Benchmarking Public Opinion on Automated Vehicles:

Comparing Toronto to Other Jurisdictions

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Executive Summary

In the face of rapid technological change, there is no shortage of speculation about the potential far-reaching consequences of automated vehicles (AVs) on our economies, cities, and daily activities. Outcomes will depend on how individual consumers choose to respond to this emerging technology. Public opinion remains malleable, and has been shown to rely to a large extent on one's familiarity with AVs. Moreover, public opinion research on AVs remains at a formative stage, and cross-jurisdictional comparisons based on subjective assessments of consumer preferences are tenuous. Recognizing these challenges, this report presents an assessment of the current state of public opinion on AVs, with comparisons between Toronto and other jurisdictions. These findings provide a point of reference in understanding where Toronto stands today and in determining what preparations may be desired.

Willingness to Use AVs

Numerous studies in North America, Europe, and Australia found between one half to two thirds of people were willing to use an AV. In focus group scenarios that provided an opportunity to educate participants, willingness to use generally increased as more information was provided. Men and younger people tend to be more enthusiastic than females and older individuals. A Toronto survey found 52% of respondents were at least somewhat interested in using an AV (Schoettle & Sivak, 2014; KPMG, 2013; Olsen, Laidlaw & Sweet, 2018).

Concerns Regarding the Technology

Levels of stated concern surrounding vehicle automation are similar in Canada and other Anglosphere countries (US, UK, Australia), with around 50% of people queried stating they are generally concerned by the technology. In terms of specific, qualitative concerns, it is apparent that GTHA residents are very similar to their international counterparts, with areas of major concern including privacy, ethics, liability and safety. In many cases, these concerns are fundamentally about further information and clarity, but it is also clear that, as far as the public is concerned, there is need for further work to resolve apparent issues within these topics (Elegant E-Learning, 2017; Schoettle & Sivak, 2014).

Opinion on the Government's Role

Currently there appears to be an ambivalence in the global public regarding the desired role for government in relation to AV technology. When assessing the public opinion on AVs from Toronto (and Canada overall) and other jurisdictions (mainly the US), it is clear that there is an agreement that the government has a role to play. A 2016 GTHA survey found 74% support for government efforts to regulate and support the use of AVs. While supporting government

involvement in principle, there is a general sentiment that too much intervention may lead to over-regulation of the AV industry, resulting in the unreasonable restriction and delay of AV technology, and its expected benefits. In Toronto especially, there is also clear opposition to any government efforts that would require higher taxes (Olsen, Laidlaw & Sweet, 2018).

Beliefs Regarding Why Automation/AVs Are Beneficial

Safety benefits are widely noted in numerous public opinion surveys. Other benefits reported in surveys include the potential to engage in other activities while driving, increased convenience and quality of life, benefits for those with mobility limitations, environmental benefits such as reduced emissions, and reduced costs for parking and insurance. A New York survey noted congestion reduction as the second priority, after safety benefits. Several international surveys note broad optimism. Toronto studies find similar results, with safety and benefits for people with disabilities among the most commonly cited benefits (Lustgarten & Levine, 2017; Sweet, Comeau & Olsen, 2018).

Consumer/Price Considerations

Pricing incentives and disincentives may be effective policy levers in managing consumer adoption of AVs. Several surveys have found limited consumer willingness to pay for automation features, with one quarter of US and UK respondents willing to spend $2,000 (USD) to add full automation and half of respondents not willing to pay any extra amount at all. A GTHA survey found much higher willingness to pay compared to these international studies, with only 28% unwilling to pay extra and 25% willing to pay between $3,750 and $7,500 (USD). However, an Austin, Texas study found even higher measures of willingness to pay, as compared to Toronto. These discrepancies may be due to the scope of the surveys compared (i.e. national vs. the urbanized GTHA), potentially identifying a need for further urban-scale research of consumer demand to better benchmark Toronto (Schoettle & Sivak, 2014; Olsen, Laidlaw and Sweet, 2018; Bansal, Kockelman & Singh, 2016).

Introduction

Vehicle automation is emerging at a rapid rate, with potentially far-reaching consequences — beneficial and detrimental — for our economies, cities and daily activities. There is an abundance of speculation on the topic in academia and elsewhere, regarding the potential consequences, the implementation timeline, and what the public and private sectors could do to maximize the net benefit of automated vehicles (AVs). While undeniably valuable, this research on AVs necessarily relies on expert estimations or extrapolations based on past technological progress.

However, in dealing with this new and potentially disruptive technology, past trends or previous experience may not serve as reliable indicators (CAVCOE, 2018). Ultimately, the overall outcome will depend on how individual consumers choose to respond to the regulations and technologies. To better inform predictions, empirical data is needed to understand how members of the public perceive the technology, how likely they are to adopt and use AVs, as well as the public appetite for various forms of regulation.

The body of research on public opinion of vehicle automation is in its formative stage, gathering breadth of coverage in different countries, regions, and cities (Lustgarten & Le Vine, 2017). Given the subjectivity of public opinion/consumer preference, as well as the potential for variation across jurisdictions, conclusions must be understood as context-specific, with sampling across numerous contexts needed if overall generalizations are to be made. There is still room for wider analysis to be done, but initial returns allow for a preliminary review.

This report will review existing international studies and then benchmark them against data available for Toronto, to situate Toronto's public opinion in comparison to other jurisdictions—highlighting differences and, where they exist, global similarities. The findings are organized by the following five topics of interest:

1. Willingness to use AVs
2. Concerns regarding the technology
3. Opinion on the government's role in regulating AVs
4. Beliefs regarding why automation/AVs are beneficial
5. Consumer/price considerations

It is important to consider that opinions observed are subject to change, especially with regards to AVs, where so much is still uncertain regarding the future forms of the technology, many people are still relatively unfamiliar, and marketing initiatives to shape public perception are still very much in their infancy. A respondent's willingness can vary greatly with their level of information and familiarity with AVs (KPMG, 2013). The studies included in this report

represent snapshots in time. They are all apt to change as the technology solidifies, as familiarity builds, and as information proliferates. For the moment, however, the findings provide a valuable point of reference for better understanding Toronto as it stands currently, predicting its AV future and determining what preparations may be desired.

Willingness to Use AVs

Numerous studies from various countries have examined the public's willingness to use AVs. In many cases, these studies have explored the monetary amount that an individual would be willing to pay to purchase a car with automated capabilities or to access a shared fleet service. This section will focus on the broad demographic factors underlying general willingness to use AVs either in a privately owned or shared fleet model. The pricing implications and other ensuing questions regarding individuals' willingness to pay for AVs will be discussed in the *Consumer/Price Considerations* section.

Other jurisdictions

KPMG (2013) conducted one of the earliest studies on consumer willingness to use AVs through a series of focus groups in Los Angeles, Chicago, and Iselin, New Jersey (a suburb of New York City). Recognizing that small focus groups do not provide a statistically valid prediction of the broader population's sentiment, the results are nonetheless informative in identifying a diversity of perspectives.

Importantly, the study found that participants' willingness to use AVs changed considerably over the course of a two-hour session as more information about AVs was provided and participants had an opportunity to discuss the implications. Participants responded favourably when informed that AVs could reduce commute times, reduce variability in travel time, and provide the ability to turn on or off the AV functionality. It was found that consumers trust technology companies more than automobile manufacturers, suggesting that there may be greater willingness to use an Apple or Google AV, rather than one produced by a traditional car manufacturer. Aesthetics and emotional factors were perceived as important, with those expressing a passion for the experience of driving also indicating less willingness to adopt AVs. Women were slightly more receptive than men regarding to AV use (a finding that was contradictory to most other studies), with some males expressing resentment that an AV would adhere to speed limits and be less likely to weave through traffic. Participants in Los Angeles expressed a greater likelihood to adopt AVs earlier than respondents in Chicago (KPMG, 2013).

A later survey (Schoettle & Sivak, 2014) assessed public opinion in the US, UK, Australia, China, India, and Japan. Across all countries, more than 3 in 4 respondents were "very concerned" or "moderately concerned" about riding in an AV without manual controls. However, the majority of respondents were also willing to have AV capabilities in their vehicle, with respondents from China and India most interested and those from Japan showing the least interest. The results of interest in AV capabilities are shown in the following table:

Table 1 Interest in Having AV Capabilities in Your Vehicle

	China	*India*	*Japan*	*U.S.*	*U.K.*	*Australia*
Not interested	3.6%	4.7%	22.7%	33.7%	36.6%	32.3%
Slightly interested	20.0%	15.4%	36.6%	22.4%	22.8%	26.5%
Moderately interested	36.2%	33.0%	32.1%	22.6%	22.6%	27.3%
Very interested	40.2%	46.9%	8.5%	21.4%	18.0%	13.9%

Source: Schoettle & Sivak, 2014

A 2015 study by McKinsey & Company examined consumer perspectives in the US, Germany, and China. Similar to the KPMG study, respondents were much more receptive to purchasing an AV if it came with an option to turn on or off AV functionalities. As shown in the table that follows, willingness to purchase varied considerably between the three countries, with American respondents least likely to choose an AV (67%), and Germans valuing the ability to manually drive the vehicle.

Table 2 Willingness to Purchase AVs in Different Formats

		U.S.	*Germany*	*China*
Willingness to Choose a Car With…	…AV Mode only	40%	33%	76%
	…Both Conventional and AV Mode options	67%	76%	93%

Source: McKinsey & Company, 2015

There have been several studies in Texas that examined consumer willingness to adopt AVs. A Texas-wide survey (Bansal and Kockelman, 2015) found 50% were "moderately interested" or "very interested" in level 4 AVs. Only 14% were interested in being early adopters, with 32% responding that they would adopt when half their friends were using AVs and 39% stating that they would never adopt a level 4 AV. Most were interested in private vehicle ownership, with only 7.3% hoping to rely entirely on shared fleet services. Older individuals were less enthusiastic about AVs, and males were more likely than females to prefer automation. Another study of Austin, Texas residents (Zmud et al., 2016) also found 50% willingness to use AVs, with 14% "extremely likely" to adopt and 36% "somewhat likely". Again, males were more likely than females to use AVs. However, this study suggests that age did not play a significant role, with a non-linear association between age segments and willingness to adopt. Importantly, all 11 respondents with mobility restricting disabilities were likely to use an AV.

A study in La Rochelle, France (Piao et al., 2016) found that more than half of respondents would consider using AVs if they became available. One in three was not interested in AVs at all. The majority preferred to own, although there was more interest in shared fleet services compared to the Texas studies, with 27% wishing to use an SAV.

A survey of 1603 respondents in Germany (Hohenberger, 2016) sought to gain a better understanding of gender differences commonly found in the literature. It was found that affective responses of anxiety and pleasure explain why males are more likely to be willing to adopt AVs than females. Females have more concerns about AVs and tend to express greater anxiety about potential problems with AVs, whereas males were found to have more positive associations with AVs.

Looking to other Canadian jurisdictions, an Alberta study (Platt, 2017) of drivers in Edmonton and Calgary found that more than half would be willing to use an AV, but only if further testing shows they are safe and reliable. Contrary to some other studies, this research found the greatest willingness to use was among older adults over the age of 50.

Toronto

In the Toronto area, the most extensive research on public opinion has been conducted by Ryerson University's Transportation and Land Use Research Laboratory (TransForm). A 2016 survey of 3201 adults in the Greater Toronto and Hamilton Area assessed interest to use AVs and willingness to purchase a vehicle with self-driving capabilities. Qualitative data was also collected through a series of small focus groups in 2017 and 2018.

The survey data (Olsen, Laidlaw, & Sweet, 2016) shows results that are comparable to other jurisdictions. More than half (52%) of respondents were at least somewhat interested in using an AV, with 27% unsure and 21% uninterested. A strong age effect was observed, with 64% of those under 35 being somewhat or very interested in regularly using an AV, compared to 38% of those over 55 years old. A gender effect was also noted, with 58% of males expressing interest compared to 48% of females.

Respondents were asked how soon they would be willing to purchase an AV. About one in ten (9.8%) would buy one as soon as they become available, while the largest group (31.3%) would wait until half of their friends own one. A further 30.2% stated that they had no intention of purchasing an AV.

Willingness to use shared fleet services varied significantly with price. About a third (31%) had no intention of ever using SAV services, even at the lowest price point. Most expected to use an SAV only occasionally. At the lowest price point, 31% stated they would use SAVs less than once a month, and 24% expecting to use them between one and three times a month. Only 1 to 3% expected to use an SAV daily. Only 34% were willing to share a ride with others, with 27.4% unsure and 38.6% opposed. Males were more willing to share a ride with a stranger than females (39% vs 30%), and increased age was negatively correlated with willingness. In addition, residents of the City of Toronto were marginally more interested in residing in a neighbourhood with high access to SAV services.

The subsequent focus groups provide insight into some of the reasons why individuals may be willing or unwilling to use an AV. Many participants expressed a cautious, wait and see approach, with one expressing "I need to make sure the safety issues have been worked out first. I don't want to feel like I'm a test pilot."

Aesthetic and emotional factors were frequently raised. One participant felt it would be "really

weird" to be sitting in front of a steering wheel without touching it. "You'll have the instinct to grab the wheel," another said. There was a sense of loss of individual expression, both aesthetically and in terms of driving style. One participant wondered whether an AV could be reprogrammed "to be more aggressive off the stoplight, so it doesn't become just like a vanilla experience?" If all cars drive the same, "would you really want a Porsche?" Image and style considerations were especially important to young male respondents, with the prototype Google car called out as looking "pretty bad" and "clunky". Not all participants agreed; one felt that "a car is just a box which gets me somewhere. The part about the image of it will fade away."

Contrary to the survey results, most focus group participants indicated a preference for the shared ownership model. "No, I don't want one parked in my driveway. I want to call one up," said one participant. However, consistent with the survey, many individuals felt that SAVs would be used infrequently, and primarily for special trips such as completing an errand that would be difficult without a car. Participants generally viewed SAVs as only one component of a future transportation system that would comprise a diverse array of transportation modes.

There was a strong willingness to use an AV to pick something or somebody up, for example to place an online order and have an AV go to the store to pick it up. However, there were questions around the appropriateness of allowing children to be transported unsupervised in an AV.

Willingness to use an AV for longer trips was dependent on the perceived pleasure of the driving experience. One person felt they would "end up in a car more often than I do now. The fatigue and boredom of long drives would be gone for me." Others thought it would still be more enjoyable to travel by other modes, such as the train: "Am I going to go 120 kilometers an hour down the 401 to Montreal with my hands on my knees? I don't think so."

Perhaps the most significant conclusion from the focus groups is that willingness to use an AV might significantly change with new information or education, and that there appears to be a major role for public education. The quantitative survey data revealed that seniors and those with mobility challenges were less willing to use an AV, even though increased mobility for these groups is often touted as a major benefit of AVs. One participant who initially expressed considerable apprehension about AVs had a different viewpoint after watching a three-minute video of a blind man using an AV. People with mobility constraints were very enthusiastic but had many questions about the details. There are many concerns related to getting into and out of the vehicle and moving from the vehicle to the building entrance. One participant summed it up by saying "I don't understand the last 100 feet and the first 100 feet of the trip."

Discussion

Significant variations in public opinion are noted throughout the literature. Respondents in China and India are the most willing to use AVs, with two separate studies reporting over 90% willingness to use AVs in China. Results from Anglosphere countries find a range of about 40% to 67% willingness to use AVs, with both extremes of this range coming from the same KPMG study — in this case, willingness to use increased significantly when AV functionality could be manually turned on or off. The 52% willingness found in a GTHA survey falls near the middle of this range, and is comparable to results from several studies in Texas and one in France. Results from a study in Edmonton and Calgary also produced similar results. This suggests that GTHA residents are about as willing to use an AV as those in other regions of Canada, the US, or Europe.

A "wait and see" consumer approach is widely noted in many surveys and focus groups, with attitudes in the GTHA largely consistent with other Canadian and American jurisdictions. About 10% of GTHA respondents were willing to be early adopters of AVs, compared to 14% in a Texas study. In both the GTHA and Texas, the largest number of respondents (31% to 32%) stated that they would wait until half of their friends had adopted an AV. Meanwhile in Alberta, willingness to use was strongly predicated on further testing to establish the safety and reliability of AVs. GTHA respondents were less likely to state that they would never adopt an AV, at 30% compared to 39% in Texas.

Concerns Regarding the Technology

The level of public concern towards AVs can be understood in two ways through the research. First, in terms of a general concern: an overall sense of worry or apprehension towards using the technology. The more concern there is in a population, the more resistant it will likely be to AV technology, prolonging its adoption—and the onset of potential collective benefits to safety and congestion. High general concern may also be an indication of a public with an appetite for greater oversight and regulation of the technology.

In the second view, some research dives further into understanding the nature of the concern. Typically this is done through more qualitative approaches, attempting to understand what it is, in particular, that causes consumers to be apprehensive. This provides insights into which issues could be prioritized in public and private sector efforts to prepare for vehicle automation. This may be a matter of concentrated efforts on informing the public about perceived issues—in this early, uncertain stage, information appears to be a key tool for allaying concern with AVs—or it may indicate where, indeed, more resources should be directed to ensure the technology and regulation adequately address actual problems.

This section will cover, where possible, both elements of concern. First it will touch on international research and then draw comparisons with results seen in Canada and Toronto.

Other Jurisdictions

In terms of measures of general concern, research conducted by Schoettle and Sivak (2014) on the opinions of the public in China, India, Japan, US, UK and Australia indicate that though all countries show similar levels of moderately concerned consumers (around 30%), there are large differences among those that are highly concerned. This seems to make the difference in the total general concern.

India is, by a large margin, the most concerned with around 80% of the public polled expressing some level of concern over driving fully automated vehicles. The Anglosphere countries indicate less concern than India, with roughly a 50-60% share of concerned population. China appears to be the least concerned, with under half of the population expressing concern.

With regards to specifics, available research suggests there are four consistent areas of concern in public opinion surrounding AVs (Lee, 2017; Schoettle & Sivak, 2014):

1. Cybersecurity and Privacy
2. Ethics
3. Liability/Legal Issues
4. Safety

Cybersecurity and Privacy

AVs will potentially collect a substantial amount of information to determine their surroundings, to find appropriate routes, and to coexist with other vehicles. People are uncertain who will get access to the information their vehicles collect. How and what data will be stored onboard and for how long? How and what data will be shared with others? And does the consumer have control over what data can be collected or shared? There is a concern that the collection of data might lead people to believe that their car is “spying” on them. There is also a concern that AVs could be hacked, revealing people’s personal data and potentially causing their vehicle to drive to unexpected locations (Lee, 2017).

In 2015, McKinsey surveyed consumers regarding connected and automated cars in Germany (sample size: *n* = 1,123), the US (*n* = 1,051) and China (*n* = 1,010). The survey revealed that 37% of respondents were "highly concerned" about the digital safety and data privacy issues of connected and automated cars (McKinsey, 2015). Comparatively, a survey conducted in France on public opinions highlighted concerns regarding hacking, as participants raised significant concerns that their travel locations might be disclosed, a perceived breach of privacy (Piao et al., 2016).

Research in Austin, Texas found that respondents consistently brought up hacking and identity theft among their concerns with AVs. There was a specific concern related to how an AV would differentiate between its true owner and a thief. (Zmud et al., 2016).

A recent public opinion survey conducted in Australia highlights hacking or the fear of potential hacking as one of the most common concerns with AV technology. Further respondents indicated that this concern, in their mind, remained a problem that still needed to be addressed. (Koing & Neumayr, 2017). Similarly, a survey in La Rochelle, France, found 54% of respondents reported they were very concerned about hacking in particular.

Ethics

AVs will be involved in challenging ethical choices, literally taking human lives into account—passengers, pedestrians and riders in other vehicles. While AVs are anticipated to reduce vehicle collisions, it is also inevitable that situations will arise where the vehicle’s systems will be in control of or at least influence a driver’s ethical choices made in emergency situations where harm is unavoidable (Bonnefon et al., 2016).

A public opinion study conducted in the United States on ethical decisions revealed that a majority of respondents reported that AVs should be programmed following a utilitarian model, killing the fewest number of people when possible, even if that meant the passenger (the respondents themselves) in the AV. Interestingly, the same respondents reported being less

likely to purchase an AV, knowing that it may sacrifice themselves or their loved ones for the greater good (Bonnefon et al., 2016).

Similarly, a study completed by Schoettle & Sivak (2014) on public opinion found the top concern amongst people in the United States (53.1%) and Japan (32.3%) was how AVs will react when confronted with unexpected situations.

Liability/Legal Issues

There is significant uncertainty when it comes to liability and legal concerns regarding AVs. Who will be held responsible if there is a collision? How is responsibility determined? Could the technology somehow fail and who, then, would be at fault? Addressing the legal complications that could arise in a future where AVs are commonplace will be an important element in paving the way for the technology's adoption.

A survey conducted by Howard & Dai (2017) on AVs in the United States found that people still feel the liability framework for AVs is uncertain and unresolved. Many respondents felt that they regularly experienced failures in our increasingly technology reliant world and felt that AVs might also be an unreliable form of technology. They expected that AVs would still have collisions, and believed there should be a framework for resolving the ensuing liability issues.

Similarly, respondents for a study conducted in Austin, Texas noted there are often bugs or glitches in technology when it is first released, which can potentially lead to malfunctions causing a collision or potentially leaving the passenger or vehicle owner stranded. They wanted clear answers on how such a situation would be fixed. (Zmud, 2016).

Respondents to public opinion surveys in France, and Austria, found that liability was a leading cause of concern for people (Piao et al., 2016; Koing & Neumayr, 2017). Similarly, more than 90% of respondents in a survey administered in six countries (China, India, Japan, U.S, U.K, and Australia) were at least "slightly concerned" about the legal liability of drivers and owners of self-driving vehicles" (Schoettle & Sivak, 2014).

Safety

Various reports and studies indicate the prevalence of safety concerns relating to AVs.

Pew Research Centre (2017) found that "roughly 7 in 10 Americans who would not want to ride in a driverless vehicle mention a lack of trust, a fear of losing control and/or general safety concerns when asked why they would not want to use the technology."

Two recent reports released in 2017 and 2018 indicated that 87% and 84% of Americans, respectively, would favour a requirement that all driverless vehicles have a human in the driver

seat who can take control of the vehicle in the event of an emergency (Pew Research Centre, 2017; Advocates for Highway & Auto Safety, 2018). Likewise, a survey administered in Berkeley, California confirmed a dominant concern for safety from respondents.

Schoettle & Sivak (2014) found that safety was a concern for substantial shares of people in China (68%), India (59%), UK (45%) and Australia (44%).

Similarly, a recent study conducted in La Rochelle, France found that the public is concerned with the safety of using automated buses, especially the use of riding in automated buses when there are no staff present on board during the evening and nighttime services (Piao et al., 2016). In Austria, survey results across all sub-groups indicated a high degree of concern relating to trusting their safety to an unfamiliar technology (Koing & Neumayr, 2017).

Toronto

This report was not able to identify research that measured the level of concern of Toronto or Toronto-region residents with regards to AVs—a clear opportunity for future research to address. However, Canadian national research is available. A poll of visitors (sample size: $n >$ 20,000) to Canadian driver's education websites—a sample that, admittedly, skews to a younger demographic with roughly 75% under the age of 35—indicated that nearly 55% expressed some level of concern riding in fully automated vehicles.

Table 3 Respondents Concerned About Using a Fully Automated Vehicle

	Canada	*China*	*India*	*Japan*	*US*	*UK*	*Australia*
Very Concerned	30.0%	12.3%	40.4%	19.8%	35.9%	26.0%	27.9%
Moderately Concerned	25.0%	36.7%	38.5%	32.5%	30.9%	31.1%	29.5%
Total Concerned	**55.0%**	**49.0%**	**78.9%**	**52.3%**	**66.8%**	**57.1%**	**57.4%**

Source: Elegant E-Learning, 2017; Schoettle & Sivak, 2014

Benchmarking this result internationally, it is fairly similar to results seen in other Anglosphere countries, with similar breakdown between moderate and extreme concern. Currently, this is the closest indicator for what Toronto's level of general concern may be.

In terms of more specific concerns, in 2017 Ryerson University's Transportation and Land Use Research Laboratory (TransForm) conducted focus groups investigating the qualitative nature

of concerns of GTHA residents regarding AVs. Ultimately, these can be organized along similar lines to global findings: cybersecurity and privacy, ethics, liability/legal implications, and safety.

The study found that individuals desire clarity and details on the insurance system for AVs. Participants raised questions and concerns relating to the course of action in the event of a collision, what the transition period will look like, and how insurance companies will navigate situations involving a collision between an AV and a non-automated vehicle. Participants also expressed the concern that various car manufacturers might implement different technology systems in their AVs, and felt that it would be better if it were standardized across all vehicles (Sweet, Comeau & Olsen, 2018).

Respondents expressed concerns around morality and the decisions to be made by an AV in emergency situations. Would they protect the riders, the pedestrians, or the other objects and vehicles on the road?

Almost all respondents in the focus groups articulated an apprehension for the safety of using AVs. Some respondents expressed uncertainty regarding the technology, and indicated that they would not be early adopters. In a survey conducted in 2016, 47.3% of respondents in the GTHA agreed that driving gives them a sense of control (Laidlaw et al., 2018). Several focus group participants were surprised that others would consider putting their lives in the hands of technology. Another common theme from the focus groups was a concern for hacking—specifically the fear that AVs might be hacked, a stranger might take control of the car and gain access to the riders' personal information (Sweet, Comeau, & Olsen, 2018).

Discussion

To the extent that the Canadian research can be taken as an indication of Toronto's level of general concern, it would place it on a similar footing to other Anglosphere countries such as the UK, US and Australia. Roughly half of the population expresses general concern towards using a fully automated vehicle, approximately evenly split between those of moderate and extreme concern. This is far less general concern than India (around 80%), but a little more than China where a slight majority do not express general concern.

In terms of specific, qualitative concerns, it is apparent that GTHA residents are very similar to their international counterparts, with major concerns classifiable as relating to:

1. Cybersecurity and Privacy
2. Ethics
3. Liability/Legal Issues
4. Safety

In many cases, these concerns may be mitigated through further information and clarification, but it is also clear that, as far as the public is concerned, there is need for further work to resolve these topics.

Opinion on the Government's Role in Regulating AVs

Governments around the world are currently investing efforts, resources, and time to develop a framework that will regulate and govern the implementation and use of AVs. Thus, it is crucial to understand the efforts governments are making to ensure that the positive externalities of AVs are satisfying the public interest and that the negative externalities and impacts are controlled and minimized.

This section is divided into two parts. The first will discuss the international public opinion and expectations of how governments should be involved in the AV industry. It will address the current governance practices in regulating AVs. It will also delve into the intersection of government with the moral dilemma associated with AVs, user data privacy management, and employment. The final portion of this section will focus on the Toronto context.

Other Jurisdictions

International

The American government is attempting to develop a framework that will regulate AVs, taking into consideration their ethical, legal and safety aspects, as well as commercial viability and social impact. Considering that approximately 56% of Americans expects cars to become completely driverless in the next 50 years, this endeavor could be crucial in determining future outcomes (Hao, 2017). The National Highway Traffic Safety Administration (NHTSA) is currently supporting research that involves AVs, human interactions with AVs, and the safety performance and requirements of the vehicles. In addition, the federal government has been investing funds into research and pilot programs, while encouraging the private sector to invest in the AV industry (Isaac, 2017).

European countries such as Sweden, Germany, and the United Kingdom are also in the process of developing regulations regarding AV technologies and conducting research and testing. Isaac (2017) has identified that government officials from various European countries are waiting for policies and regulations to be issued by the government of the United States, in order to set a precedent for developing a framework that will govern the European AV industry.

In order to implement appropriate regulations, governments should be making investments in the development, testing, integration, and deployment of AVs on public roads and highways (Hanna & Kimmel, 2017). In 2016, the United States Department of Transportation released a 15-point safety standard, encompassing a wide range of topics such as technology failure, passenger privacy, collision liability, etc. These guidelines were designed to be flexible in order to permit freedom for automakers and technology companies to invest in the AV industry

without being constrained by over-regulation (Kang, 2016).

Observing survey results from the PEW Research Centre, it is clear that the level of policy and regulation imposed by the government on the AV industry is an important factor in the public's willingness to embrace this new technology. Surveys indicate 74% of Americans that have identified themselves as AV enthusiasts expressed low levels of worry about the overall impact AVs may or will have on society. However, crucially, the group of enthusiasts did not support the notion of governments restricting AV use to certain designated areas, with only 16% in favor (Smith & Anderson, 2017). The research also shows that 85% of AV-supporters feel safe sharing the road with other driverless vehicles, including trucks. However, only 38% supported policies that required a human behind the wheel in the case of an emergency and only 33% were in favor of having AVs in dedicated lanes (Smith & Anderson, 2017). So, while various government efforts are underway to create systems of regulation for AVs, there is some resistance—especially among those already identified as enthusiasts of the technology—to the exact nature and extent of government regulation. Striking a balance of regulation and support appropriate to local desires will be a delicate act but of critical importance.

Collisions and Moral Dilemmas

AVs may play an important role in reducing the rate of collisions and car-related fatalities by eliminating human error. However, uncertainties arise when speculating how AVs will respond to potential collisions. The decision whether to sacrifice the passengers or pedestrians in the case of a collision will be left to the algorithm programmed into the AV (Bonnefon, Shariff, & Rahwan, 2016).

Bonnefon, Shariff, and Rahwan (2016) explain that if the AV market provided self-protective AVs (i.e. prioritizing the passengers' life) and utilitarian AVs (i.e. vehicles that sacrifice passengers or pedestrians, in order to save the most amount of lives), a majority of consumers would most probably choose self-protective AVs over utilitarian AVs, even though they would prefer that others choose utilitarian AVs. As a result of this dilemma, policymakers and public officials could perhaps mandate utilitarian algorithms in AVs in order to resolve the issue and ensure the optimum collective interest results. The study also explores the public's willingness to purchase AVs that have been regulated by the government. Survey results indicate that individuals are less willing to purchase regulated AVs compared to unregulated ones, which would presumably be more responsive to user preferences (Bonnefon, Shariff, & Rahwan, 2016). The article argues that while the regulation of AVs may be collectively beneficial, individuals' tolerance for such efforts, and the market response that results, may conflict (Bonnefon, Shariff, & Rahwan, 2016).

User Data Privacy & Management

Privacy is a major area of concern with AV technology. The development of AVs is heavily reliant on user data, with potential for violations of personal privacy. As a result, in 2016, the US federal government has mandated under the *SELF DRIVE Act* that AV manufacturers and companies must develop a privacy plan outlining and clarifying how user data will be collected and used (Hanna & Kimmel, 2017).

In 2014, the US automotive industry developed the *Consumer Protection Privacy Principles*, outlining the "best practices for the collection, use, and sharing of information" and data obtained from vehicular technology and services. These principles are enforced by the Federal Trade Commission (FTC). Manufacturers who fail to implement security measures to protect consumer data and information are in violation of the FTC's prohibition against *Unfair, Deceptive or Abusive Acts or Practices* (ADAAPs), or FTC's *Practices Act*. The purpose of these Acts is to protect consumers from "reasonably foreseeable and avoidable" harm or "breach of privacy" (Hanna & Kimmel, 2017, pg.34).

As mentioned in the previous section of this report, the notion of sharing personal data with AV companies, which could be used to potentially harm the consumer is a major concern for many people. This creates an opportunity for government intervention. Fagnant and Kockelman (2015) state that legislation must consider and balance privacy concerns along with the potential data-use benefits. They propose the federal government must set out parameters and limits in terms of "what types of AV data should be shared, with whom it should be shared, in what way the data will be made available, and for what ends it may be used" (Fagnant & Kockelman, 2015, p. 180).

A Deloitte report found that 54% of US consumers are more willing to use a self-driving car if standards and regulations were imposed by the government on manufacturers in order to ensure that cybersecurity issues are being addressed and taken seriously (Deloitte Insights, 2018). There is apparently a clear mandate and substantial support for government to require the AV industry to be transparent with their consumers in terms of how and what information is being collected, with whom it is being shared with, and the potential for security/privacy breaches (Issac, 2017).

Employment

Another major concern is the potential impact of AVs on employment. According to PEW Research, approximately 81% of Americans expect that AV technology will result in the loss of many jobs (Smith & Anderson, 2017). Looking at employment projections for logistics services, this sentiment appears to have substantial foundation. For example, the use of autonomous trucks in the US will allow the freight industry to save approximately $168 billion annually. $70

billion of those savings will come from a reduction in the labor force. Since truck driving is among one of the most common jobs in 29 states, the implementation of AVs or autonomous trucks will have a negative impact for many American families. A report by Hanna and Kimmel (2017) recommends that the federal government provide training and counseling services and workshops, in order to facilitate the transition of laid-off drivers into the AI and AV industries as new employment opportunities begin to emerge (Hanna & Kimmel, 2017).

Canada

The implementation of AVs in Canada is highly dependent on the partnership between government and the AV industry, at both federal and provincial levels. Such a partnership ensures that the government is working directly with the AV industry, establishing the necessary rules and regulations around safety, accessibility, and other required standards (Council of Ministers of Transportation and Highway Safety, 2018). In addition to the regulatory framework, this government-industry partnership could consider harmonizing the regulatory framework with its American and Mexican counterparts, as to allow for an integrated and seamless system for the trade and movement of goods.

In January of 2018, the Standing Senate Committee on Transportation and Communications released a report on AVs. The recommendations in the report highlight the need for the development of a national strategy for AVs. Specifically, the Senate Committee urges the federal government to act quickly, especially relating to safety and privacy issues (Tkachuk, Dawson, Bovey, and MacDonald, 2018).

According to a Deloitte Insights article, if issues such as safety and privacy are being addressed by the government, the public is more willing to embrace AVs. 50% of Canadians would be more comfortable riding in a fully automated vehicle if it were regulated and approved by the government (Giffi, Vitale, Robinson, & Pingitore, 2017).

The Senate Committee has recommended that Transport Canada and the Innovation, Science and Economic Development Canada (ISED) develop a joint policy that will direct federal efforts and guide the implementation process of a national AV strategy. This is intended to allow for governments across Canada to address AV-related issues such as potential job loss, user-data privacy, cybersecurity or hacking, urban sprawl, and the need for intricate AV-receptive infrastructure (Tkachuk et al., 2018).

Canadian provinces are currently working with the Council of Ministers and Deputy Ministers Responsible for Transportation and Highway Safety to develop AV guidelines and policies. Provinces such as Alberta and British Columbia are in the process of developing guidelines for AVs and determine best practices in regards to their implementation and deployment (Tkachuk et al., 2018).

Ontario is seen as comparatively the most proactive, as the only province to introduce a bill regulating AVs (Ontario Reg. 306/15). This regulation outlines a 10-year pilot program, initiated by the Ministry of Transportation in 2016, allowing for the testing of AVs on Ontario roads (Tkachuk, et al., 2018). The Ontario government has signaled awareness of the environmental, economic, social, and safety benefits of AVs, such as reducing greenhouse gas emissions, congestion, and minimizing collision rates caused by human error. Hence, embracing the AV technology at an early stage is hoped to allow the province of Ontario to get a head start on AV deployment (Ministry of Transportation, 2015).

Toronto

According to a study conducted by Ryerson University's Transportation and Land Use Research Laboratory (TransForm), governments have an active role to play in developing a regulatory framework for AVs. Focus group participants indicated that they recognize too much government involvement and regulation may have negative implications. Survey results found that 74% supported, in general, efforts from the government to regulate and support the use of AVs.

However, regarding the specific nature of that effort, there appears to be preference for an observational, reactive stance from government. The largest share of GTHA residents polled (48%) said the government should only "monitor the use of [AVs] and respond when necessary," as opposed to actively encouraging or discouraging their use in some way.

As well, there was some measure of support for government investment to encourage, support and/or regulate AVs, but very strong opposition to such an effort if it would involve increased taxes. 47% of GTHA residents polled said they would support government investment, with the remainder opposed (21%) or uncertain (31%). But if that investment would require additional taxes, only 15% indicated support for such an initiative, with 62% opposed (Olsen, Laidlaw, Sweet, 2018).

The following three key government-related themes arose from the focus groups, conducted with residents from the GTHA:

Built Environment

One of the major concerns survey participants had with AVs is the specialized infrastructure these vehicles require to operate on public roads and highways. It was clearly stated that there is an important role municipalities should play in ensuring that roads and infrastructure are standardized upon the introduction of AVs in GTHA (Sweet, Comeau, & Olsen, 2018).

Public Education

Focus group participants generally agreed that the government and public sector have a role in educating the public on AVs, in order to ensure that individuals are able to identify the difference between AVs and conventional cars. A participant commented that AVs should be clearly identifiable, similar to the signage on vehicles operated by "student drivers". Other participants expressed the need to educate the public regarding the details of the technology and the expected benefits of AVs, in order to potentially mitigate against existing concerns, worries, and questions that the public may have (Sweet, Comeau & Olsen, 2018).

Insurance

Another area of uncertainty raised by the focus group participants was insurance. One participant explained that insurance costs may increase drastically with AVs on the road. Additionally, many raised concerns regarding the question of liability in the event of a collision. As such, participants were in general agreement that the government and other entities have a significant amount of ground to cover and a large role to play in defining the regulations and policies as they relate to insurance (Sweet, Comeau, & Olsen, 2018).

Discussion

Overall, when assessing the public opinion on AVs from Toronto (and Canada overall) and other jurisdictions (mainly the US), it is clear that there is an agreement that the government has a role to play. Study participants from other jurisdictions and from Canada have highlighted the necessity for government involvement in regulating AVs. 50% of Canadians and 54% of Americans have expressed that they would be more comfortable riding in a fully automated vehicles if it were regulated and approved by the government (Giffi, et al. 2017; Deloitte Insights, 2017).

It is, however, important to note that the public seems to have an ambivalent stance. While supporting government involvement in principle, they are also concerned that too much intervention may lead to over-regulation of the AV industry, resulting in the unreasonable restriction and delay of AV technology, and its expected benefits. In Toronto especially, there is also clear opposition to any government efforts that would result in higher taxes.

Beliefs Regarding Why Automation / AVs Are Beneficial

This section provides a summary of key findings from recent studies as they relate to the public's expected benefits of AVs. In theory, the benefits of AVs are numerous, ranging from environmental protection (reduced greenhouse gas emissions), decreased demand for parking infrastructure, increased road safety (reduced collisions caused by human error), and improved accessibility and mobility for seniors and individuals with physical disabilities (Horl, Ciari, & Auxhausen, 2016; Ticoll, 2015; Greenblatt & Shaheen, 2015; Alessandrini et al., 2015).

The literature reviewed in this section covers large geographies, including findings from the following countries: United States (specifically Texas, New York, and California), Japan, Australia, China, United Kingdom, Austria, and France. Common themes across the global studies include convenience, environmental protection, congestion reduction, increased accessibility (mobility), and cost savings.

Other Jurisdictions

International

In an online survey on public opinion regarding self-driving vehicles in the United Kingdom, Australia, China, Japan, India, and the United States, results indicate that improved emergency response to collisions, better fuel economy, fewer collisions, and reduced severity of collisions were the most commonly cited benefits of self-driving vehicles (Schoettle and Sivak, 2014). Across the six countries, the majority of survey participants have optimistic expectations regarding the benefits of self-driving vehicles, with China (87% positive) and India (84%) viewing self-driving vehicles most positively, Japanese respondents the most pessimistic (43%), and Australian (62%), US (56%), and UK (52%) falling in the middle of the range (DeGroat, 2014).

United States

An Austin, Texas internet-based survey polled members of the public in order to understand their thoughts on new vehicle technologies (Bansal, Kockelman, & Singh, 2016). Most respondents indicated that a reduction in crashes would be the most significant benefit of AVs (63%). When asked about which tasks and activities they would engage in while riding in AVs, "text or talk" and "look out the window" received the most votes (74% and 77%), while approximately half voted for "sleep" (52%), "work" (54%), and "watch movies/play games" (46%) (Bansal, Kockelman, & Singh, 2016).

A recent study on public opinion and consumer preferences relating to AVs from the state of New York reveal the safety benefits of AVs as a top priority, with "congestion reduction" being cited second most frequently in terms of public priority (Lustgarten & Le Vine, 2017). In

addition, over half of the respondents indicated that they would accept slower travel in exchange for greater comfort (54%). Another recent study conducted in the state of New York found that among the potential benefits of AVs, the surveyed participants indicated that fewer traffic jams, easier parking, and increase mobility and independence are the most appealing (Daziano et al., 2016).

A study conducted in Berkeley, California reports convenience and amenities provided by driverless cars as the most attractive features of AVs (Howard & Dai, 2013). As such, personal benefits such as the expectation that AVs would improve their lives was ranked at a higher value than social benefits such as environmental friendliness.

Europe

An online survey conducted in Austria reported a general interest in self-driving cars among members of the public (Konig & Neumayr, 2017). In terms of potential benefits of self-driving cars, survey respondents indicated the highest level of agreement with the following statement: "A self-driving car could solve the transport problems of older or disabled people." Another highly perceived benefit was the option to engage in activities other than driving (Konig & Neumayr, 2017). It is also important to note that only 2% of survey respondents indicated "very negative" opinions about self-driving cars.

A survey conducted in La Rochelle, France examined public opinions on the implementation of AVs in urban areas. Among a variety of potential benefits, the majority of respondents identified "increase mobility for the elderly, disabled and other" and "reduce fuel consumptions and emissions" as the most attractive benefits of AVs (Piao et al., 2016). Other benefits commonly expressed among participants were the reduction in bus fares, insurance rates, and parking costs. In general, the survey respondents were optimistic about AVs and would consider using them if and when they become available, with three quarters indicating that they would prefer owning their own AV, and the remaining one quarter would prefer the shared model (carpool or taxis) (Piao et al., 2016).

Toronto

In 2016-2017, Ryerson University's Transportation and Land Use Research Laboratory (TransForm) conducted focus groups and an online survey designed to explore the opinion of residents living in the Greater Toronto and Hamilton Area (GTHA) in relation to AVs.

General results from all focus groups suggest that residents are interested and curious about AVs and have many questions. Several participants indicated that AVs have the potential to improve safety by eliminating the dangers of human error (i.e. drunk, aggressive, or distracted driving). Some respondents believe that AVs could improve traffic flow as automated cars

would have the ability to drive both faster and closer to one another.

Several participants expressed interest in the shared ownership model over the private model, motivated by the elimination of parking fees and being stuck in traffic in the downtown core. As such, many highlighted the benefit of using a shared model/transit/taxis for getting around in the central city.

Most focus group participants expect AVs to have significant benefits for target populations such as seniors and individuals with physical disabilities. In line with this, increased mobility and independence were cited as the most common benefits. It is important to note that several participants communicated a greater acceptance and appreciation for the potential benefits of AVs after watching a video of a blind man using an AV operated by Google (this video was shown halfway through the focus group discussions in order to initiate conversations and reactions). In sum, most participants highlighted the possible benefits of AVs and what they have to offer in terms of increased transportation choice and increased mobility.

As per the findings from the online survey, the most common perceived benefits of AVs include those related to safety improvements, parking avoidance, better traffic flow, and disability services (40% to 50%). It is important to note that the perceived benefits of AVs varied by age, especially the benefits regarding multitasking, connection to data services, and support for disabilities. However, about one quarter (23.5%) of respondents found AVs to be entirely unattractive.

Over half of respondents (58.6%) indicated that they would be willing to commute further distances for work in AVs permitted faster travel. Hamilton, Toronto, and Peel Region show the greatest willingness to extend their commutes.

Discussion

Numerous studies from around the world indicate that the public expects significant benefits from AVs. Despite the existing uncertainties and common concerns, the public is in general agreement that AVs carry the potential to significantly improve the mobility and independence of seniors and individuals with physical disabilities. Aside from the expected social benefits, the results from the surveys and focus groups suggest that the public expects AVs to improve road safety in general, by eradicating the possibility of human error. Other common perceived benefits relate to increased productivity and convenience provided to passengers riding in AVs.

Direct comparisons between the GTHA and other jurisdictions are challenging. While a broad international survey assessed general opinions of self-driving vehicles, GTHA data reports on the public opinion of specific perceived benefits. Slightly more than half of respondents in the US (56%) and UK (52%) expressed overall positive views of AVs, while in the GTHA, half (49.6%)

were interested in the specific benefit of improved safety. It is important to highlight that findings across studies suggest that education may potentially play an important role in shaping the public opinion of AVs. Therefore, governments, municipalities, organizations, and corporations have a role to play in framing the dialogue around this emerging technology, while educating each other as well as the public.

Consumer / Price Considerations

Public opinion and consumer preferences are key variables in determining the ultimate impact of AVs. In particular, the demand of consumers—linked to their willingness to pay for automated technology—will likely determine how quickly the technology infiltrates the market. Price, understandably, is believed to be a key factor in consumer acceptance and use of AV technology. If one cannot afford a technology, whether or not they have a preference for using it becomes irrelevant. Understanding the characteristics of different types of interested or disinterested consumers can also help to predict who early adopters will be and forecast longer term outcomes in AV use (Bansal, Kockelman & Singh, 2016).

If potential barriers to consumer adoption are not properly understood and addressed, they could negatively impact the overall market uptake of AVs. Such a scenario could further delay the onset of possible collective benefits, such as congestion relief, efficiency improvement, safety improvement and travel cost reduction. By understanding the consumers' willingness to pay, both automotive industry leaders and public-sector regulators could focus efforts on addressing the barriers of groups with lower willingness to pay (Lustgarten & Le Vine, 2017). Alternately, if the price of buying and using AVs is unreasonably low, it may be so attractive that greater congestion, greater emissions, increasing sprawl and the erosion of transit use and active transportation may result.

Ultimately, this matter of price provides a potential route for not just predicting the roll out of AVs, but of influencing it as well. As can be seen in the case of Ontario's incentives promoting the initial uptake of electric powered cars (Ministry of Transportation, 2017), subsidies, taxes and/or fees could be used as AV policy levers, incentivizing or constraining their purchase and use, to direct particular market outcomes so as to maximize net social benefit.

But an effective intervention requires first requires an effective, verified understanding of the target.

Other Jurisdictions

Internationally, several studies have been conducted directly investigating consumers' willingness to pay for AVs.

From an online survey of 3255 adults across the UK, US, Australia, China, India, Japan in 2014, Schoettle and Sivak (2014) found that 54.5% respondents in the US, 59.8% in the UK, 55.2% in Australia, 21.6% in China, 29.8% in India, and 67.5% in Japan were not willing to pay additional money beyond the current cost of a vehicle to add automated technologies. Because of these high thresholds of unwillingness, the study uses the 75th percentile (highest 25% of

respondents) to compare willingness to pay values. At that level, respondents were willing to spend at least $2000 to add full self-driving automation in the US, while same proportion of respondents in the UK, Australia, China, India and Japan were willing to spend at least (USD) $1710, $2350, $8000, $1600 and $465 respectively.

Bansal, Kockelman and Singh (2016) conducted an online survey in 2014 of 347 residents in Austin, Texas on a variety of topics related to advanced vehicle technology. They found that, presented with a given cost of $5,000, 24% of respondents were willing to add partial automation technology (similar to levels three and four on the SAE scale) to their next vehicle purchase. At the same price point for full automation technology (level five on the SAE scale), the willing share was 57%. In terms of characteristics, it was determined that "male respondents with a greater number of children, living in higher-income neighborhoods, and who drive alone for social trips, ceteris paribus, are willing to pay more" (p. 8) to add automation to their next vehicle purchase.

Based on a 2015 national survey of 2167 Americans, Bansal & Kockelman (2017) found fairly similar results to the earlier surveys. A slight majority of respondents were completely unwilling to pay anything extra for partial and full automation (52% for partial, and 56% for full automation), similar to Schoettle and Sivak's (2014) findings.

In 2015, Zmud et. al. (2016) conducted qualitative interviews (sample size: n = 44) with residents in Austin, Texas. The following willingness to pay questions were asked in the interviews: "With a baseline of the current price of purchasing a private vehicle and the price of currently using a shared vehicle, how much more would the respondent be willing to pay for the same, but with fully autonomous capabilities?" The multiple choice response spectrum ranged from "zero", to "a slight amount", to "a great amount". For both private vehicles and shared vehicle services, the dominant response was "a slight amount." Further explanations indicated that consumer demand for fully automated vehicles was weak in the sample group. Additionally, while there was an assumption that a premium would be required to access AV technology—as a private vehicle for purchase or a shared vehicle for hire—there were also common expectations that the price would decline over time

Toronto

The only identified data source for the Greater Toronto and Hamilton Area regarding willingness to pay for AVs is a 2016-2017 research project conducted by Ryerson University's Transportation and Land Use Research Laboratory (TransForm). This project included an online survey of 3201 GTHA residents, followed with focus groups for further qualitative investigation.

Table 4 Willingness to Pay Extra for Fully Automated Vehicle Capacity ($ in USD)

	GTHA	*U.S.*	*U.K.*	*Australia*	*China*	*India*	*Japan*
% With No WTP	28.2%	54.5%	59.8%	55.2%	21.6%	29.8%	67.5%
WTP at 75th Percentile	$3750 - $7500	$2000	$1710	$2350	$8000	$1600	$465

Source: Laidlaw and Sweet, 2017; Olsen, Laidlaw and Sweet, 2018; Schoettle & Sivak, 2014

As indicated in the table above, the GTHA survey revealed that 28% of respondents had no willingness to pay extra to add automated technology to their vehicles. These results are comparable to findings from India and China (29.8% and 21.6% respectively), but relatively lower than results from the US, UK and Australia (54.5%, 59.8%, and 55.2% respectively) (Schoettle & Sivak, 2014).

The survey further found that the 75th percentile (indicating the price at which only 25% of the respondents are willing to pay to add full self-driving automation) ranges from USD $3,750-$7,500 (CAD $5,000-$9,999). These results are substantially higher than most international findings, with the exception of China (Schoettle & Sivak, 2014).

Both comparisons—low absolute unwillingness to pay, high measure of willingness to pay—suggest that the GTHA residents surveyed have a relatively robust demand for AV capability, compared to other international locations. This may be due, in part, to the national scale of the other surveys, which would encompass more rural areas—these areas may not experience the same issues motivating AV adoption (i.e. congestion, long commutes, parking costs), or be exposed to as much automated vehicle information—whereas the population surveyed from the GTHA is an urban sample.

Table 5 Measures of Willingness to Pay for Partial and Full Automation ($ in USD)

	GTHA	*Austin, TX*	*U.S.*
% Willing to Add Partial Automation for $5000	< 19.6%	24%	-
% Willing to Add Full Automation for $5000	< 32.8%	57%	-
% With No WTP for Partial Automation	37.6%	-	52%
% With No WTP for Full Automation	28.1%	-	56%

Source: Laidlaw and Sweet, 2017; Olsen, Laidlaw and Sweet, 2018; Bansal, Kockelman and Singh, 2016; Bansal and Kockelman, 2017

As shown in the table above, Bansal, Kockelman and Singh's survey of Austin (2016), as well as Bansal and Kockelman's (2017) US-wide survey sheds further light on the GTHA's willingness to pay compared to America. In the GTHA, at a price point of $5,000 (USD), less than 19.6% would be willing to add partial automation and less than 32.8% would be willing to add full automation to their next vehicle purchase. This is a substantially lower willingness than the results from Austin, Texas.

However, a much smaller share of respondents in the Toronto survey expressed a total unwillingness to pay for partial or full automation (37.6% and 28.1%), compared to US residents (52% for partial, and 56% for full automation). The discrepancies may be a result of urban-specific vs. national sampling (Austin vs. United States), but there appears to be a stronger willingness to pay for partial or full automation in Austin in comparison to Toronto, at least at the $5000 price point. When comparing the GTHA's results to the United States overall, there is less hard opposition in the GTHA of individuals unwilling to pay anything additional for the technology. It may be that GTHA residents are willing to pay, but relatively more sensitive to price.

In terms of consumer characteristics related to price-sensitivity, GTHA research found that

young (under 35), tech-savvy urbanites, with flexible work schedules and locations, that currently use Uber, chauffeur others in their household, and/or currently own a vehicle of a price more than $30,000 are willing to pay more to add full automation to their next vehicle.

Table 6 Characteristics Associated with Greater Willingness to Pay for Private AVs

	GTHA	*Austin, TX*
Pay more for PAVs	Young (under 35) Tech-savvy Urban Flexible work schedules and locations Uber user Chauffeur Own a vehicle > $30,000	Male Greater number of children Living in higher-income neighborhoods Drive alone for social trips

Data from (Laidlaw and Sweet, 2017; Bansal, Kockelman and Singh, 2016).

Finally, in terms of qualitative observations, in the GTHA focus groups, it was found that there was little appetite for paying anything additional for automated technology, in a private or shared context. This is similar to Zmud's (2016) qualitative observations of Austin, Texas. However, the GTHA findings indicated a divergence among focus group participants as to whether the price of transportation services (car sharing services, taxis, and transit) would decrease with the arrival of autonomous technologies. Some indicated that the price should decrease due to the replacement of labour (i.e. no driver), but others were skeptical that businesses and agencies would be willing to reduce their prices and pass the savings along.

Discussion

Drawing conclusions from this data must be done with caution, as there are still relatively few sources to draw from specifically dealing with prices and willingness to pay. It is also important to highlight that the data sampling contexts differ, as some represent national findings (US, UK, China, Japan, Australia), while others are more urban and local (GTHA and Austin).

That said, it appears that the GTHA has a relatively low proportion of people absolutely unwilling to pay for AV technology, nearly half the rate of national surveys of the United States,

the United Kingdom and Australia. Its rate is more in line with China and India, with which it also shares a similar value of willingness to pay, at least at the high end (75th percentile) of its population. However, compared at the individual urban scale to Austin, Texas—the only other individual city for which data was available—the GTHA appears to have a relatively low willingness to pay.

The different sampling scales complicate the ability to closely compare results. There may be greater willingness to pay at the urban scale than at the aggregate national scale. It may be that GTHA residents have a relatively high willingness to pay compared to less urban areas. Existing research supports the finding that urban populations have greater pure interest in AV technologies, price aside (Olsen, Laidlaw, Sweet, 2018; Bansal, Kockelman, Singh, 2016). However, the GTHA's willingness to pay compared to other individual cities could vary. Further data is needed to confirm.

In terms of consumer profile characteristics, GTHA residents that indicated a higher willingness to pay for AVs do not exactly fit the characteristics found in similarly prone Austinites, although they do share the general quality of pre-existing driving habits.

Lastly, it is interesting to note that among residents of the GTHA, there is a greater presence of skepticism that vehicle automation will lead to reduced transportation costs, when compared to the responses of Austinites.

Conclusion

The arrival of automated vehicles is expected to transform the ways in which we navigate, interact with, and understand urban environments. With time, this transition will necessitate adapting to change and to new technologies, in addition to 'unlearning' certain habits and forming new ones. In order to adequately prepare for the AV future, this report has outlined an understanding of Toronto's public opinion of AVs in comparison to its international counterparts. As a final note, there are several overarching global trends in public opinion—Toronto included—that can be identified. Organized by the same five topics of interest, those trends are as follows:

Willingness to Use AVs

In terms of the public's willingness to use AVs, international findings suggest significant variations across the available literature and between places. However, generally men and younger people tend to be more enthusiastic than females and older individuals about AV technology.

In focus group scenarios that provided an opportunity to educate participants, willingness to use generally increased as more information was provided. This has been found in other information sessions and surveys. At this early stage, with information and familiarity fairly narrowly distributed, information appears to be an essential tool for improving willingness to use AVs. If this holds true, willingness will only increase with time, with the inevitable spread of information and increased familiarity through social degrees of separation.

Concerns Regarding the Technology

Despite the potential benefits of AVs, there remain many uncertainties and concerns with regard to the final form and impacts of the technology. Overall levels of stated concern vary, but in terms of specific, qualitative concerns, it is apparent that GTHA residents are very similar to their international counterparts, with major concerns classifiable as relating to cybersecurity and privacy, ethics, liability/legal issues and safety. In many cases, these concerns are fundamentally expressed as a desire for further information and clarity on what is otherwise an uncertain future. Again, strategically deploying information appears to have a key role to play with regards to this issue.

Opinion on the Government's Role in Regulating AVs

In the research reviewed, there is an apparent ambivalence in the global public regarding the desired role for government in relation to AV technology. There is clear agreement that the government has a role to play to some extent—setting regulations that will steer the industry

towards public benefits that it may not implicitly concern itself with and mitigating negative impacts of this potentially disruptive technology. While supporting government involvement in principle, there is also a general skepticism that too much intervention may lead to over-regulation of the AV industry, resulting in the unreasonable restriction and delay of AV technology, and its expected benefits. Research would have further to go to tease apart the finer points within this tension as to how exactly the balance is desired to be struck. However, the public is hungry for clarity on what to expect, emphasizing a rising need for proactive communication and information from government authorities.

Beliefs Regarding Why Automation/AVs are Beneficial

Results from an international public opinion surveys highlight perceived benefits such as better fuel economy, fewer and reduced severity of collisions, and improved emergency response to collisions. Reported in the majority of available research on the topic, participants expect AVs to have significant benefits for seniors and individuals with physical disabilities, potentially allowing for greater mobility and independence. Other commonly reported expected benefits across all studies include better traffic flow, safety improvements, parking avoidance, ability to multitask.

Consumer/Price Considerations

Drawing conclusions from the data here must be done with caution, as there are still relatively few sources to draw from specifically dealing with prices and willingness to pay. This in itself identifies a need for further research, especially for more urban-scale studies, to enable inter-city comparisons without the identified pitfalls of comparing to the national scale. However, from the limited results available, there appears to be remarkably higher measures of willingness to pay at the urban level than at the aggregate national level. This is consistent with existing findings of greater urban enthusiasm for AVs, perhaps due to the urban-specific problems they appear to be able to resolve. The key takeaway for governments is that taxation and subsidies, through this route of consumer demand, can be a potent policy lever for guiding AV use and adoption rates towards optimum collective outcomes.

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