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The politics of new driving technologies: Political ideology and autonomous vehicle adoption

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A B S T R A C T

Autonomous vehicles (AVs) typify the nexus of smart Internet-based technology and prior innovations in transportation. A challenge with AV research is that the technology is not yet readily available for consumers to experience. Thus, public perceptions of AVs are often assessed through survey research which has uncovered demographic and socio-economic differences in the willingness to adopt and pay for AVs. It has also provided information about the perceived benefits and risks associated with AVs and how these perceived benefits and risks affects support for self-driving car technology. More recently, studies have found that political ideology is linked to perceived concerns about self-driving cars but have not yet assessed whether this link extends to the intent to adopt AVs. Given this gap in our knowledge, the contributions of the present paper our twofold. One, we will assess whether political ideology impacts the intention to adopt AVs. Two, we will assess whether political ideology directly or indirectly affects the intention to adopt AVs. As regards the latter, we will conduct a mediation analysis with a path model to assess the extent that political ideology indirectly affects the intention to adopt via the perceived benefits and concerns survey respondents expressed about AVs. Our results reveal political ideology is an important predictor of individuals' intent to adopt AVs, as characterized by both willingness to ride in and to own AVs. Specifically, compared to conservative participants, moderates and liberals reported higher AV adoption intentions. We also find that the effect of political ideology on AV adoption intention is mediated by participants' perceived benefits and concerns about AVs. Compared to conservatives, political moderates reported AV adoption intention via higher perceived benefits about AVs. Compared to conservatives, liberals reported higher AV adoption intention through both higher perceived benefits and lower perceived concerns about AVs.

1. Introduction

Since the invention of the steam engine in the early 19th century, scholars have identified five distinct periods of economic growth or Kondratiev cycles associated with innovative technologies (Taylor and Flint, 2000). The most recent Kondratiev cycle is associated with Internet technologies (Dicken, 2003) that enable real-time communication across vast distances and the use of "smart" devices that are monitored with computers over Internet connections. Autonomous vehicles (AVs) typify the nexus of smart Internet-based technology and prior innovations in transportation. AVs can be categorized according to five levels, ranging from complete human control (level 0) to full vehicle autonomy (level 5) (SAE International, 2019). In levels 1 and 2, the driver governs the driving environment, assisted by an automated navigation system. From levels 3 through 5, the vehicle, instead of the driver, is in charge of most driving tasks. However, for level 3 humans must still be available for some driving tasks, while in levels 4 and 5 the car is in control. In level 4, the driving system controls the vehicle for a particular operation (e.g., high-speed freeway cruising, closed circuit shuttle or

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bus). A level 5 AV performs all driving functions under all conditions and the driver has the option to control the vehicle. Currently, level 3 AVs are entering the market. These vehicles can operate autonomously under select circumstances, although humans must monitor and take control of the vehicle regularly.

While forecasts vary as to when fully automated level 5 vehicles will be on the road (Litman, 2020; NHTSA, 2017; Lavasani et al., 2016), understanding consumer perceptions of AVs is necessary to enhance and guide adoption (Pyrialakou et al., 2020) as well as to help researchers understand the likelihood of network effects on adoption (Bansal et al., 2016). A challenge with understanding people's willingness to adopt this emerging technology is that the technology is not yet readily available for consumers to experience AVs through riding in them or seeing them on the roadways. Thus, many people are not as familiar with AVs as they might be of technologies that are more pervasive in society – such as smartphones or computers. This makes gauging public perceptions of AVs more difficult, as perceptions may not be accurate due to lack of familiarity or experience with them. Given this challenge, public perceptions of AVs are often assessed through survey research (Casley et al., 2013; Bansal et al., 2016; Penmetsa et al., 2019; Singleton, 2019; Soteropoulos et al., 2019). This survey based work has uncovered a variety of demographic and socio-economic differences in the willingness to adopt and pay for AVs (Casley et al., 2013; Payre et al. 2014, Kyriakidis et al., 2015; Hulse et al., 2018). It has also provided information about the perceived benefits and risks associated with AVs (Woldeamanuel and Nguyen, 2018; Kim et al., 2019; Liu et al., 2019; Wang et al., 2020) and how these perceived benefits and risks affects support for self-driving car technology (Dixon et al., 2020).

More recently, studies have found that political ideology is linked to perceived concerns about self-driving cars (Peng, 2020). This is an important finding because it suggests a link between political ideology and the likelihood of adopting AVs. To this point in time however, work on AV perceptions has not determined whether there is a statistical association between political ideology and AV adoption. This is an important gap in our knowledge because research has uncovered that political ideology is connected to several aspects of people's lives, including views on socio-political and economic issues (Webster and Kruglanski, 1994; Jost et al., 2003, 2007) and views on science and technology (Gauchat, 2012; Drummond and Fischoff, 2017). Given this gap in our knowledge, the contributions of the present paper our twofold. One, we will assess whether political ideology impacts the intention to adopt AVs. Two, we will assess whether political ideology directly or indirectly affects the intention to adopt AVs. As regards the latter, we will conduct a mediation analysis with a path model to assess the extent that political ideology indirectly affects the intention to adopt via the perceived benefits and concerns survey respondents expressed about AVs.

2. Public opinion about AVs

Because AVs are not yet available for general use by the public, but are likely to be an important transportation technology of the future, studies are using survey data to understand people's perceptions of and willingness to adopt AVs (Payre et al., 2014; Bansal et al., 2016; Penmetsa et al., 2019; Moody et al., 2020). Early work examined demographic and socio-economic differences in attitudes about and inclination to adopt AVs (e.g. willingness to ride or willingness to pay). More recent work is examining people's perceptions about the benefits and concerns or risks associated with AVs.

2.1. Sociodemographic characteristics

Survey studies present mixed evidence about the relationship between age and openness to AVs (Kadylak and Cotten, 2020). Some find that relative to younger adults, older adults prefer non-automated vehicles and are not interested in AV technologies (Haboucha et al., 2017; König and Neumayr, 2017). Other studies find that the intent to use increases with age (Rödel et al., 2014) and that older adults are more willing to accept AVs but less willing to pay for them (Payre et al., 2014). Hulse et al. (2018) showed that older (60 years and older) and younger adults (21–34 years) expressed the highest willingness to pay for AVs. The KPMG (2013) study provides some explanation for findings related to age. It suggested that older adults have age-related impairments that enhance their need for AVs, and they also have the ability to pay for these vehicles. Alternately, young adults place a high value on AVs, and are less concerned with their cost because they assume their parents will pay for AVs. The relationship between openness to AVs and income appears more robust than AVs and age. Bansal et al. (2016) and Kyriakidis et al. (2015) observed a significant positive relationship between higher income and willingness to pay for automated driving technologies. Openness to AVs is also positively associated with education, which is often positively associated with income (e.g., Haboucha et al., 2017). Regarding gender, studies have found men display greater acceptance of AVs (Hulse et al., 2018) and are more likely to report being willing to purchase AVs in the future (Casley et al., 2013; Payre et al., 2014; Kyriakidis et al., 2015). This finding could be linked to gender-based perceptions of AVs which will be discussed below.

2.2. Benefits and concerns associated with AVs

In addition to demographic and socio-economic factors, perceptions are an important factor affecting openness to AVs – as people make choices based on their perceived costs, risks, efforts, and benefits (Woldeamanuel and Nguyen, 2018; Kim et al., 2019; Liu et al., 2019; Wang et al., 2020). To this end, studies have inventoried and analyzed the benefits and concerns associated with support or openness to AVs (Howard and Dai, 2014; Schoettle and Sivak, 2014; Kyriakidis et al., 2015; Gkartzonikas and Gkritza, 2019). Benefits related to AVs include enhanced safety, enhanced convenience, and the ability to multi-task (Howard and Dai, 2014). Studies also point to several environmental benefits of AVs, including reduced emissions, reduced fuel consumption, and increased energy efficiency (Fagnant and Kockelman, 2014; Rafael et al., 2020; Kopelias et al., 2020; Wang et al., 2020). Vehicle platooning enabled by AVs

for example is anticipated to reduce air resistance during travel which could reduce fuel consumption by 3 to 25% (Wadud, MacKenzie and Leiby, 2016).

Examples of concerns and risks associated with AVs include increased liability, cost, and the potential for losing control of the vehicle (Howard and Dai, 2014). Personal privacy and cybersecurity are other AV concerns (Kaur and Rampersad, 2018). Other studies have connected demographic and socio-economic factors to perceived benefits and concerns (Casley et al., 2013; KPMG, 2013; Schoettle and Sivak, 2014). In particular, women are more likely to have AV concerns (Casley et al., 2013; Schoettle and Sivak, 2014; Charness et al., 2018) and less likely to perceive AV benefits (Schoettle and Sivak, 2014). Zhu, Chen, and Zheng (2020) found that exposure to information about AVs from mass media can significantly reduce risk perceptions associated with AVs.

2.3. Political ideology

An emerging body of work is moving beyond demographic and socio-economic characteristics to examine factors that predict support for AVs. These studies suggest that factors including risk perceptions, trust in regulatory bodies, and individualism impact support for autonomous vehicles (Kaur and Rampersad, 2018; Dixon et al., 2020). This type of work and our understanding of perceived benefits and concerns highlight that AV perceptions and their subsequent willingness to adopt AVs is related to several facets of individuals that underscore perceptions and decision-making including but not limited to: their worldview, psychological traits, and personality traits. A good example of the link between personality traits and driving technology is the body of work examining preferences for manual cars (Boeglin, 2015; Kohl et al., 2017). This preference may be tied to people who score high on the individualism scale and place high values on freedom and independence (Boeglin, 2015; Kohl et al., 2017; Dixon et al., 2020).

Many of the perceived benefits and concerns about AVs are likely to be related to social and political issues that shape people's worldviews. For example, Sanbonmatsu et al. (2018) showed that there is a relationship between knowledge and openness to AVs; people with less knowledge about AVs are less open to them. Similarly, Tennant et al. (2019) found that people with higher levels of technological optimism were more likely to perceive AVs positively and be more open to adopting them. Based on this body of work, studies of AVs are beginning to point towards political ideology as a driver of AV perceptions (Peng, 2020). This is because political ideology is connected to several aspects of people's lives, including views on socio-political and economic issues (Webster and Kruglanski, 1994; Jost et al., 2003, 2007), views on science and technology (Gauchat, 2012; Drummond and Fischoff, 2017), psychological traits (Hibbing et al., 2014; Jost et al., 2003) and personality traits (Jost et al., 2003; Carney et al., 2008; Jost et al., 2008).

Prior studies find that political ideology is related to views on a variety of societal issues, such as the environment (Anderson, 2012), immigration (Neiman et al., 2006), abortion (Abramowitz, 1995), and the role of government in society (Faricy and Ellis, 2014). People with a conservative ideology have been shown to exhibit a greater preference for order and traditional values while liberals instead value progress and flexibility (Jost et al., 2008). In terms of personality traits, studies reveal important linkages that could impact AV perceptions. Carney et al. (2008) note that conservatives are likely to express a desire for order while liberals are typically more open to new experiences. Jost et al. (2003) also note that conservatives are more likely to be concerned with managing threats to their sense of security and are more likely to display greater fear for threat and loss. The relationships between political ideology and science and technology are somewhat more complex, however, which makes it difficult to say that particular political ideologies uniformly support or do not support science and technology. This complexity is reflected by the Drummond and Fischoff (2017) study who find that political ideology is linked to some (e.g., stem cell research, big bang theory, human evolution) but not all scientific issues (e.g., nanotechnology and genetically modified foods).

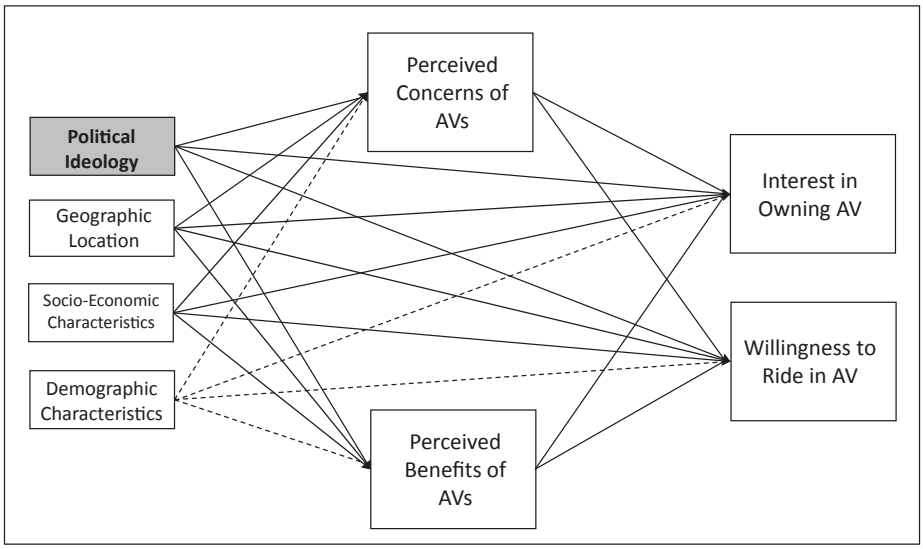

Fig. 1.

Because of these linkages, recent research on AVs is beginning to evaluate the connection between political ideology and AV perceptions. Peng (2020) found for example that conservatives are more likely to express concerns about AVS and are also more likely to support restrictive regulations related to AVs. This same study also found that familiarity and literacy efforts reduce concerns about AVs but were less likely to do so for social conservatives. Other research finds that perceptions of benefits and enjoyment for AVs impacts support for AV use (Dixon et al., 2020; Liang et al., 2020). Together, these findings indicate that it is important to consider benefits as well as risks of AVs in examining AV acceptance, and that exposure to information about AVs and attitudes towards technology may be related to perceptions of benefits and risks. Our study expands on this emerging body of work in two ways. First, we examine the link between political ideology and willingness to adopt AVs. Next, we examine whether perceived concerns and benefits mediate this relationship, given the growing body of work on support for AVs and perceived benefits and concerns associated with AVs (Dixon et al., 2020; Liang et al., 2020; Peng, 2020).

3. Methodology

Fig. 1 outlines the conceptual model for our analysis. It illustrates that a variety of personal factors including socio-economic characteristics, demographic characteristics, geographic location and political ideology impact indicators of AV adoption (e.g., willingness to ride in and willingness to own AVs). The box for political ideology is highlighted in grey to indicate the driving hypothesis of this paper: Political ideology impacts AV adoption. Included in this figure are boxes for perceived benefits and concerns to reflect our secondary hypothesis that both benefits and concerns mediate the relationship between ideology and AV adoption.

3.1. Data

To test these hypotheses, this study estimates statistical models from survey data from the Fall 2017 State of the State Survey (SOSS) administered by the Institute for Public Policy and Social Research at Michigan State University (Pierce, 2018). In brief, the SOSS is a public opinion survey that employs a stratified random sample of Michigan adults. It is the only survey designed to provide a consistent systematic monitoring of the public mood in Michigan. The survey is administered quarterly and contains core questions (e.g., demographic characteristics) as well as unique questions specific to the survey. In terms of unique questions, the Fall 2017 survey asks about a wide range of topics including the economy, politics, climate change, crime, energy use, and self-driving cars. Respondents were contacted via list-assisted random-digit-dial (RDD) as well as sampling of household landline and cell phone telephone numbers. The pool of potential respondents was the "English-speaking adult population of Michigan age 18 and over". The survey response rate was 19.7% and was computed using the American Association of Public Opinion Research guidelines (Pierce, 2018).

The total sample includes 968 completed responses; however, the analytic sample (N = 776) is limited to respondents who provided complete information on the demographic predictors of interest and familiarity with AVs. Of the 968 respondents, 65 indicated not being familiar with the concept of AVs or refused to answer this question. Of the remaining, 11 did not answer questions related to AV adoption, characterized as a willingness to ride in or own an AV. Another 116 respondents did not provide demographic information, resulting in our final analytical sample of 776. A comparison of demographic characteristics of those included in the analysis against those excluded from the analysis indicates no omission bias related to age or geographic location (results available from authors).

Appendix A contains the wording of the questions pertaining to AVs and their associated response options. Here it is important to note that these questions centered on cars only. No references were made to other types of autonomous vehicles (e.g. buses or trains). In the survey, respondents were asked two open-ended questions designed to gauge their knowledge of AVs and self-driving cars. The rationale was that there might be some conceptual ambiguity surrounding these terms. These open-ended questions would elicit respondents' immediate thoughts upon hearing these terms. They were first asked: When you hear the term "self-driving vehicles," what is the first thing that comes to mind? This was an open-ended question and their response was collected. Next, they were asked: When you hear the terms "autonomous vehicles," what is the first thing that comes to mind?

Next, respondents were read the following statement: Self-driving vehicles have features that operate without direct driver input. No human driver is needed in a completely self-driving vehicle. The next survey item asked: Have you heard of self-driving vehicles before today? Responses options included: Yes/No. Then, they were asked: Would you ride in a self-driving vehicle? Response options included: Yes, maybe yes, maybe no, and no. Finally, respondents were queried as to their interest in owning or leasing a self-driving vehicle: How interested would you be in owning or leasing a completely self-driving vehicle in the future? Would you say very interested, moderately interested, slightly interested, or not at all interested?

Here, it is important to note that the level of automation of AVs was not asked because at the time of the survey in 2017 and even more recently (Hancock et al., 2019), the general public was not generally familiar with autonomous vehicles and nuanced levels of automation. Instead, these levels are most often discussed among individuals working in industry, transportation, and government arenas, with the general public having less of a conceptual understanding of these delineations. Thus, referencing specific automation levels without providing substantial detail as to what those levels mean would not be informative for the general public. To address this lack of familiarity, the survey uses the term "self-driving cars" in the survey questions, which was defined for the participants as "vehicles have features that operate without direct driver input. No human driver is needed in a completely self-driving vehicle." This definition is consistent with the Society for Automotive Engineers (SAE) level 5 automation of a fully autonomous vehicle.

3.1.1. AV adoption questions

Of particular interest in this study are questions related to people's willingness to ride in and willingness to own an AV. To incorporate these models into probit regression models, respondents that said yes, they would ride in an AV were coded as a "1",

responses for no or unsure were coded as a "0". For willingness to own an AV, respondents that were very and moderately interested in owning were coded as a "1", and respondents that were slightly interested or not at all interested were coded as a "0". We elect to keep these two facets of adoption separate for several reasons. One, it follows the precedence of prior studies that model interest in riding and interest in owning AVs separately (Payre et al., 2014; Howard and Dai, 2014; Zmud, Sener, and Wagner, 2016; Pakusch et al., 2018). Two, AVs are not yet pervasive in society and are not likely to be pervasive in society for at least a decade (Yankelevich et al., 2018). Thus, there is a substantial lack of clarity as to what actually constitutes an autonomous vehicle (Hancock et al., 2019), and a lack of information available regarding safety issues and potential ownership and use models. Therefore, it is important to use a finer-grained approach to assess participants' intentions because willingness to ride in versus willingness to own may represent different levels of acceptance of the technology. Three, a statistical analysis of the correlation between participants' willingness to ride in and willingness to own AVs reveals they are correlated at R = 0.50, which translates to about a 25% overlap in the variance of these two variables. This suggests that empirically, these two variables are not redundant, and each communicates unique information about participants' intent to adopt AVs. Four, an intention to own an AV represents a stronger adoption intention than an intention to ride. Willingness to ride in AVs can be viewed as reflecting the 4th or the trial stage of the product adoption cycle, where consumers test or try the new product (Klonglan and Coward, 1970). Willingness to own AVs can be viewed as reflecting the 5th or the highest stage of product adoption cycle of actual ownership of the new product (Klonglan and Coward, 1970). Given the relative newness of AVs to society, the public may have different intentions at this point in time; they may be willing to ride in an AV but not yet ready to own one.

3.1.2. Political ideology

To construct our main independent variable of interest related to political ideology, we recoded question one in Appendix A about political ideology into three categories (Guber, 2013): conservative, liberal, and moderate. This means that people identifying as very conservative or somewhat conservative are coded as "conservative." Respondents indicating they lean conservative, middle, or lean liberal were coded as "moderate." Finally, respondents indicating they were somewhat liberal or very liberal were coded as "liberal." Participants who chose "do not know" or "prefer not to answer" were considered as missing data.

3.1.3. Perceived benefits and concerns

The survey contained fourteen questions about the perceived benefits of and perceived concerns about AVs (see Appendix A). These questions are modeled after measures included in other studies (Schoettle and Sivak, 2014; Benleulmi and Blecker, 2017). All of the benefits questions use the same 4 point Likert scale: 1 = very important, 2 = moderately important, 3 = slightly important, 4 = not at all important. Each of the concerns questions also use a 4 point Likert scale: 1 = very concerned, 2 = moderately concerned, 3 = slightly concerned, 4 = not at all concerned. To facilitate the interpretation, we reverse-recoded these items so that a higher score would indicate higher importance (i.e., 4 = very important and 1 = not at all important for benefits items) or higher concerns (i.e., 4 = very concerned and 1 = not at all concerned for concerns items). The score for the perceived benefits and concerns about AVs were computed by averaging the items for the respective scales. Similar to the item-level data, a higher score on the composite benefits question means more perceived benefits and a higher score on the composite concerns question means more perceived concerns.

3.1.4. Control variables

Table 1 summarizes other control variables that we included in the analytical model. Specifically, we controlled for respondents' age, the squared term of age, own income, regional income, average travel time, own travel time, gender, and geographic location in our analysis. Respondents' geographic location were categorized into one of three groups: large metro, small metro/urban, and small city/rural. To construct this variable we cross-referenced the zip code of the respondent to the corresponding county designation to align the survey data with 2013 Rural-Urban Continuum Codes (RUCC) from the USDA (USDA, 2020). We condensed the nine reported

Table 1
Description of Variables.

Variable	Description	Source
Age	Age in years	State of the State Survey 2017
Age-squared	Age squared	State of the State Survey 2017
Own income	Midpoint of income tiers from survey data	State of the State Survey 2017
Regional income	Median Family income at the ZIP code level	2014–2018 American Community Survey (ACS)
Average travel time	Mean travel time to work (minutes) at the ZIP code level	State of the State Survey 2017
Own travel time	Recoded variable (see Appendix question 19) characterizing number of hours driven in an average week: 0 = no hours driven; 2.5 = between 1 and 5 h; 7.5 = between 6 and 10 h; 15 = more than 10 h	State of the State Survey 2017
Gender	Binary variable where 1 is female and 0 is male	State of the State Survey 2017
Large Metro	Binary variable where 1 is large metro and 0 is urban	USDA Rural-Urban Continuum Codes (RUCC) 2013
Small city/rural	Binary variable where 1 is small city/rural and 0 is urban	USDA Rural-Urban Continuum Codes (RUCC) 2013
Conservative ideology	Binary variable where 1 = conservative and 0 = non-conservative	State of the State Survey 2017
Concerns	Average value across all concern questions in the survey	State of the State Survey 2017
Benefits	Average value across all benefit questions in the survey	State of the State Survey 2017

RUCC codes into three categories that represent the urban/rural divide within the State of Michigan: Large Metro (RUCC={1,2}), Metro/Urban (RUCC={3, 4, 5}) and Rural (RUCC={6, …, 9}). The large metro category is meant to capture the two largest cities in the State of Michigan: Detroit and Grand Rapids. The small metro/urban category is designed to capture the other cities in Michigan that are much smaller than Detroit and Grand Rapids. The rural category captures all other locations in Michigan that are non-urban.

3.2. Statistical models

Three types of models were estimated to understand the relationship between AV adoption and political ideology. First, we conducted ANOVA to compare the AV adoption variables and perceived benefits and concerns about AVs across the three political ideology groups. This comparison provides the initial information for us to evaluate our hypothesis concerning the effect of political ideology on AV adoption.

Next, we estimated regression models (ordinary least squares regressions for perceived benefits and concerns and probit regression models for AV adoption variables) with the demographic variables included as control variables. These regression models allow us to probe the unique effect of political ideology on AV-related variables while simultaneously controlling for demographic characteristics of the participants. This is important because prior research has indicated these sociodemographic variables are important for AV adoption (Laidlaw et al., 2018; Peng, 2020; Talebian and Mishra, 2018). Thus, compared to the barebones approach with the ANOVA, the regression models with sociodemographic factors included as controls reflect a more conservative statistical approach to allow us to narrow in on the unique effects associated with political ideology.

Finally, we conducted a path model analysis to understand the mechanism through which political ideology may be related to AV adoption. Specifically, we argue that political ideology may be related to AV adoption through their associations with perceived benefits and concerns about AVs. The path model directly assesses this hypothesized mediation effect, while simultaneously controlling for the effects of all the sociodemographic variables, to provide information about the extent to which the political ideology is related to willingness to ride in and own AVs via perceived benefits and concerns about AVs.

Table 2
Comparison of Respondent Characteristics with Census Data.

Demographic	Our Sample Frequency	Percentage	National Population Frequency	Percentage	Chi-square test
Age					$\chi2 = 118.67^{***}$
15–19	51	6.6%	21,094,597	8.0%	
20–29	72	9.3%	45,371,257	17.1%	
30–39	62	8.0%	43,114,781	16.3%	
40–49	146	18.8%	40,476,486	15.3%	
50–59	183	23.6%	43,278,449	16.4%	
60–69	155	20.0%	36,721,684	13.9%	
70–79	78	10.1%	21,533,719	8.2%	
80 and over	29	3.7%	12,426,454	4.7%	
Total	776		264,017,427		
Gender					$\chi2 = 1.28$
Male	396	51%	160,045,920	49%	
Female	380	49%	164,939,619	51%	
Total	776		324,985,539		
Income					
Less than $10,000	14	1.8			
$10,000–19,999	56	7.2			
$20,000–29,999	83	10.7			
$30,000–39,999	69	8.9			
$40,000–49,999	80	10.3			
$50,000–59,999	76	9.8	Median income: $61,372		
$60,000–69,999	88	11.3			
$70,000–89,999	86	11.1			
$90,000–99,999	36	4.6			
$100,000–149,999	119	15.3			
$150,000 or More	69	8.9			
Total	776				
Political ideology					$\chi2 = 8.72^{*}$
Conservative	251	32%	Conservative	36%	
Liberal	183	24%	Liberal	25%	
Moderate	300	39%	Moderate	34%	
No data	42	5%	No data	5%	
Total	776				

4. Results

Table 2 breaks out the characteristics of survey respondents in terms of age, gender and income. It also provides comparative data about U.S. residents. The table indicates that our sample is similar to the national average in terms of gender. The survey sample is also similar in terms of income; the national median income of $61,372 falls into the $60,000–69,999 range which also contains the median for our survey data of $65,000. Chi-square tests indicate statistical differences between the two groups as well. Our sample is somewhat older and more politically moderate than the U.S as a whole.

4.1. ANOVA comparisons

Table 3 provide a breakdown of benefits and concerns associated with AVs. Conservatives perceived significantly lower benefits associated with AVs than moderates and liberals. Moderates and liberals perceived similar levels of benefits associated with AVs as outlined in this table. Conversely, liberals perceived fewer concerns about AVs overall compared to conservatives and moderates. Specifically, liberals were less concerned with equipment failure and cybersecurity issues compared to moderates and conservatives. Liberals also reported lower concerns related to data privacy issues compared to moderates. Finally, conservatives reported higher concerns related to the inability to drive the way they want with AVs compared to liberals and moderates. Taken together, while liberals consistently reported higher perceived benefits and lower concerns compared to conservatives, moderates showed a more complex pattern of responses. On the one hand, moderates had a similar response pattern as liberals when it comes to perceived benefits of AVs. On the other hand, moderates showed a more similar response pattern as conservatives when it comes to perceived concerns about AVs. These results further support the importance of categorizing participants into three political ideology groups.

The top portion of Table 3 breaks down survey responses by political ideology for our two indicators of AV adoption, willingness to ride and willingness to own. This portion of the table shows that for both measures of adoption (riding and owning), respondents identifying as conservatives were statistically less likely to adopt compared to respondents identifying as either moderates or liberals. Alternatively, there was no statistical difference between liberals and moderates for either indicator of AV adoption.

4.2. OLS results for perceived benefits and concerns

Table 4 presents the OLS results to help us understand the unique effect of political ideology on perceived benefits and concerns about AV after controlling for the effects of other sociodemographic characteristics. In this table we present two sets of results, one where the dependent variable is the average score for survey questions related to perceived benefits and a second where the dependent variable is the average score for survey questions related to perceived concerns. These results reveal that after controlling for demographic, socio-economic, and geographic characteristics, respondents with conservative ideologies were statistically less likely to perceive benefits of AVs compared to those with liberal and moderate ideologies. Respondents with conservative ideologies were also more likely to perceive concerns related to AVs compared to those with liberal ideologies. These results are consistent with prior work

Table 3
Indicators of AV Adoption and Perceived Benefits and Concerns.

Variable	All Respondents	Conservatives	Moderate	Liberal	F-ratio	DF
Indicators of AV Adoption						
Willingness to Ride in AV	0.40	0.30^{B,C}	0.44^{A}	0.48^{A}	8.558***	2, 731
Willingness to own AV	0.49	0.34^{B,C}	0.57^{A}	0.61^{A}	21.736***	2, 731
Benefits	**2.91**	**2.68^{B,C}**	**3.02^{A}**	**3.11^{A}**	**17.302*** **	**2, 731**
Going places without having to drive myself	2.03	1.77^{B,C}	2.18^{A}	2.22^{A}	11.514***	2, 726
Staying independent as I get older	3.02	2.86^{B,C}	3.11^{A}	3.14^{A}	4.368*	2, 720
Fewer crashes	3.23	3.00^{B,C}	3.30^{A}	3.43^{A}	8.639***	2, 706
Improved emergency response	3.22	3.02^{B,C}	3.28^{A}	3.46^{A}	8.727***	2, 698
Reduced traffic	2.96	2.72^{B,C}	3.09^{A}	3.14^{A}	9.800***	2, 698
Better for the environment	3.18	2.86^{B,C}	3.25^{A}	3.48^{A}	18.763***	2, 695
Fewer driving related expenses	2.95	2.75^{B,C}	3.07^{A}	3.05^{A}	6.867**	2, 700
Concerns	**2.99**	**3.07^{C}**	**3.04^{C}**	**2.84^{A,B}**	**6.555****	**2, 731**
Equipment or system failure	3.29	3.34^{C}	3.41^{C}	3.08^{A,B}	6.743**	2, 727
Security from hackers	3.32	3.36^{C}	3.47^{C}	3.10^{A,B}	8.222***	2, 726
Data privacy and location tracking	3.15	3.22	3.24^{C}	2.98^{B}	3.983*	2, 722
Being on the road with non-self-driving vehicles, peds. & cyclists	3.07	3.11	3.09	2.98	0.968	2, 718
Learning to use self-driving vehicles	2.38	2.42	2.39	2.32	0.428	2,719
Not driving the way I want	2.66	2.92^{B,C}	2.58^{A}	2.41^{A}	11.484***	2,721
Greater vehicle expenses	3.08	3.13	3.08	3.02	0.624	2,717

Notes: F ratio: omnibus ANOVA test to compare the three political ideology group; DF: degrees of freedom for the ANOVA test.
uperscript: results from Bonferroni corrected post-hoc paired comparisons to compare two political ideology groups at a time.
Superscript A: group mean is significantly different from the group mean of Conservatives group.
Superscript B: group mean is significantly different from the group mean of Moderate group.
Superscript C: Group mean is significantly different from the group mean of Liberals group.

Table 4
Ordinary Least Squares Regression Results.

Predictor	Concerns Coefficient	S.E.	Benefits Coefficient	S.E.
Age	0.003	0.004	0.002	0.005
Age-squared	−0.000	0.000	−0.000	0.000
Own income	0.000	0.001	0.001	0.001
Regional income	−0.000*	0.000	−0.000	0.000
Average travel time	−0.002	0.006	0.006	0.007
Own travel time	0.004	0.005	−0.002	0.006
Gender	0.177***	0.052	0.119	0.062
Large Metro vs. Small Metro/Urban	−0.104	0.060	0.051	0.073
Large Metro vs. Rural	−0.156	0.060	−0.200	0.106
Moderate vs. Conservative ideology	−0.012	0.020	0.098***	0.024
Liberal vs. Conservative ideology	−0.088***	0.023	0.123***	0.027
Constant	3.095	0.200	2.850	0.241
F	3.877		6.134	
p for F test	0.000		0.000	
df for F test	11, 722		11,722	
R-squared	0.056		0.085	

Note: N = 723; * $p < .05$; ** $p < .01$; *** $p < .001$; Gender was coded as 0 = male and 1 = female.
Large Metro vs. Small Metro/Urban was coded as 0 = large metro and rural and 1 = urban/small metro.
Large Metro vs. Rural was coded as 0 = large metro and urban/small metro and 1 = small city/rural.
Conservative vs. moderate ideology was coded as − 1 = conservative ideology, 2 = moderate, and − 1 = liberal ideology.
Conservative vs. liberal ideology was coded as − 1 = conservative ideology, −1 = moderate, and 2 = liberal ideology.

(Peng, 2020) and indicate that participants' political ideology explains perceptions of benefits and concerns about AVs above and beyond their demographic, socio-economic, and geographic characteristics.

4.3. Probit results for AV adoption

Table 5 presents the probit results for our two indicators of AV adoption. Four models are estimated, two predictors only models which include respondent characteristics, excluding benefits and concerns, and two full models which contain respondent characteristics as well as perceived benefits and concerns. The predictor-only models allow us to evaluate whether participants' political ideology has unique effects on their intention to adopt AVs beyond their demographic, socio-economic, and geographic characteristics.

Table 5
Probit Regression Results.

	Willingness to Ride in AVs				Willingness to Own AVs			
	Predictors only model		Full model		Predictors only model		Full model	
Predictor	Coefficient	S.E.	Coefficient	S.E.	Coefficient	S.E.	Coefficient	S.E.
Age	−0.015	0.008	−0.021*	0.009	−0.001	0.008	−0.001	0.009
Age-squared	0.000	0.000	0.000*	0.000	−0.000	0.000	−0.000	0.000
Own income	0.002	0.001	0.001	0.001	0.002*	0.001	0.001	0.001
Reginal income	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Average travel time	−0.013	0.011	−0.020	0.012	0.001	0.011	−0.003	0.011
Own travel time	0.005	0.009	0.011	0.010	0.007	0.009	0.013	0.010
Gender	−0.666***	0.101	−0.801***	0.115	−0.150	0.098	−0.198	0.109
Large Metro vs. Small Metro/Urban	0.011	0.117	−0.068	0.128	−0.005	0.114	−0.102	0.124
Large Metro vs. Rural	0.017	0.172	0.041	0.191	−0.054	0.166	−0.024	0.183
Moderate vs. Conservative ideology	0.089	0.066	0.082	0.073	0.151*	0.065	0.147*	0.071
Liberal vs. Conservative ideology	0.262**	0.076	0.085	0.086	0.285***	0.075	0.142	0.084
Concerns			−0.643***	0.085			−0.472***	0.082
Benefits			0.881***	0.084			0.891***	0.078
Constant	0.389	0.389	−0.072	0.526	−0.048	380	−1.205	0.512
Chi-square	90.635		265.426		64.777		243.721	
p for Chi-sqaure test	0.000		0.000		0.000		0.000	
df for Chi-square test	11		13		11		13	
−2 Log likelihood	899.260		724.468		952.758		773.814	
Cox & Snell R-squared	0.116		0.304		0.085		0.283	

Note: N = 723; * $p < .05$; ** $p < .01$; *** $p < .001$; Gender was coded as 0 = male and 1 = female.
Large Metro vs. Small Metro/Urban was coded as 0 = large metro and rural and 1 = urban/small metro.
Large Metro vs. Rural was coded as 0 = large metro and urban/small metro and 1 = small city/rural.
Conservative vs. moderate ideology was coded as − 1 = conservative ideology, 2 = moderate, and − 1 = liberal ideology.
Conservative vs. liberal ideology was coded as − 1 = conservative ideology, −1 = moderate, and 2 = liberal ideology.

The full models, which include the control variables, political ideology, and the perceived benefits and concerns about AVs allow us to explore if perceived benefits and concerns about AVs contribute to intention to adopt above and beyond other respondent characteristics. This is important to establish as the initial evidence for the hypothesized mediation model outlined in Fig. 1 (Baron and Kenny, 1986; Preacher and Hayes, 2008).

The results in Table 5 highlight that in both sets of models, political ideology is a significant predictor for both willingness to ride in and willingness to own AVs. In the predictors only models, those who had a conservative political ideology, when compared to those with a liberal political ideology, were less likely to be willing to ride in or to own an AV. Additionally, compared to those with a moderate political ideology, participants with a conservative ideology also showed a lower interest in owning an AV. In the full models, the statistical significance of political ideology largely disappears. Instead, both perceived benefits and concerns are significant predictors for willingness to ride in and to own an AV. Participants who perceived more benefits were more likely to report a higher willingness to ride in and to own an AV. On the other hand, those with more perceived concerns were less likely to report a willingness to ride in or to own an AV. Women were less likely to report a willingness to ride in an AV compared to male participants. There was no such linkage with gender for willingness to own an AV.

4.4. Results of mediation analysis with path model

The OLS and probit regression results showed that political ideology was a significant predictor for participants' perceived benefits and concerns about AVs, which were significant predictors for AV adoption. The results of the full probit regression model suggest however that this linkage may be mediated by perceived benefits and concerns since the statistical significance on political ideology disappeared when benefits and concerns were incorporated as variables into the models.

Combined, these results provided preliminary support for the hypothesized research model illustrated by Fig. 1. In this model, we argue that the relationships between participants' political ideology and their willingness to ride in and to own AVs are mediated by their perceptions of benefits and concerns of AVs. In other words, participants' political ideology indirectly predicts their intent to adopt AVs by affecting more proximal evaluations of AVs. Therefore, to evaluate how political ideology impacts participants' willingness to ride in and own AVs, we conducted a path modeling test to simultaneously estimate the relationships between demographic, socio-economic, and geographic characteristics, political ideology, perceptions of benefits and concerns of AVs, and willingness to ride in and willingness to own AVs.

Because willingness to ride in and willingness to own AVs were dichotomous variables, the path model was estimated using the weighted least square mean and variance adjusted estimators using MPlus version 7.0 (Muthén and Muthén, 2012). For the hypothesized exogenous variables (e.g., political ideology, demographic, socio-economic, and geographic characteristics) that had a

Table 6
Mediation Analysis Results.

	Concerns		Benefits		Willingness to Ride in AVs		Willingness to Own AVs	
	Coefficient	**S.E.**	**Coefficient**	**S.E.**	**Coefficient**	**S.E.**	**Coefficient**	**S.E.**
Predictors								
Age	0.005	0.004	0.003	0.006	−0.012	0.007	−0.001	0.007
Age-squared	−0.000	0.000	0.000	0.000	0.000	0.000	−0.000	0.000
Own income	0.000	0.001	0.001	0.001	0.001	0.001	0.001	0.001
Reginal income	−0.000*	0.000	−0.000	0.000	0.000	0.000	0.000	0.000
Average travel time	−0.006	0.005	0.002	0.007	−0.016	0.010	−0.004	0.010
Own travel time	0.005	0.005	−0.001	0.005	0.004	0.008	0.009	0.008
Gender	0.195***	0.053	0.111	0.061	−0.675***	0.090	−0.200*	0.086
Large Metro vs. Small Metro/ Urban	−0.119	0.062	0.020	0.072	−0.054	0.105	−0.036	0.102
Large Metro vs. Rural	−0.114	0.093	−0.207*	0.097	0.056	0.153	0.118	0.145
Moderate vs. Conservative ideology	−0.013	0.020	0.098***	0.024	0.082*	0.036	0.129***	0.034
Liberal vs. Conservative ideology	−0.091***	0.024	0.120***	0.027	0.096*	0.041	0.141***	0.040
Mediators								
Concerns					−0.352***	0.059	−0.202**	0.062
Benefits					0.616***	0.048	0.668***	0.040
R-squared	0.055		0.086		0.436		0.405	

Note: N = 776; * $p < .05$; ** $p < .01$; *** $p < .001$; Gender was coded as 0 = male and 1 = female.
Large Metro vs. Small Metro/Urban was coded as 0 = large metro and rural and 1 = urban/small metro.
Large Metro vs. Rural was coded as 0 = large metro and urban/small metro and 1 = small city/rural.
Conservative vs. moderate ideology was coded as − 1 = conservative ideology, 2 = moderate, and − 1 = liberal ideology.
Conservative vs. liberal ideology was coded as − 1 = conservative ideology, −1 = moderate and 2 = liberal ideology.

significant relationship at the 5% level with the hypothesized mediators (e.g., perceptions of concerns and benefits of AVs), we then estimated the effect size of the point estimate and the bootstrapped 95% confidence intervals (CI; 5000 bootstraps: Preacher and Hayes, 2008) of their direct and indirect effects on the willingness to ride in and willingness to own AVs via perceived benefits and concerns of AVs. Results are summarized in Tables 6 and 7.

In Table 6, we show that when contrasted with participants with a conservative political ideology, those with moderate andliberal political ideologies had significant, positive relationships with perceived benefits of AVs. This suggests that both liberals and moderates reported higher perceived benefits compared to conservatives. On the other hand, when contrasted with participants with a conservative political ideology, only those with a liberal ideology had a significant, negative relationship with perceived concerns of AVs. This suggests that respondents identifying as conservatives reported higher levels of perceived concerns compared to those identifying as liberals. This pattern is consistent with our hypothesis. In terms of the control variables, demographic, socio-economic, and geographic variables had limited predictive capability for perceptions of concerns or benefits with a few exceptions. Gender emerged as a significant predictor for perception of concerns about AVs. In this case, female participants reported higher perceived concerns of AVs. Regional income had a significant, negative relationship with perceived concerns. Residents in the large metro areas also reported significantly more perceived AV benefits compared to those in the rural areas.

Both perceptions of AV concerns and benefits were significant predictors of participants' willingness to ride in AVs. Consistent with our expectation, participants who perceived fewer AV concerns or more AV benefits were more likely to indicate a willingness to ride in AVs. Given that political ideology was a significant predictor of the two mediators (perceived AV benefits and concerns), we used the bootstrapping method to estimate the indirect effects and their confidence intervals for the association between political ideology with

Table 7
Direct, Indirect, and Total Effects of Political Ideology and Gender.

	Effect	S.E.	t	*p*	95% CI boundaries
Moderate political ideology (versus conservative ideology) → Willingness to ride in an AV					
Total effect	0.146***	0.039	3.730	0.000	0.073, 0.226
Direct effect	0.082*	0.036	2.253	0.024	0.015, 0.155
Indirect effect					
Mediator 1: Perceived concerns	0.005	0.007	0.633	0.526	−0.010, 0.019
Mediator 2: Perceived benefits	0.060***	0.015	3.920	0.000	0.031, 0.091
Liberal political ideology (versus conservative ideology) → Willingness to ride in an AV					
Total effect	0.202***	0.045	4.477	0.000	0.118, 0.296
Direct effect	0.096*	0.041	2.348	0.019	0.018, 0.182
Indirect effect					
Mediator 1: Perceived concerns	0.032**	0.010	3.119	0.002	0.014, 0.055
Mediator 2: Perceived benefits	0.074***	0.018	4.111	0.000	0.041, 0.111
Moderate political ideology (versus conservative ideology) → Willingness to own an AV					
Total effect	0.197***	0.039	5.121	0.000	0.128, 0.278
Direct effect	0.129***	0.035	3.688	0.000	0.065, 0.202
Indirect effect					
Mediator 1: Perceived concerns	0.003	0.004	0.602	0.547	−0.006, 0.012
Mediator 2: Perceived benefits	0.065***	0.016	3.991	0.000	0.035, 0.098
Liberal political ideology (versus conservative ideology) → Willingness to own an AV					
Total effect	0.240***	0.045	5.381	0.000	0.159, 0.332
Direct effect	0.141***	0.040	3.500	0.000	0.069, 0.225
Indirect effect					
Mediator 1: Perceived concerns	0.018*	0.008	2.356	0.018	0.005, 0.036
Mediator 2: Perceived benefits	0.080***	0.019	4.183	0.000	0.044, 0.120
Gender → Willingness to ride in an AV					
Total effect	−0.675***	0.101	−6.702	0.000	−0.887, −0.488
Direct effect	−0.675***	0.091	−7.413	0.000	−0.867, −0.508
Indirect effect					
Mediator 1: Perceived concerns	−0.069**	0.022	−3.132	0.002	−0.116, −0.030
Mediator 2: Perceived benefits	0.069	0.039	1.767	0.077	−0.007, 0.146
Gender → Willingness to own an AV					
Total effect	−0.165	0.097	−1.698	0.090	−0.363, 0.018
Direct effect	−0.200*	0.088	−2.272	0.023	−0.380, −0.033
Indirect effect					
Mediator 1: Perceived concerns	−0.039*	0.017	−2.340	0.019	−0.076, −0.011
Mediator 2: Perceived benefits	0.074	0.042	1.785	0.074	−0.008, 0.156

willingness to ride in AVs via the perceived benefits and concerns of AVs.

We found that compared to participants with a conservative political ideology, those with a moderate ideology were more likely to report a higher willingness to ride in AVs as they perceived more AV benefits. Additionally, compared to conservative participants, those with a liberal ideology were more likely to report a higher willingness to ride in AVs due to higher perceived AV benefits and lower perceived AV concerns.

Perceptions of AV concerns and benefits were also significant predictors of participants' willingness to own AVs. Consistent with our expectation, participants who perceived fewer AV concerns or more AV benefits were more likely to indicate a willingness to own AVs. Using the bootstrapping technique, we estimated the indirect effects and their confidence intervals for the association between political ideology with willingness to own AVs via the perceived benefits and concerns of AVs.

Perceived benefits and concerns mediated the association between political ideology and willingness to own AVs. Specifically, compared to participants with a conservative political ideology, those with a moderate ideology were more likely to report a higher willingness to own AVs as they perceived more AV benefits. Additionally, compared to conservative participants, those with a liberal ideology were more likely to report a higher willingness to own AVs as they perceived higher AV benefits and lower AV concerns. Finally, females reported a lower willingness to own AVs because they perceived more concerns about AVs. Results for the bootstrapped direct, indirect, and total effects of political ideology and gender are summarized in Table 7.

Taken together, our hypothesized mediation model provides support for political ideology, such that perceived benefits and concerns of AVs help explain the socio-economic differences in participants' willingness to ride in and to own AVs. We found significant indirect effects of political ideology on willingness to ride in and to own AVs via the perceived benefits and concerns of AVs. We also found significant indirect effects of gender on willingness to own and ride AVs via increased perceived AV concerns. These significant indirect effects suggests that perceived benefits and concerns explain why conservative participants reported lower willingness to own or ride in AVs.

It is important to note that for political ideology, its indirect effects on willingness to own and ride in AVs showed different patterns depending on the contrasting groups. In particular, compared to the conservative participants, those with a liberal political ideology showed higher willingness to own and ride in AVs via both higher perceived benefits and lower perceived concerns. However, participants that identified as politically moderate did not differ from conservative participants when it comes to perceived concerns of AVs and as such, they were more willing to own and ride in AVs because they perceived more AV benefits. These different patterns have important implications for organizations interested in promoting AVs, as they suggest different strategies that may be uniquely effective for individuals with different political ideologies. Specifically, highlighting the benefits of AVs may be more impactful to generate more interests in the new technology among politically moderate individuals. On the other hand, it will be important to not only promote the benefits, but also explicitly address the concerns associated with AVs, in order to help generate more openness to the technology among participants with conservative ideologies.

Interestingly, the direct effects of political ideology on willingness to ride in and to own AVs remained significant after the mediators of perceived concerns and benefits of AVs were accounted for. This suggests that the effects of political ideology on willingness to own AVs were only partially mediated by the perceptions of benefits and concerns of AVs, and additional mechanisms may exist to explain why conservative respondents reported lower willingness to own or ride in AVs. For example, the perceived acceptability or social norms of owning/riding in AVs, as well as the perceived ease of owning/riding in AVs may also partially explain the observed demographic and socio-economic differences in participants' intention to own/ride AVs.

5. Discussion

Autonomous vehicles are slowly being phased into society as new vehicles include an increasing number of autonomous features with each passing year. While the exact time frame when fully autonomous vehicles (level 5) will be on the road is uncertain and likely to be at least a decade away (Yankelevich et al., 2018), the research and policy communities are increasingly examining societal perspectives about this emerging technology. Understanding these perspectives is important because of the network effects likely associated with AV benefits (e.g., reduced crashes, traffic congestion and vehicle emissions) (Stern et al., 2018, 2019; Litman, 2020; Moody et al., 2020). Our research contributes to this discussion by examining the impact of political ideology on people's intention to adopt AVs. We also examine how perceived benefits and concerns may mediate this relationship given prior research linking political ideology to several issues that may shape perceptions of AVs (Webster and Kruglanski, 1994; Jost et al., 2003, 2007; Gauchat, 2012; Drummond and Fischoff, 2017).

Our analytical results showed that in support of our hypothesis, political ideology was an important predictor for individuals' intent to adopt AVs, as characterized by both willingness to ride in and to own AVs. Specifically, compared to conservative participants, moderates and liberals reported higher AV adoption intentions. Additionally, we found support that the effect of political ideology on AV adoption intention is mediated by participants' perceived benefits and concerns about AVs. Compared to conservative participants, politically moderate participants reported AV adoption intention via higher perceived benefits about AVs. On the other hand, compared to conservatives, liberals reported higher AV adoption intention through both higher perceived benefits and lower perceived concerns about AV: these effects held after controlling for the demographic, socio-economic, and geographical characteristics of the participants. These findings build upon prior research showing that perceived benefits and concerns are associated with support or openness to AVs (Howard and Dai, 2014; Schoettle and Sivak, 2014; Kyriakidis et al., 2015; Gkartzonikas and Gkritza, 2019).

The link between political ideology and AV adoption suggests that elected leaders and their support for AVs could influence adoption in two ways. One, their messaging around AVs could influence people's intention to adopt. Two, elected leaders may support legislation that paves or inhibits widespread adoption of AVs. The finding that perceived benefits and concerns mediate the

relationship between political ideology and intention to adopt suggests that the messaging used to market and inform the public about AVs is important. In particular, targeted marketing to particular audiences is likely necessary to convince people about the benefits of AVs and assuage or overcome their concerns about AVs. For conservatives this targeted messaging may be more effective if it emphasizes potential benefits to help foster positive reactions towards AVs. To overcome the concerns expressed about AVs it may be more influential to provide conservatives with more information to change their existing, negative evaluations. To do this, mass media, rather than social media, may be a particularly effective means of influencing the public given the findings of recent research which indicate that information about AVs from mass media rather than social media significantly reduced risk perceptions associated with AVs (Zhu et al., 2020).

That said, it is important to note a few limitations to this study. First, this study is based on survey data from individuals across the state of Michigan. As mentioned previously, this sample is somewhat older and more moderate than the U.S. average. The age difference is of minimal concern however given the results of a moderation analysis conducted prior to our mediation analysis. This assessment revealed no significant moderation effects related to age on either of the indicators of AV adoption and perceived benefits and concerns about AVs. Thus, we do not anticipate that this characteristic of the sample skewed our findings. The moderate leaning of our sample is also not cause for concern, it indicates our sample is not skewed towards the very liberal or very conservative portions of the political ideology scale.

Second, the survey questions did not specify or describe different levels of automation (level 3, 4, or 5) (SAE International, 2019). Instead, survey respondents were provided with a definition of AVs consistent with the Society of Automotive Engineers (SAE) level 5 automation. This was necessary given the lack of familiarity of the general public at the time the survey was administered and even more recently (Hancock et al., 2019). However, it will obscure any variations in AV openness by varied levels of autonomy. As vehicles are disseminated with more autonomous features (e.g. automatic steering, lane departure control, etc.) and the general public becomes more familiar with AVs, this may represent a fruitful area for future research. Third, our study is cross-sectional in nature, which prevents us from analyzing the evolution of intentions to adopt over time. These limitations suggest two areas for future research. One, national level studies of the linkage between political ideology and the intention to adopt AVs should be conducted. In this line of work, variations in the intention to adopt for different levels of automation (3, 4, or 5) could be explored as well. Two, longitudinal studies are needed to track public sentiment about AVs over time and assess changes in public sentiment (or lack thereof) (Tennant et al., 2019).

6. Conclusion

While the economic downturn associated with COVID-19 may affect the pace of development and dissemination of higher levels of automated vehicles, they are the transportation technology of the future. Understanding the evolution of societal openness and acceptance to AVs over time will be critical to their widespread adoption, particularly if there are network effects to adoption that reinforce or mitigate individual perceptions. This study contributed to the growing body of knowledge about AV perceptions and adoption intentions by illustrating how political ideology shapes people's intention to adopt AVs.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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Appendix A: Survey Question Text

1. Self-Driving: Would Ride: Would you ride in a self-driving vehicle?

Code	LABEL
1	Yes YES
2	Unsure/maybe
3	No
8	Do not know
9	Refused

2. Self-Driving: Own

How interested would you be in owning or leasing a completely self-driving vehicle in the future? Would you say very interested, moderately interested, slightly interested, or not at all interested?

Code	LABEL
1	Very interested
2	Moderately interested
3	Slightly interested
4	Not at all interested
8	Do not know
9	Refused

3. Political: Ideology – Lean

Code	LABEL
1	Very conservative
2	Somewhat conservative
3	Lean conservative
4	Middle
5	Lean liberal
6	Somewhat liberal
7	Very liberal
8	Do not know
9	Refused

4. Self-Driving Benefits: Not Driving

How important do you view the following as potential benefits of self-driving vehicles? For each, please tell me whether it is very important, moderately important, slightly important, or not at all important.

Going places without having to drive myself.

Code	LABEL
1	Very Important
2	Moderately Important
3	Slightly Important
4	Not at all important
8	Do not know
9	Refused

5. Self-Driving Benefits: Age

(How important do you view the following as potential benefits of self-driving vehicles? For each, please tell me whether it is very important, moderately important, slightly important, or not at all important.)

Staying independent as I get older.

Code	LABEL
1	Very Important
2	Moderately Important
3	Slightly Important
4	Not at all important
8	Do not know
9	Refused

6. Self-Driving Benefits: Crashes

(How important do you view the following as potential benefits of self-driving vehicles? For each, please tell me whether it is very important, moderately important, slightly important, or not at all important.)

Fewer crashes

Code	LABEL
1	Very Important
2	Moderately Important
3	Slightly Important
4	Not at all important
8	Do not know
9	Refused

7. Self-Driving Benefits: Emergency Response

(How important do you view the following as potential benefits of self-driving vehicles? For each, please tell me whether it is very important, moderately important, slightly important, or not at all important.)

Improved emergency response

Code	LABEL
1	Very Important
2	Moderately Important
3	Slightly Important
4	Not at all important
8	Do not know
9	Refused

8. Self-Driving Benefits: Traffic

(How important do you view the following as potential benefits of self-driving vehicles? For each, please tell me whether it is very important, moderately important, slightly important, or not at all important.)

Reduced traffic

Code	LABEL
1	Very Important
2	Moderately Important
3	Slightly Important
4	Not at all important
8	Do not know
9	Refused

9. Self-Driving Benefits: Environment

(How important do you view the following as potential benefits of self-driving vehicles? For each, please tell me whether it is very important, moderately important, slightly important, or not at all important.)

Better for the environment

Code	LABEL
1	Very Important
2	Moderately Important
3	Slightly Important
4	Not at all important
8	Do not know
9	Refused

10. Self-Driving Benefits: Expenses

(How important do you view the following as potential benefits of self-driving vehicles? For each, please tell me whether it is very important, moderately important, slightly important, or not at all important.)

Fewer driving related expenses

Code	LABEL
1	Very Important
2	Moderately Important
3	Slightly Important
4	Not at all important
8	Do not know
9	Refused

11. Self-Driving Concerns: Failure

How concerned are you about the following issues related to self-driving vehicles? For each, please tell me whether you are very concerned, moderately concerned, slightly concerned, or not at all concerned.

Equipment or system failure

Code	LABEL
1	Very concerned
2	Moderately concerned
3	Slightly concerned
4	Not at all concerned
8	Do not know
9	Refused

12. Self-Driving Concerns: Security

(How concerned are you about the following issues related to self -driving vehicles? For each, please tell me whether you are very concerned, moderately concerned, slightly concerned, or not at all concerned.)

Security from hackers

Code	LABEL
1	Very concerned
2	Moderately concerned
3	Slightly concerned
4	Not at all concerned
8	Do not know
9	Refused

13. Self-Driving Concerns: Privacy

(How concerned are you about the following issues related to self -driving vehicles? For each, please tell me whether you are very concerned, moderately concerned, slightly concerned, or not at all concerned.)

Data privacy and location tracking

Code	LABEL
1	Very concerned
2	Moderately concerned
3	Slightly concerned
4	Not at all concerned
8	Do not know
9	Refused

14. Self-Driving Concerns: Sharing Road

(How concerned are you about the following issues related to self-driving vehicles? For each, please tell me whether you are very concerned, moderately concerned, slightly concerned, or not at all concerned.)

Being on the road with non-self-driving vehicles, pedestrians, and cyclists

Code	LABEL
1	Very concerned
2	Moderately concerned
3	Slightly concerned
4	Not at all concerned
8	Do not know
9	Refused

15. Self-Driving Concerns: Learning

(How concerned are you about the following issues related to self -driving vehicles? For each, please tell me whether you are very concerned, moderately concerned, slightly concerned, or not at all concerned.)

Learning to use self-driving vehicles

Code	LABEL
1	Very concerned
2	Moderately concerned
3	Slightly concerned

(*continued on next page*)

(*continued*)

Code	LABEL
4	Not at all concerned
8	Do not know
9	Refused

16. Self-Driving Concerns: Not Way I Want

(How concerned are you about the following issues related to self-driving vehicles? For each, please tell me whether you are very concerned, moderately concerned, slightly concerned, or not at all concerned.)

Not driving the way I want

Code	LABEL
1	Very concerned
2	Moderately concerned
3	Slightly concerned
4	Not at all concerned
8	Do not know
9	Refused

17. Self-Driving Concerns: Expenses

(How concerned are you about the following issues related to self-driving vehicles? For each, please tell me whether you are very concerned, moderately concerned, slightly concerned, or not at all concerned.)

Greater vehicle expenses

Code	LABEL
1	Very concerned
2	Moderately concerned
3	Slightly concerned
4	Not at all concerned
8	Do not know
9	Refused

18. How many hours do you spend driving in an average week?

Code	LABEL
1	Do not drive/0 hours
2	1 to 5 hours (include less than 1 hour if greater than 0)
3	6 to 10 hours
4	More than 10 hours
8	Do not know
9	Refused

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