how best to do so. Additionally, to ensure that community colleges have the resources necessary to create these pathways, the state should fully fund MCCCD and PCCCD to their statutory requirements and make targeted investments in the development of these programs.

PCCCD's AVDOSC program   offers   an autonomous vehicle driver and operations specialist certificate program   to CDL drivers. MCCCD should form corporate partnerships and develop similar educational programs that can be scaled, creating pathways and upward mobility for tens of thousands of workers while driving economic expansion for the state.

Arizona is poised with a unique opportunity to integrate the autonomous vehicle sector into the regional economy. While this report focuses on workers in high-risk jobs, such an investment would lead to the continual growth of autonomous-vehicle companies, creating jobs in areas such as engineering, IT, and business management. Rather than create suffering, automation would transform our economy and transportation landscape, resulting not just in economic prosperity, but safer communities thanks to fewer person-operated vehicles on the road. This bright future is within our grasp, all that waits is for us to reach out and seize the opportunity.

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Appendix A: Methodology

How many transportation workers in Arizona are in jobs with a high risk of automation? To answer this question, this report utilizes the findings of Frey and Osborn (2013), who estimate the likelihood of automation for all occupations classified in the U.S. government's Standard Occupational Classification (SOC) system.[62] These estimates are then matched with Bureau of Labor Statistics (BLS) occupation data for 2019 specific to Arizona.[63]

As stated earlier, research articles generally classify occupations as "low-risk" if less than 30% of tasks in that occupation can potentially be automated, "medium risk" for 30% to 70% automation potential, and "high risk" if there is a greater than 70% automation potential. Occupations in Arizona that are considered high-risk are therefore designated as any occupation identified by Frey and Osborn (2013) as having a greater than 70% potential for automation.[64]

BLS data for average educational attainment for each occupation is then added to the dataset.[65]   While occupation data is specific to Arizona, average education levels are national. Workers with no college degree are determined based on the percentage of workers with less than a high school diploma, a high school diploma or equivalent, and some college.

Of the 227,680 transportation workers in Arizona, 1,550 worked in occupations that were not assigned an automation potential score by Frey and Osborn. Consequentially, these workers were not classified.

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[62] Frey & Osborn, 2013
[63] Bureau of Labor Statistics, 2019a
[64] Frey & Osborn, 2013
[65] Bureau of Labor Statistics, 2019b

Appendix C: Occupation-Level Details of Arizona's Transportation Sector

Table 1A

High-Risk Transportation-Sector Occupations in Arizona

OCC Code	OCC Title	Employment	Median Salary	Automation Potential	No College Degree	Less Than High School	High School/GED	Some College	Associate's Degree	Bachelor's Degree	Master's Degree	Doctorate
53-7062	Laborers and Freight, Stock, and Material Movers, Hand	57860.0	30,580	0.85	86	16.8	47.7	21.5	6.2	6.5	1	0
53-3032	Heavy and Tractor-Trailer Truck Drivers	30830.0	47,040	0.79	85.8	15.5	47.2	23.1	6.7	6.4	0.9	0
53-3058	Passenger Vehicle Drivers, Except Bus Drivers, Transit and Intercity	11180.0	30,790	0.89	73.6	10.5	36.3	26.8	8.7	13.7	3.1	1
53-7051	Industrial Truck and Tractor Operators	10910.0	36,820	0.93	90.5	18.6	51	20.9	5.5	3.4	0.4	0
53-3031	Driver/Sales Workers	8450.0	25,990	0.98	85.8	15.5	47.2	23.1	6.7	6.4	0.9	0
53-6021	Parking Attendants	4460.0	27,640	0.87	79.6	11.7	44.3	23.6	7.8	10.1	1.7	1
53-7081	Refuse and Recyclable Material Collectors	2800.0	38,120	0.93	86.1	26.4	44.7	15	6.1	7.3	0.3	0
53-6031	Automotive and Watercraft Service Attendants	2010.0	28,940	0.83	84.6	15	44.6	25	8.3	6.1	0.9	0

**Estimates not released by the Bureau of Labor Statistics

OCC Code	OCC Title	Employment	Median Salary	Automation Potential	No College Degree	Less Than High School	High School/GED	Some College	Associate's Degree	Bachelor's Degree	Master's Degree	Doctorate
53-6051	Transportation Inspectors	520.0	63,580	0.9	63.5	5.7	28.2	29.6	13.2	20.5	2	1
53-7063	Machine Feeders and Offbearers	460.0	31,260	0.93	84.8	19.2	51.9	13.7	5.5	8.1	1.1	1
53-7011	Conveyor Operators and Tenders	170.0	31,590	0.93	95.3	16.9	56.9	21.5	2.6	1.7	0.3	0
53-6041	Traffic Technicians	160.0	50,590	0.9	70.3	5.6	40	24.7	12	15.7	1.7	0
53-2022	Airfield Operations Specialists	120.0	67,270	0.71	42.9	0.4	11.9	30.6	15.3	35	6.3	1
53-7072	Pump Operators, Except Wellhead Pumpers	110.0	52,750	0.9	76.1	15.8	40.1	20.2	8.5	12.9	2.5	0
53-7121	Tank Car, Truck, and Ship Loaders	70.0	49,490	0.72	86.6	17.4	49.6	19.6	6.2	5.8	1.4	0
53-6061	Passenger Attendants	70.0	26,040	0.75	82.1	14.1	42.5	25.5	9	6.8	2.1	0
53-4022	Railroad Brake, Signal, and Switch Operators and Locomotive Firers	**	48,220	0.83	76	3.3	35.8	36.9	9	11.4	3.5	0
53-4031	Railroad Conductors and Yardmasters	**	55,360	0.83	77.3	1.7	39.9	35.7	10.3	11.6	0.7	0
53-7021	Crane and Tower Operators	**	72,280	0.9	87.5	12.2	54.3	21	7.2	4.8	0.3	0
53-4011	Locomotive Engineers	**	56,480	0.96	77.2	1.5	41.1	34.6	10.1	10.3	2.1	0

Table 2A

Educational Attainment (Weighted Average) for High-Risk Occupations

No College Degree	Less Than High School	High School/GED	Some College	Associate's Degree	Bachelor's Degree	Master's Degree	Doctorate
85%	16%	47%	22%	7%	7%	1%	0%

Table 3A

Summary Statistics for High-Risk Occupations

Total High-Risk Jobs	130,180
Percent of Total Transportation-Sector Jobs	54%
Median Pay—Weighted Average	$34,977.75

Table 4A

Medium-Risk Transportation-Sector Occupations in Arizona

OCC Code	OCC Title	Employment	Median Salary	Automation Potential	No College Degree	Less Than High School	High School/GED	Some College	Associate's Degree	Bachelor's Degree	Master's Degree	Doctorate
53-7065	Stockers and Order Fillers	51380	29,830	0.64	81.2	13.2	42.8	25.2	8.1	9	1	0.3
53-3033	Light Truck Drivers	17610	36,390	0.69	85.8	15.5	47.2	23.1	6.7	6.4	1	0.3
53-7064	Packers and Packagers, Hand	10090	26,520	0.38	87.4	30.3	40.5	16.6	5.7	5.8	1	0.4
53-7061	Cleaners of Vehicles and Equipment	7680	26,260	0.37	88.4	27.1	44.8	16.5	6.1	4.7	1	0.2
53-3052	Bus Drivers, Transit and Intercity	3680	44,670	0.67	78.8	8.4	40.8	29.6	9.9	9.3	2	0.4
53-2012	Commercial Pilots	1070	79,200	0.55	19.7	0.8	4.8	14.1	7.9	56.9	13	2.6
53-5022	Motorboat Operators	**	50,770	0.62	71.3	8.7	33.5	29.1	5.9	17.4	5	0.9

Table 5A

Educational Attainment (Weighted Average) for Medium-Risk Occupations

No College Degree	Less Than High School	High School/GED	Some College	Associate's Degree	Bachelor's Degree	Master's Degree	Doctorate
83%	16%	43%	23%	7%	8%	1%	0%

Table 6A

Summary Statistics for Medium-Risk Occupations

Total High-Risk Jobs	91,510
Percent of Total Transportation-Sector Jobs	38%
Median Pay—Weighted Average	$31601.86

Table 7A

Low-Risk Transportation-Sector Occupations in Arizona

OCC Code	OCC Title	Employment	Median Salary	Automation Potential	No College Degree	Less Than High School	High School/GED	Some College	Associate's Degree	Bachelor's Degree	Master's Degree	Doctorate
53-1047	First-Line Supervisors of Transportation and Material Moving Workers, Except Aircraft Cargo Handling Supervisors	10350	53,090	0.029	72.6	6.7	37	28.9	10.5	15	2.1	0
53-2011	Airline Pilots, Copilots, and Flight Engineers	1850	130,140	0.18	19.7	0.8	4.8	14.1	7.9	57	12.9	3
53-2021	Air Traffic Controllers	400	111,110	0.11	42.9	0.4	11.9	30.6	15.3	35	6.3	1
53-3011	Ambulance Drivers and Attendants, Except Emergency Medical Technicians	200	33,080	0.25	78.3	1	45	32.3	10.3	11	0.9	0
53-1041	Aircraft Cargo Handling Supervisors	190	41,030	0.066	72.6	6.7	37	28.9	10.5	15	2.1	0

Table 8A

Educational Attainment (Weighted Average) for Low-Risk Occupations

No College Degree	Less Than High School	High School/GED	Some College	Associate's Degree	Bachelor's Degree	Master's Degree	Doctorate
64%	6%	32%	27%	10%	21%	4%	1%

Table 9A

Summary Statistics for Low-Risk Occupations

Total High-Risk Jobs	12,990
Percent of Total Transportation-Sector Jobs	5%
Median Pay—Weighted Average	$65,365.37