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Autonomous Vehicle as a Future Mode of Transport in India: Analyzing the Perception, Opportunities and Hurdles

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Abstract: This empirical research investigates into perception of Autonomous Vehicles' (AV) acceptance among forth-coming probable users in India. Multinomial Logistic regression (MNL) and exploratory analysis were undertaken to interpret the users' degree of interest regarding AVs in relation to socio-economic variables like users' education and employment standards and other variables like cost and expenses incurred, overall safety issues, obstacles and benefits concerning AV. 91.1percent respondents had knowledge of AV but 50 percent expressed concern regarding AVs' reliability and 40percent showed interest in AVs. MNL results highlighted that expressing high order of interest towards AV increases with education and employment standards. Respondents expressing higher concern for AVs reliability, had the maximum probability of exhibiting least interest in adopting AV majorly due to dearth of consumer readiness and fear of accepting advanced technology. This study can aid in adding new layers to the epistemology of the emerging field of AV in Indian scenario.

Keywords: Autonomous Vehicles, User perception, Challenges and benefits, Safety concern, Interest

1. INTRODUCTION

World has witnessed a rapid advancement in autonomous technology integrated with artificial intelligence based approaches which has further boosted self-driving vehicles to arrive at the forefront of public interest. The Autonomous Vehicle (AV) also connoted as 'self-driving' or 'automated' vehicle, a recent advancement in automotive industry can steer driver less in all predetermined situations. AVs have gained importance since 2010s when several countries allowed the use of these vehicles in road traffic. Several car manufacturers like NVidia, Audi, Ford, BMW and Volvo would be launching high level automated vehicles or even Level 4 AVs by 2021 (Liljamo, Liimatainen, & Pöllänen, 2018).

In 2004, Defense Advanced Research Projects Agency's (DARPA), US great challenge was launched with the intention of elucidating the viability of autonomous technology by traversing approximately 150 miles path. Subsequently, with the launching of self-driving car

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in 2007, Google successfully performed a 14 miles on-road test of their AVs in 2012. Till April 2014, Google's self-driving cars have traversed more than 700,000 miles in California, Texas, Washington, Arizona in US in collaboration with well-established car manufacturing enterprises like Audi, BMW, Ford, GM, Nissan, Toyota etc. (Fagnant & Kockelman, 2015). Other internationally recognized auto manufacturers have scheduled to emerge with varying types of AVs like Ford and BMW by 2021 and Daimler trucks by 2025. According to Victoria Transport Policy, world will experience the emergence of AVs at a mass-scale by 2045s. On the same note, Europe's CityMobil2 project is lately testing low speed AV application in five cities (Fagnant & Kockelman, 2015).

With National Highway Traffic Safety Administration (NHTSA) releasing the initial policies and guidelines on AVs in 2015, 33 states in US have come up with AV related legislations (X. Xu & Fan, 2018). California, Michigan, Washington DC, Florida, and Nevada have ratified notices and bills to control AV licensing and operation. Especially, California has already directed its department of motor vehicles (DMV) to provide AV certification requirements by 2015 (Fagnant & Kockelman, 2015).

AVs are expected to deliver notable benefits to the transportation system, including enhanced traffic safety and efficiency by avoiding deadly crashes, offering hassle less mobility to young, elderly and disabled, increasing road capacity, reducing fuel consumption and trimming down carbon emissions (Liljamo et al., 2018). Moreover adoption of automotive technology in car-sharing system would change the notion of vehicles from an owned product to an on-demand service. Other possible sectors where AV would impact include parking services, parking demands, infrastructure and operational cost modification, freight transportation systems, land use patterns etc.

However, the process of advancement of AV technology has not been smooth till date. Previously several significant innovations have collapsed immediately after their market launch owing to failure in achieving user requirements and satisfaction. Apart from technological challenges, the major impediment in new technology innovations includes psychological concerns such as negative user perception and lack of acceptance towards contemporary concepts. Recently a significant amount of research has showcased users' perception towards acceptance of autonomous vehicle technology from different countries (Z. Xu et al., 2018). Studies conducted on people's attitude towards AVs elucidate how they accept the new technology and how equipped they would be to begin adopting them (Kyriakidis, Happee, & De Winter, 2015). Jourdes, Mol, Cedex, & Appliqu, (2018) predicted that by 2050s, automated driving will be comprised as a typical feature of forthcoming vehicles and AVs would comprise of 50-80 percent of vehicle travels and 40-60 percent of vehicle fleets. Bansal & Kockelman, (2017) concluded that AVs would be adopted by 24.8-87.2 percent of vehicle fleets by 2045. Market penetration of AV technology was also estimated by Nieuwenhuijsen, Correia, Milakis, van Arem, & van Daalen, (2018). Previous studies mostly comprise of online surveys with non-representative samples (Becker & Axhausen, 2017). Peoples' attitude towards implementing an advanced technology without any uncertainties and skepticism influence how fast a technology will be accepted and how well the possible benefits from AVs can be recognized (Hemant & Regina, 2007).

In developing nations like India, maximum population suffer from unemployment, poor education access, inferior environmental conditions and mass death-toll owing to road crashes. Hence, in this context queries might upsurge about the challenges entrenched in peoples' mind, their behaviorism and skepticism regarding AVs' safety issues and finally whether driverless vehicles would create or displace jobs. The novelty of this study lies in exploring peoples' attitude towards AV and their concerns regarding challenges of AV technology in Indian scenario with a special focus on forward section of the society. According to Roger Everett's

classic model, the 'Diffusion of Innovations', among the five categories of Innovators, Early Adopters, Early Majority, late Majority and Laggards, the Early Adopters adopt the technology faster (Sullivan, 2015). Because the forward section of the society with high positions and managerial skills possess the unique characteristic of technological fluency, or because they harbor positive views towards cutting-edge AV technology, we hypothesize that the respondents considered in this survey will be within the early adopters (Woldeamanuel & Nguyen, 2018). This study, through adoption of online survey, objectively intends to analyze the peoples' mindset, attitudes as well as impressions on smart car technologies and strategies. Owing to lack of adequate literature regarding AV technology emergence in India and its acknowledgement, this study would be of its initial kind to probe into the forward-section user perception towards AVs in Indian scenario.

2. LITERATURE REVIEW

2.1 Potential Benefits and Applications of Autonomous Vehicles

The perceived efficacy, reliability, ease of use and cost of a technology, as well as general attitudes towards it, are emphasized as significant factors in models elucidating how new technologies become more conventional (Hemant & Regina, 2007). AVs, inherently different from human-driven vehicles have certain unique potential factors to be considered which include smooth functioning, reliability of vehicle related services, cost of technology etc. (Fagnant & Kockelman, 2015).

AV technology is heralded for several positive and negative effects across multiple sectors. AVs can be proved effective in reducing on road traffic crashes specifically owing to human related causes (Woldeamanuel & Nguyen, 2018). NHTSA has reported driver error to be the foremost reason behind 90 percent of road crashes (NHTSA, 2008). Over 40 percent of the fatal crashes involve reasons like alcohol consumption, distraction, drug involvement and fatigue other than inattention, distraction, or speeding caused by drivers. Adeel, Frank, & Ify, (2014) had predicted a possible reduction of around 1.86 million less injurious crashes, including up to 27,000 less fatalities per year with advent of AV technology. While driver less AVs can reduce the chances of crashes owing to driver error, the challenges regarding AVs' performance in a safe environment cannot be ignored or eradicated completely at this moment. Designing a system for AV, with object recognition power on the road is critical. Different objects with varying activity recognition make the AV sensor complex with advanced artificial intelligence strategies. However, AVs often connoted as 'crash-less cars' would prove safer in future with forthcoming advanced sensor installation.

Experts predict that AVs also have huge impact over traffic congestion (Silberg, 2012). AV's ability of sensing and anticipating lead vehicles' braking and other decisions makes it also efficient in reducing fuel consumption as well. AVs with advanced braking and speed regulating technologies lead to fuel savings, and reductions in traffic-destabilizing shockwave propagation of platooning vehicles (Sullivan, 2015). Profound use of existing lanes and efficient intersections, coordinated platoons, and route choices are some of the estimated benefits of AVs. Research cites that AVs' advantages like congestion reduction, lesser fuel consumption and improved safety concerns would also impact travel behavior. Furthermore, driver-less AVs can be utilized by youngsters as well as elderly and differently abled.

Other benefits include smart parking decisions like self-parking capabilities in less expensive zones and independence and mobility, avoiding human-driven physical limitations like unfamiliar roads, night-time driving, poor weather, heavy traffic etc. Delays during peak

period can also be reduced with advent of AV by introducing smart routing coupled with advanced infrastructure, quicker reaction times, and closer spacing between vehicles to counter increased demand.

Moreover, efficiency in use of travel time while riding in AVs might encourage people to shift their home locations to more remote areas and enjoy lower land prices, and bigger properties. Paradoxically, urban core may turn even denser with the integration of AV technology (Anderson et al., 2016). With major land shifts being the key constraints, studies have also explored the residential shifts as motivated by AV access (Bansal, Kockelman, & Singh, 2016).

Thus, AVs once extensive are likely to deduct human errors, optimize traffic flow, and enhance safety and experience of on-road travelers by enabling enhanced communication with other vehicles, infrastructure and pedestrians. Literature cites increased safety and fuel efficiency (Adeel et al., 2014), reduced travel time, decreased needs for right-of-way, independent mobility, increased efficiency through multitasking, lower private vehicle ownership, less traffic congestion and lower insurance rates as key benefits of AV technology. Berry (2010) had estimated that AVs would reduce 20-30percent acceleration and deceleration rates which would further reduce 5percent fuel consumption. Researchers have also identified lesser stress levels and increased productivity as potential benefits of AVs.

Semi-autonomous features such as adaptive cruise control, lane departure cautions, parking support arrangements, crash evading technologies, and on-board navigation are now commercially available in market. Furthermore, AVs have a wide range application in fields of military, mining and agricultural sectors.

2.2 Challenges Regarding AVs

AVs are also assumed to harbor complex negative externalities, along with predicted benefits (Woldeamanuel & Nguyen, 2018). Although AVs play a significant role in delivering safety of transportation systems, they would face safety and security challenges as well. Uncertainty prevails regarding the proper functioning of AV technology in its infancy with our existing technological capabilities (Sullivan, 2015). In a catastrophic event or on failure of single component of AV, the whole in-vehicle network might get disrupted. In other cases, if the on-board computer system executes a wrong command, the traffic safety and passengers' life would be compromised. Failure or tampering of Global Position System (GPS) data would affect the AV localization and might lead to traffic disturbance or crash hazard. The disruption in connection through exchange of wrong information and miscommunication with nearby AVs would also degrade the traffic situation and lead to hazardous crashes. Thus, adequate safety and security countermeasures need to be implemented to mitigate failure attacks. Furthermore, other than the technological issues, economical barriers stand up as major hurdles in the way of proliferation of autonomous vehicles (Howard & Dai, 2013). High manufacturing and operational costs might hinder mass-production and would not be consumer friendly.

Other challenges regarding AV technology involves privacy and passenger safety concerns, insurance regulations, licensing features, cyber security and legal and liability issues and ethical and hacking issues. Gaps still persist in AV legislation and provision of federal guidance to partial or full AVs for testing purpose on public roads.

2.3 User Behaviorism towards Autonomous Vehicles

People's mind-set and attitudes exert a strong influence on how quickly a new technology is

adopted, thus also affecting how well the benefits incurred from AVs can be realized. A public opinion based survey was conducted in China, India, Japan, the USA, the UK and Australia on people's perception towards AV taking approximately 500 samples per country. The survey results indicated that people in China and India exhibited high interest towards automated vehicles, with 85percent respondents delivering positive attitude. Japan observed 50percent respondents with neutral views towards AVs. However, 16 percent respondents from USA showed negative or somewhat negative attitude towards AVs (Schoettle & Sivak, 2014). Another exhaustive online survey was conducted on the general opinion about autonomous vehicles taking over 5000 samples from 109 countries worldwide (Kyriakidis et al., 2015). The finding suggested that the primary apprehensions of the respondents were cyber security, traffic safety, privacy issues and legal aspects. The overall survey clarified mixed reviews on AV with some respondents expressing positively towards AV, while others were not willing to pay for it and did not view AV to be enough assuring. Passenger data sharing with traffic and insurance authorities were other reasons behind the dislike towards AV working principles.

An US based study proposed and validated a questionnaire based framework for evaluating pedestrian receptivity towards AVs using safety, interaction and compatibility as major surrogate measures. Gender was found to be a dominant factor with male showing greater perception of safety towards AVs. Younger generation was found to be more interested in interacting with AVs in traffic environment (Kyriakidis et al., 2015). Overall, the survey results indicated that people showing positive behavior believed that AV's introduction would vehemently improve traffic safety. Several public opinion based research conducted in US has focused on aspects like beliefs, confidence level, adoption decisions and benefits and concerns related to attributes of AVs.

A survey based study from China investigated the risk perceptions of AVs to reveal that AVs had highly positive impression in China and that 42.35percent of respondents expect lower risk for AVs (X. Xu & Fan, 2018). Another survey conducted over vehicle owners in Seoul, South Korea demonstrated that perceived usefulness and trust are the major determinants of intention to use AVs (Choi & Ji, 2015). The study also concluded that system transparency, situation management and technical competence have a positive effect on trust. The major factors that affect the AV acceptance are driver related personality traits like locus of control. Liu, Yang, & Xu, (2018) had conducted an interview of 452 individuals to assess the acceptance, willingness-to-pay and intention to use AVs. The results indicated that social trust has a direct effect on behavioral intention and willingness-to-pay. Jiang, Zhang, Wang, & Wang, (2018) had conducted a study in Japan over 1000 samples to explore the ownership behavior due to emergence of AVs. It was observed that respondents are willing to pay an excess of 4-8, 00,000 JPY for buying AVs in future.

Public opinion based literature has also established men to express more interest towards AV technology and usage than that of women (Alessandrini, Alfonsi, Site, & Stam, 2014). Furthermore, similar studies have noted that men with high education level, higher income and those residing in compact metropolitan cities and those living in households without a car had a tendency of showing keen interest towards AV than others (Bansal et al., 2016, Liljamo et al., 2018). Additionally, younger generation was observed to have higher preferences towards AV than older people (Kyriakidis et al., 2015). Few literature have revealed distrust towards AV, loss of self-belonging and attachment towards own vehicle and pleasure in driving to be foremost reasons behind lack of respondents' interest towards AV (Cohen, Jones, & Cavoli, 2017). Potential cyber-attacks and disruption in automation systems are other revealed reasons why people refuse to hand vehicle controls over to automation. The major obstructions in the path of mass adoption of AVs may be psychological and not technological. In order to interpret the dominant factors that influence people's acceptance

and perception of AVs a field experiment based study was conducted in China for 300 participants (Z. Xu et al., 2018). The model included behavioral intention, willingness to ride, perceived usefulness and perceived ease of use, trust and safety as major determinants. In a response to this context, the user perception based study in Indian scenario needs to be ventured as well.

Parameters affecting the early adoption has been studied in segments such as influence of trust on the technology, behavioral aspects of the users, life style factors and the supply adoption policies of the respective country or region.

It has been pointed out that trust an 'anthropomorphic factor', can be captured through behavioral, physiological, and self-report measures (Waytz, A., Heafner, J., & Epley, N., 2014). Parameters affecting the environment such as carbon dioxide emission has also been discussed in various studies, however, studies also pointed out probable negative effects of longer distance travels and increased travel speed (Brown, A., Gonder, J., & Repac, B., 2014). Further, Lavieri, P. S., et al (2017), argued that lifestyle factors play an important role in shaping AV usage. Further suggesting that younger, educated and more technological savvy groups may be the early adopters. Wadud, Z. (2017), argued that commercial use (taxis and trucks) might have higher return than personal use. Based on the above mentioned factors, the survey was designed to capture factors that might influence early adoptions of AV in India.

3. DATA AND METHODOLOGY

3.1 Data Collection

In October-November 2018, a preliminary survey was conducted in India on the user perception towards automated vehicles and their degree of interest in using AVs among high professionals of India. The exploratory survey was mainly given to extremely reputed university students and other senior officials of global service organizations. Majority of the respondents, other than university students possess high education standards and are holding top positions of managing directors (MDs), chief executing officers (CEOs) in internationally renowned information technology (IT) sectors, Information Technology Enabled Services (ITES) companies, financial and management consultant companies. Some of them include Choice Solutions Ltd, Macaws Infotech, Meta Infotech, EPMS Global Enterprise etc. The main intention of the survey was to explore into the public perception and their opinion regarding emerging AVs with a focus on the top class citizens with high management skills. Table 1 represents the general characteristics of the respondents.

Table 1. Characteristics of respondents (number of respondents=123)

Category	**Sub-category**	**Percent**
Gender	Male	86.2 percent
	Female	13.8 percent
Age	19-30 years	43.9 percent
	31-45 years	38.2 percent
	46-60 years	17.9 percent
Education level	Less than graduate	8.9 percent
	Graduate	46.3 percent
	Post Graduate	44.7 percent

Monthly income (INR)	Unemployed (no salary)	35.8 percent
	Less than 30,000	6.5 percent
	30,000-50,000	3.3 percent
	50,000-100,000	8.9 percent
	More than 100,000	45.5 percent
Owning vehicle		89.4 percent
Mode choice for daily travel	Own vehicle	60.2 percent
	Public transport (Bus, Train, Auto)	28.5 percent
	App based (Uber/Ola)	11.4 percent

The survey was created in order to answer questions aiming to investigate general perceptions regarding various elements of AV. The survey questionnaire was divided into categories, Part I- socio-economic status of respondents, Part II- Knowledge and general opinion regarding AVs, Part-III: potential benefits and barriers of AV growth and most importantly Part IV: Perception and acceptance of respondents. The online survey form consisting of 60 questions took around 20-30 minutes to complete. The questions consisted of propositions with Likert scale 1-5, multiple choices, option ranking and open ended preference and feedback related. SP (Stated Preference) was used for some questions, utilizing hypothetical options. Few questions in our survey were adapted from a research done by Woldeamanuel & Nguyen, (2018). Firstly, the survey mapped the respondents' background information, such as age, gender, education level and employment status and whether they had a driving license, to help categorize the respondents. Concerning AV specific investigations, questions focused on degree of concern and interest, opinions relating to issues and perceived benefits entailing from complete AV implementation.

The survey was conducted in English and was made comparable with international studies. In the questionnaire, the general individual level data was followed by general opinion towards automated vehicles. This question was placed first so that the respondents could answer it immediately, without the questionnaire affecting the answers. All people who were selected for the survey were sent a Google online form on October 12, 2018. The sample population was identified through their email id which acted as unique identification code. The last responses were received on November 30, 2018. Post data collection process involved a detailed descriptive analysis in order to inspect probable inter-linkages between user interests and selected input variables.

The selected controlled-group consisted of respondents within the range of 19-60 year old population. A total of 123 respondents participated in the survey out of which 106 were male and 17 were female participants. 43.9 percent belonged to the age group of 19-30 years, 38.2 percent in the middle age group of 31-45 years while remaining 17.9percent belonged to the age working category of 46-60 years. 46.3 percent of the respondents was graduate and 44.7 percent held a post graduate or more. 91 percent of the respondents was either graduate or post graduate. 59.3 percent of the respondents was employed with 36.6percent students and 39 percent fully employed. 45.5 percent had a monthly income of more than INR 1, 00,000. 89.4percent report that they own personal vehicle, while 60.2 percent use their own can for daily travel.

3.2 Exploratory Findings and Discussion

3.2.1 Knowledge, general concern and interest

A closer assessment of the data demonstrated the difference in user perception regarding

knowledge, general opinion and interest concerning AV when gender and age of respondents was taken into account (see Figure 1).

Respondents were delivered a basic description of self-driving vehicles and then were inquired for their general opinion and knowledge of AV. It was observed that 95.5 percent of respondents belonging to the age group of 45-60 years were aware of AV followed by 93.6 percent of middle working age group and 87.0 percent of younger cohort. Although it is expected that younger cohort would be more aware about emerging technology of AVs than that of elder cohorts, it has to be observed that here most of the respondents belonging to the middle and elder age cohorts (i.e. 31-45 and 46-60 years) are highly educated possessing undergraduate and post graduate education degrees. Also, owing to their possession of higher management positions in well-established industries, they are perceptibly more aware of the state-of-the-art technological advancements trending globally. However, not much difference (8.42percent) was observed between higher and younger cohort's knowledge, as the younger cohort comprised of selected students from reputed universities. But, when the concern about AV was inquired, approximately 50 percent in each age cohort were moderately concerned about AV. Similarly, 40 percent of young cohort, 44.6 percent of middle age professionals and 36.6 percent of higher age cohort showed personal interest in owning AV.

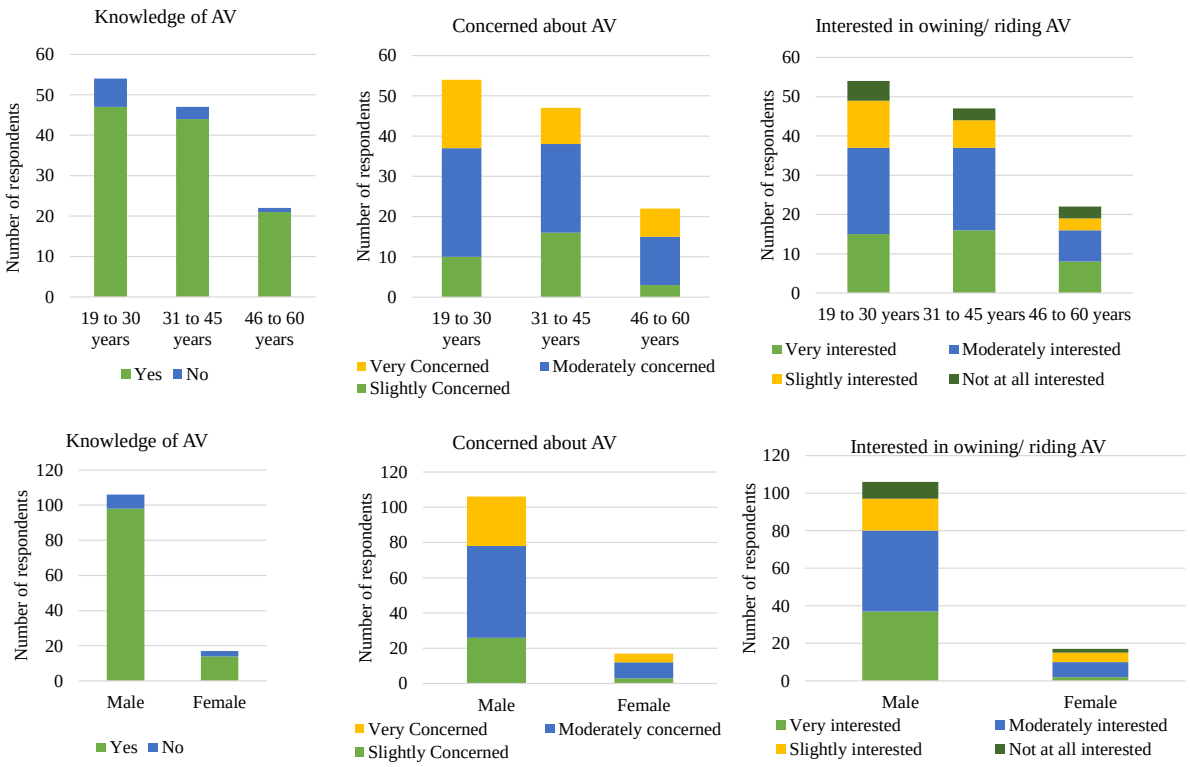

Figure 1. General opinions, knowledge and corners regarding autonomous vehicles

Similarly, when gender was taken into consideration marginally more number of males (92.4percent) had knowledge of AV than that of females (82.3percent). However, gender neutral results were observed when males (49.0 percent) and females (52.9 percent) expressed their common views regarding concern about AV. Surprisingly, women (47.0 percent) were found to express slightly higher levels of interest than men (40.5percent). This explains that although AV is well acknowledged in India, people are yet ready to accept it in reality evading concerns and reservations. This phenomenon can be assumed to get transformed with large-scale implementation of AV in reality.

3.2.2 Perceived notion of safety

Literature has established safety as a major issue in advancement of AV (Cui, Liew, Sabaliauskaite, & Zhou, 2018); hence, all the respondents were distinctly asked about the degree of safety they would perceive while riding AV. 89.4 percent of the respondents owned a car, out of which 60.2 percent used their own car for daily travel purpose. Majority of the respondents i.e. 91.1 percent had a positive attitude towards AVs and they were fully aware of the technology, but the respondents did not feel safe at all when were inquired about solely riding a fully autonomous vehicle in Indian road conditions (see Figure 2a). It was observed that 44.4 percent of the younger cohort, 38.2 percent of the middle age professionals and 45.5 percent of the higher age cohort did not feel safe at all when asked to ride AV alone.

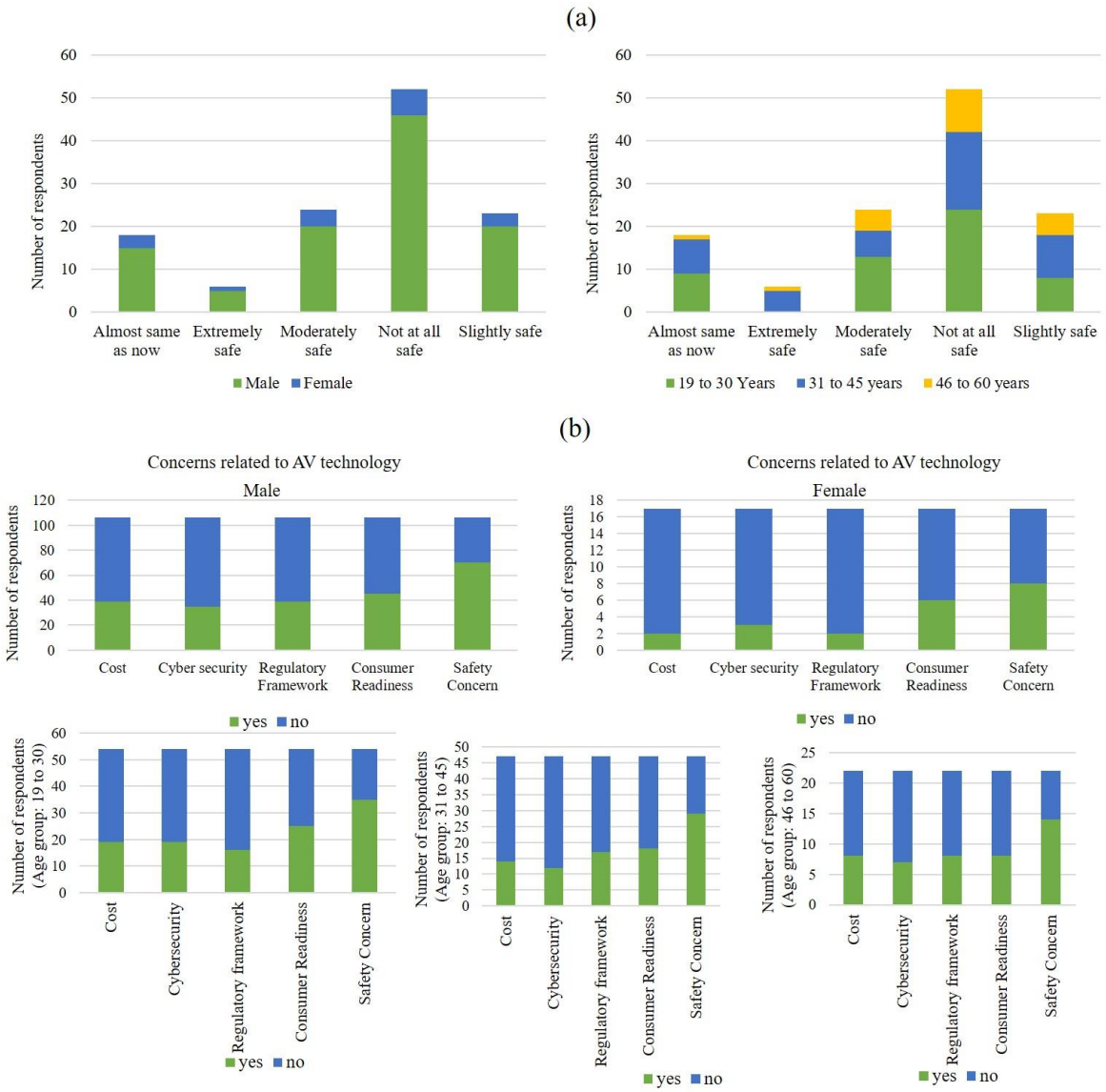

Figure 2. Perceived degree of safety (a) and perceived concerns (b) regarding autonomous vehicles

3.2.3 Perceived concerns for the AV technology

AVs have the potential to bring huge positive changes in existing transportation systems by

formulating new urban planning elements; however like other technologies, AVs would also face challenges in public adoption owing to certain perceived concerns of the users. Respondents were hence asked to reveal the major concerns they might face regarding AV integration.

Liljamo et al., (2018) had demonstrated in his study that gender and age hugely affect attitude towards AV, where 30 percent male and 17 percent female had shown positive and moderate interest towards AV in a Finnish survey. In this study, the major concern among both male (66.03percent) and female (47.05percent) respondents was observed to be safety. When age was taken into consideration, respondents in the higher age group of 46-60 years had considered cost, lack of improved regulatory framework and consumer readiness to be major concerns of AV other than safety issues. 64.81 percent of younger cohort, 61.70 percent of middle age professionals and 63.63 percent of higher age group perceived safety issue as the major concern (see Figure 2b). Thus, in contrary to the above mentioned inferences, age and gender of the respondents delivered a similar results regarding concerns of AV technology in this study.

3.2.4 Perceived activities in autonomous vehicles, while not driving

Initial researches considered travel time as negative utility; however currently, the Value of Travel Time Savings (VTTS) have been empirically calculated by researchers to analyze the importance of multi-tasking involvement during travel (Varghese & Jana, 2018), thus increasing activity participation. The advanced technology of AVs are able to relegate a person from being the vehicle's driver with full control to transforming to a passenger within the same driver-less vehicle. Thus, unlike previous scenarios, AV technology permits the driver to participate in activities similar to other passengers while riding the vehicle. A question in the survey investigated the likelihood towards participation in different activities while riding AVs.

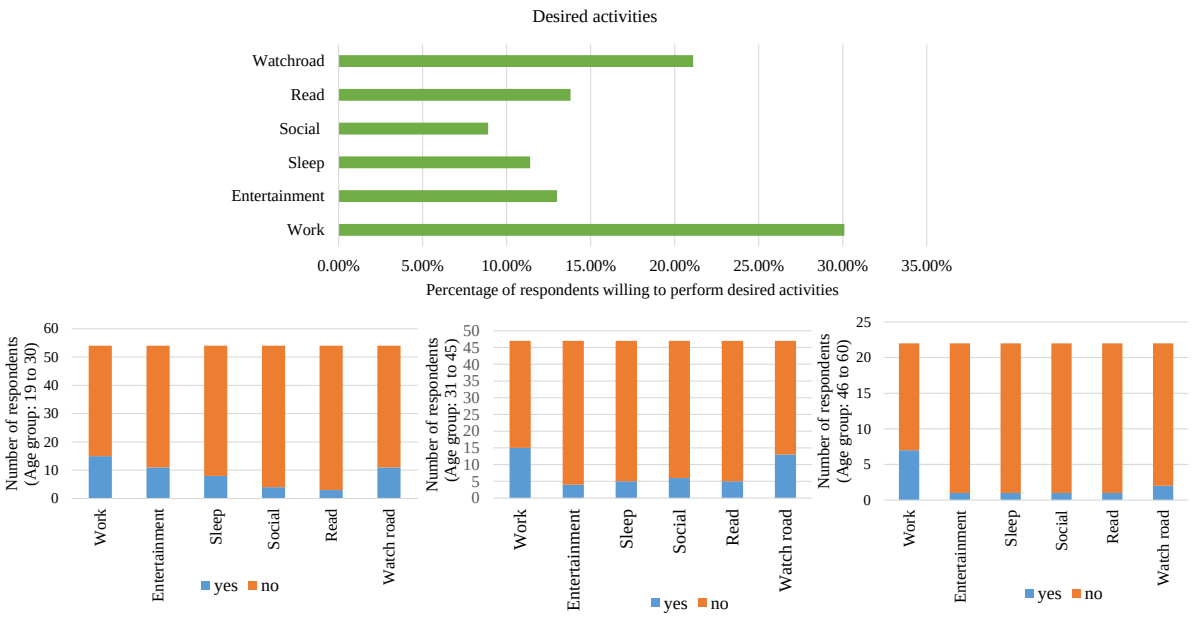

Figure 3. Responses on preferred participation of activities while riding AVs

60.2 percent of the respondents drive their own vehicle for daily travel. However, with the advent of driver-less technology in AVs, the extra travel time can be used in multi-tasking activities such working, sleeping, watching road etc. Figure 3 explicates that 30

percent respondents opted to work while riding AV. Younger age group of 19-30 years preferred entertainment (20.03percent) as major desired activity after work (27.78percent). Apart from involving in productive activities like working (31.16percent), watching road (27.6percent) and social activities (12.7percent) were also favored by the middle age group as desired activities while riding AV. 31.8 percent of respondents belonging to higher age cohort preferred to utilize their travel time by working. Therefore, respondents entrained by their education and work-place position and associated stress, majorly preferred to maximize their travel time by working and performing productive activities.

3.2.5 Perceived potential benefits

Another important aspect explored was the user perception towards potential benefits resulting from AV integration. AV is foreshadowed for many positive as well as negative implications across various sectors. The major benefits of AVs include cost savings other than reduced vehicular accidents and its associated costs. AVs can also produce a positive effect on traffic congestion and fuel savings as well (see Figure 4a).

Here, 83 out of 106 males strongly agreed reduced amount of vehicular crashes as a major benefit of AV. Reduced severity of crashes and improved emergency response to crashes are other benefits observed by male respondents. On the other hand, females recognized better fuel economy and lower vehicular emissions as potential benefits of AV.

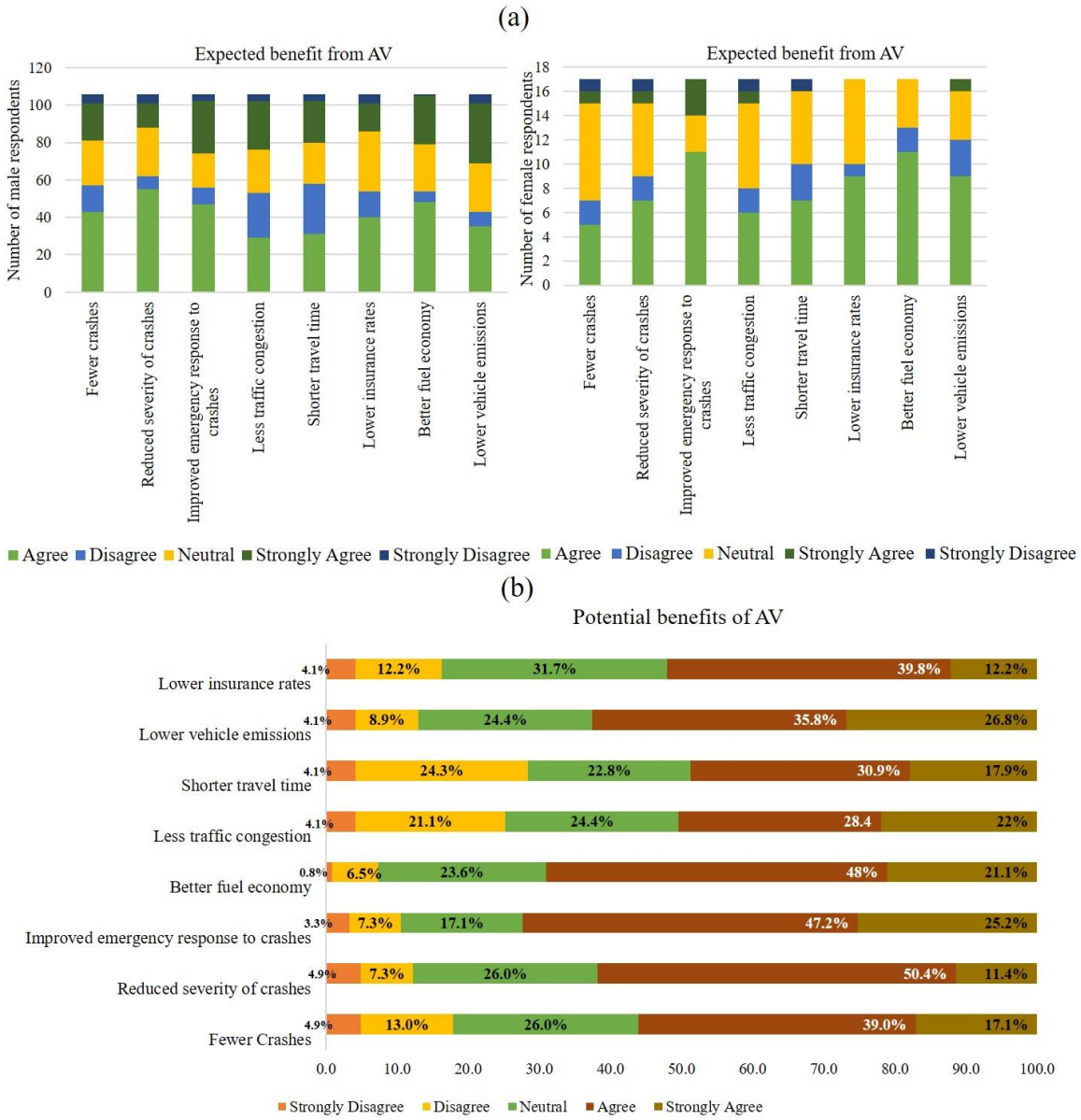

Figure 4. Perceived responses regarding potential benefits of AVs (top) and Percentage of respondents regarding order of likelihood of potential benefits of AV (down)

Taking an overall perspective as demonstrated in Figure 4b, 'improved emergency response to crashes' was strongly agreed (25.2percent) and agreed (47.2percent) as most potential benefit of AVs. Owing to artificial intelligence based vehicular control system, respondents perceived it to be the most beneficial aspect of AV integration. Reduced severity of crashes was also recommended as another perceived benefit of AV. This explicates that the respondents are aware of the fact that with complex sensor installations, AVs would be able to sense the presence of neighboring obstacles (other vehicles, pedestrians etc.); hence, they believed that severity of road accidents would reduce with AV technology. AVs leading to fuel saving strategy is among the maximum benefit believed to occur by the respondents, and has the highest response frequency for the respondents who agreed (48percent) and strongly agreed (21.1percent) to this phenomenon.

Respondents were asked the degree of agreement regarding reduced vehicular emissions. The results show that 26.8 percent and 35.8 percent of the respondents either strongly agreed

or agreed it to be the most feasible benefit. However, opposite to the spectrum, 24.3 percent of respondents disagreed 'shorter travel time' as benefit incurred from AV technology integration, as they believed that AV would not reduce travel time. The lowest frequency in context to the 'Less traffic congestion' is expressed by 21.1 percent, who disagree that traffic congestion is likely to reduce owing to AV adoption. Since, traffic congestion is unlikely to reduce due to AV integration, travel time would advertently remain same. Hence, maximum respondents disagreed 'reduced travel time' and 'less traffic congestion' to be benefits incurred from AV implementation.

3.2 Research Methodology

Theoretical evidences suggest that interest, attitude and concerns towards advanced technology of AVs depends hugely on user perception, their socio-economic background, and their preferences (Casley, Jardim, & Quartulli, 2013; Haboucha, Ishaq, & Shiftan, 2017; Anania et al., 2018; Nazari, Noruzoliaee, & Mohammadian, 2018; Bennett, Vijaygopal, & Kottasz, 2019). To study this relationship, we estimated a Multinomial logistic (MNL) model (McFadden, 1987; Wills, 1987; Society, 2017), where the user interest towards AV is the outcome variable. The model predicts user's attitude towards AV between four degrees of interest: very interested, moderately interested, slightly interested and not at all interested and draws its relationship with the socio-economic characters of users such as age, gender, employment and education levels on one hand and their desired activities, perceived concerns and benefits of AV etc. on other hand. The relationship between user characteristics and their attitude towards AVs will deliver us a comprehensive image of the opinion of varying categories of users towards forthcoming advanced technology of self-less automobiles within the country.

The MNL model offered us a global statistic i.e. one single value explaining the relationship between public interest levels and other independent variables considered in the model. It explains how degrees of users' interest towards AV depend on other input variables. Since the aim was on exploring the attitudes towards AVs, our intention was not to estimate the best fitting and most complex model. Therefore, we only estimated standard multinomial logit regression model in this research.

4. RESULTS

A strong correlation was observed between the education, employment of the respondents and their knowledge regarding AV technology (see Figure 5). As expected, people with higher education and appropriate employment status had more knowledge about AV technology.

When desired activities while riding AV was taken into consideration, a positive correlation was observed between employment, education variables and entertainment, while the variables showed a negative correlation with reading. On taking AV related concerns into account, people who had more knowledge regarding AV technology were relatively less concerned about AV technology's reliability; but considered cost and dearth of consumer readiness as major concerns for AV growth in Indian scenario. Concern related to 'Regulatory framework' was found to have a strong correlation with 'cyber security'.

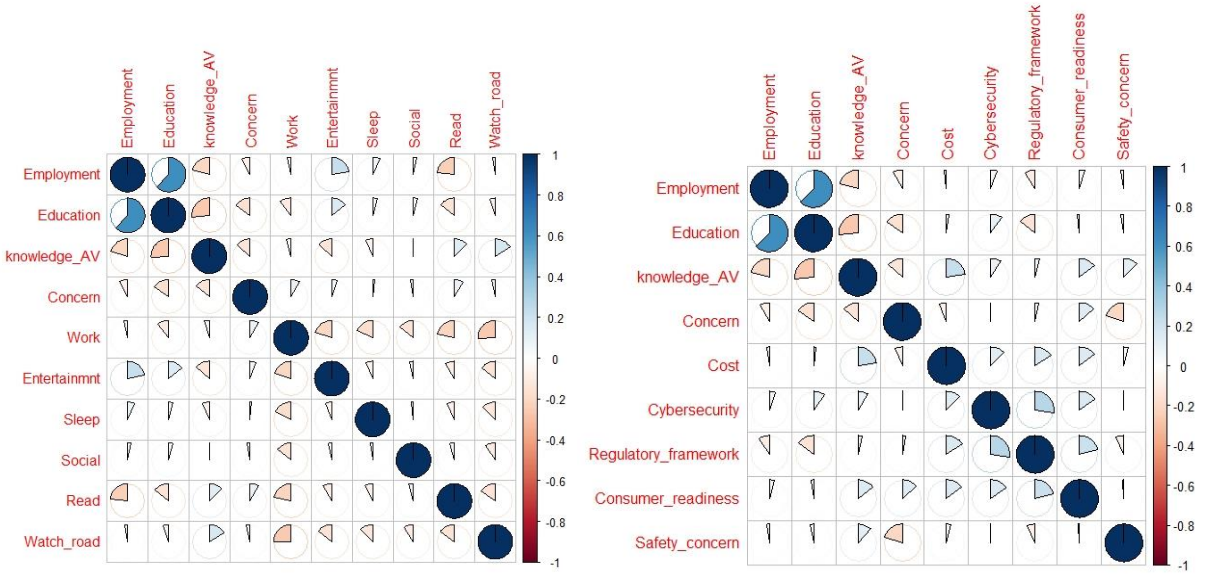

Figure 5 Correlation matrix explaining the strength and direction of relationships within variables considered in MNL: desired activities (left) and major concerns (right)

The MNL model represented an individual's likelihood towards the degree of interest for AV expressed in three major categories of 'very interested', 'moderately interested' and 'slightly interested' with 'not at all interested' as reference category (see Table 2). The model estimates exhibited positive relation between education level and high degree of interest towards AV, and showing mild increase in moderate level of interest. This explicates that the respondents with higher education standards had more probability of showing higher degree of interest towards AVs. The odds of showing higher interest also increased with the employment status of the respondent. This is majorly due to the diffusion of innovation theory, where early adopters exhibit more interest towards new technology (Sullivan, 2015). The model also showcases that the concern for AV technology has a negative relation with peoples' interest towards AV i.e. respondents who are less concerned regarding AVs' reliability had more likelihood towards higher interest intensities. If the impact of travel time utilization while riding driver-less AV is investigated, it can be observed that people expressing higher levels of interest were less preferring to use the time doing social activities like texting, talking etc. This is attributable to the fact that the employed people with higher education standards (maximum respondents) would prefer to maximize their travel time performing productive activities like work rather than involving in social connections. If we probe into the respondents' perception about major obstacles that can hinder the AV growth in Indian market, a positive relationship was observed between people who considered cost of AV technology as major obstacle and their expression of interest towards AV. Furthermore, when the major concerns regarding AV and how they relate to the odds of preferring high interest level towards AV are explored, it can be noticed that safety concerns related negatively with log odd choice preferences. Implying, people with higher safety concerns were not at all interested towards using AVs.

These results represent an average value for the whole sample collected from major cities of India, representing a holistic statistics. However, this fails to provide us the other local variations existing amongst the socio-economic or other input variables that can be more prevalent than the other. Higher sample size can provide us better relationships and can help us to interpret the association user variables have with their attitude towards AV. Last but most

importantly, the aim of the study was to inspect the perception of a particular high educated section of population who are occupying high service positions in different sectors; hence, the results of this model might counter when a heterogeneous population sample is taken into consideration.

Table 2. Model estimation results

Independent Variables	Very interested			Moderately interested			Slightly interested		
	(B)	Std. Error	T stat	(B)	Std. Error	T stat	(B)	Std. Error	T stat
Intercept	0.98	1.16	0.83	1.27	1.11	1.14	-0.22	1.22	-0.18
Education level: Less than Graduate	-2.74*	1.68	-1.63	-3.57**	1.63	-2.18	-2.24	1.58	-1.41
Education level: Graduate	0.51	1.06	0.48	0.51	1.01	0.50	0.07	1.13	0.06
Employed	1.89	1.43	1.32	2.24*	1.38	1.62	2.97**	1.45	2.04
Concern: Slight	3.41**	1.47	2.31	1.61	1.45	1.10	1.67	1.48	1.12
Concern: Moderate	1.09	0.90	1.21	1.08	0.83	1.30	0.93	0.89	1.04
Social activity	-3.56**	1.66	-2.14	-1.42	1.31	-1.08	-1.03	1.33	-0.77
Perceived Cost	2.27**	1.19	1.91	2.36**	1.15	2.04	1.79	1.21	1.47
Perceived Major concern: Safety	-1.98*	1.06	-1.86	-1.56*	1.04	-1.50	-0.69**	1.10	-0.62
Observations	123			Model fitting information					
Initial log-likelihood	204.992			Likelihood Ratio Test					
Final log-likelihood	154.283			Chi-square			df		Sig.
McFadden's Rho-squared $\bar{\rho}^2$	0.165			50.709			24		0.001

– Not relevant; *** Significant at 1percent level; ** Significant at 5percent level; * Significant at 10percent level

a. The reference category is 'not at all interested'.

5. DISCUSSIONS

This study utilized the public opinion data by performing online survey from major cities of India including Mumbai, Hyderabad, Pune, Delhi and Chennai to analyze the user perceptions, their attitude and concerns regarding the advanced technology of self-driving vehicles within high level professionals. Majority of the respondents were post-graduate, and employed with monthly salary above INR 150,000.

Descriptive statistics suggested that 91.9 percent of the respondents were pragmatically aware of the forthcoming self-driving vehicle technology and showed positive attitude

towards AV, but half of the respondents exhibited moderate anxiety about AVs' reliability (see Figure 1). This explains that the highly educated group of sample, though are aware of the state-of-the-art technological advancements, have exposure to the challenges, issues and deficiencies of current technologies. It was also observed that the concern regarding AV was gender unbiased, and the most perceived apprehensions for both male and female were safety issues and dearth of consumer readiness. High cost of the system and existing regulatory frameworks were also perceived as major barriers in the growth of AV in Indian market. When we looked into the age category, younger age cohort mostly preferred entertainment as the desired activity during time of travel, whereas middle and higher age group chose to work (Figure 3). According to Figure 4, better emergency response to crashes was perceived as the major benefit incurred from AV technology.

MNL regression model for determining user interest towards AV showed that the odds of preferring AV technology increases with education level. This is because with higher education standards, the awareness and acknowledgement of a forthcoming advanced technology increases. It also showed that how employment of a person acted as a guiding factor for choosing preferred levels of interest towards AV. This can be strongly explained as an employed individual with decent earning would more easily be able to accept and afford technologies like AV. Since age of the respondents was not distinctly investigated, it did not show significance while conveying interest towards AV. However, it can be assumed that the generation difference between non-millennials and digital natives can be another challenge behind consumer adoption of relinquishing the vehicular control to artificial intelligence (Woldeamanuel & Nguyen, 2018). It was also observed that people who expressed maximum concern or anxiety for AVs' reliability, had the probability of showing least interest in adopting the forthcoming AV. Dearth of consumer readiness and fear of accepting advanced technology can be apprehended as the major factors contributing to this phenomenon. Also, India has not yet witnessed enough AV field testing which can also develop negative outlook. Furthermore, with inferior road conditions in India, and maximum death toll rising due to road crashes, driver-less AVs would advertently be a major concern of citizens. With successful field test of AVs in India at a mass scale, the acceptance rate of AVs can be increased. This broadens the need of further research to aware Indian citizens regarding benefits of AV as well. Descriptive analysis of the data elucidated work to be most preferred activity while riding AV; in similar trails, the regression model also showed that people who least preferred to perform social activities during travel had the probability of expressing maximum fascination towards AV (refer to Table 2). With travel time saving in a driver-less vehicle, highly educated and employed passengers would maximize their time utilization in multitasking by involving in productive activities like work, read etc. MNL also explored the relationship, the perceived potential challenges of AVs have with preferring AVs with varying interest levels. Surprisingly, it was observed that amongst cost, cybersecurity, dearth of regulatory framework and consumer readiness, high cost of the forthcoming technology came out as the only significant variable. The model results suggested that people who had reasoned high cost of the technology as preferred difficulty in growth of AV, had expressed more interest towards AVs. The major factor which can be contributed to this phenomenon is that it is already well accepted globally as well in India, that AV with artificial intelligence strategies would be the most recognizable forthcoming technology in automotive industries. However, the only major challenge would be the cost and expenses incurred for manufacturing, operating, and maintaining this heavy computation-based technology. However, cost subsidization at a mass-scale can enormously increase the user acceptance of AVs. For example, in China electrical vehicles (EVs) have been highly subsidized with its implementation even in public fleets (Gandoman et al., 2019; Li & Ouyang, 2011). Based on

effective subsidization policies offered by government, AV might also be accepted in future as a major mode of transportation in India. However, large scale infrastructure development needs to be undertaken before such initiative can be practically applied on roads. Lastly, the model results also demonstrated that people with higher safety concerns had the probability of showing lesser interest in AVs. It has already been well-established in literature that safety is of paramount importance for autonomous vehicles, where planned trajectory cannot be assumed perfectly in presence of evasive maneuvers owing to tire slip, uncertain parameters, indeterminate initial states, and other distractions and disturbances (Althoff, Althoff, Wollherr, & Buss, 2010). Sets of variables like velocity, orientation, and slip angle through online safety verification should be properly computed before large-scale implementation of this technology. However, with AV technology verification, the behaviorism of users might alter.

6. CONCLUSION

Owing to the lack of adequate literature regarding AV emergence, usage and user perception concerning AVs in Indian scenario, this is the initial study as per knowledge of authors, which explores into the public opinion, their attitudes and concerns towards advanced technology of self-driving vehicles in India. On one hand, advent of new technology like AV would facilitate the users with improved level of service including smooth travel, better fuel economy, thus increasing user satisfaction level, whereas the perceived challenges of AVs like safety concerns, artificial intelligence system failures coupled with their adverse effects etc. is a sign of gaps that impose great challenge in public adoption of AVs. However, the AV industry still continues to advance the technology at a fast rate in preparation for introduction of AVs to the public domain. This research broadly aims to capture the user perception in Indian scenario by centering on public individualities, opinions and values held by respondents to answer few primary questions:

i) How interested would you be in riding a completely self-driving vehicle?
ii) Do statistical relationships exist between demographic and socio-economic variables, and specific opinions and sentiments?
iii) How does income and education standards affect level of interest for AVs?

The survey was majorly categorized into two sectors: perceived challenges and potential benefits incurred from AV. The exploratory analysis divided the results between three age cohorts which include young adults, people belonging to mid management and top management of different industries. The perceptions of rural, suburban and low-income urban population have not been considered in this study.

The findings from the surveys offered a generalized perspective regarding the user attitude towards AV and whether certain age groups are more attracted to AV technology than the others. Since, the AV adoption is in infant stage, this study can pave a way forward towards formulation of user friendly transport policies and guidelines regarding upcoming AV technology in India. Further, this study might provide valuable inputs to the automobile companies indulging in development of AV.

The study finds that Indian citizens have a positive attitude towards AV, and have optimistic views regarding AV benefits. The respondents shared gender-neutral views regarding knowledge of AV and concerns related to safety issues on one hand and gender-biased views on AV related benefits on other hand. Neutral views was observed when selecting desired multi-tasking activities while riding driver-less cars; while dichotomy in user perception was observed in expressing awareness, general concern and knowledge regarding AV when age cohort came to play role. Cost was perceived to be a major hurdle towards the

growth of AV in India.

The reservations and unreliability intertwined to the forthcoming AVs' technological progressions especially in developing nation like India have been recognized here. However, numerous queries in this field still remains under-explored, which can be speculated with the real implementation of AVs at large-scale. Further research on globally accepted AV related policies can enhance the depth of the epistemology of the evolving arena of AV addressing macro-level matters regarding the effect of global AV adoption on urbanization etc. With aid of these researches, the efficacy of AVs can be adjudicated rationally.

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