SHARED AUTONOMOUS VEHICLE TAXI SERVICES: UNPACKING THE ROUTE TO CONSUMER ADOPTION

VIJAYKUMAR KRISHNAN, Northern Illinois University
URSULA Y. SULLIVAN, Northern Illinois University
TIMOTHY W. AURAND, Northern Illinois University

In this paper, we explore the potential adoption of technology-enabled shared autonomous vehicle (SAV) taxi services. Some industry experts suggest that SAV services are expected to be widely adopted over the next decade; yet consumer likelihood of acceptance is still largely unclear. Rogers' theory of Diffusion of Innovation and Higgins' theory of Regulatory Focus are applied to develop hypotheses that are empirically tested in a survey-based, three-study approach. When controlling for several covariates, technology-friendliness is found to be a leading influencer of adoption-intention. However, this influence is completely mediated by Rogersian drivers of innovation, including relative advantage, compatibility, and complexity. Results also show a three-way interactive moderation among technology-friendliness, promotion-focus, and prevention-focus. Implications for the market acceptance of autonomous taxi services are discussed, as are the theoretical inferences from the analysis.

INTRODUCTION

The automobile industry is facing the onslaught of two technological phenomena: the sharing economy and autonomous vehicles (Bakibillah, *et al*. 2021; Lari, *et al.*2015; Schoitsch, E., (2016), Siegfried, *et al.,* 2021). The first phenomenon of sharing is enabled by numerous services made possible by mobile applications and technology-enabled consumers who, at the same time, have a declining interest in product ownership and its inherent costs (Cissé, 2020). Be it hospitality and dining (e.g., Airbnb), retail and consumer goods (Neighborgoods, SnapGoods), media and entertainment (Amazon Family Library, Wix, Spotify, SoundCloud), or transportation (Uber, Lyft), countless mobile applications in the sharing economy allow for affordable access and a means for groups and individuals to make money from underused assets (PwC, 2015; Eckhardt, *et al.*, 2019). As society moves from a long-term life strategy to a more fluid and adaptable orientation, the very ethos on how we consume changes as well (Eckhardt, *et al.*, 2019; Kathan, *et al.*, 2016). Indeed, many consumers consider possessions to be a "constraint to mobility" (Kathan, *et al.*, 2016; Schaefers, *et al.*, 2016).

The Marketing Management Journal
Volume 32, Issue 2, Pages 89-108

The next anticipated innovation in the sharing economy is the autonomous taxi (Lambert, 2021). Also referred to as shared autonomous vehicles (SAVs (Narayanan, *et al.*, 2020)), autonomous taxis are typically envisioned as a self-driving vehicle fleet owned by a ridesharing company. The future consumer is expected to hail rides via pay-per-use or subscribe to a monthly ride-plan to access an autonomous taxi service (Lambert, 2021).

With global sales of fully autonomous vehicles expected to reach 12 million units annually by 2035 (Ohio University, 2020) and global ridesharing sales expected to grow from $75.39 billion in 2020 to $117.34 billion in 2021 (Statista, 2021), auto manufacturers and ride sharing providers alike must adapt to a dramatically different transportation paradigm. Indeed, the economies of owning a car are more favorable if one can profit from its ownership and use, as opposed to garnering the benefits typically associated with personal ownership and consumption (PwC, 2015). The twin advantages of sharing and not having to drive might make autonomous vehicle sellers assume that the market will readily embrace this superior service technology and attract huge investments. However, this adoption assumption is fragile, as Hana and HyungBin (2021), in their work with consumer adoption of autonomous vehicles and technology-friendliness, found that some consumers may hesitate to adopt autonomous vehicles due to concerns with negative implications surrounding autonomous vehicle automation. Therefore, it is imperative to uncover the factors that lead to SAV adoption by consumers.

As such, this article contributes to the literature by: a) developing a theoretical framework linking consumers' technology-friendliness (defined as *consumer's favorable attitude to explore and embrace new technology*) to their adoption-intention for autonomous taxis; b) investigating the mediational role played by the Rogers' determinants of adoption (Rogers, 2003), including *relative advantage*, *compatibility*, and *complexity*; and, c) examining the moderating influence of the consumers' regulation system; that is, the extent to which a consumer's propensity to be more promotion- versus prevention-focused (Herzenstein, 2006; Herzenstein, *et al*., 2007) serves to shape adoption-intention for autonomous taxis.

To test our theoretical framework, we analyze data from Generation Z (Gen Z). Gen Z is a driving force behind the sharing economy (Jose and Senthilkumar, 2020) and increasingly influences social and economic conditions (Martinez-Gonzalez, *et al*., 2021). Furthermore, due to the segment's general technology-friendly attitude and use of many services in the shared economy, it is likely a prime segment targeted for the adoption of autonomous taxis.

To realize these contributions, we first provide background on the technology – autonomous vehicles – that we are investigating. We subsequently develop our hypotheses based on a theoretical framework built upon a literature review that explicates the key factors of adoption for autonomous taxis; namely that of Rogers' (2003) theory of adoption along with Higgins' (1997) regulatory focus theory. We then provide and implement the methodology for testing our hypotheses, as well as discuss the results of our analyses. We follow the methodology section with both theoretical and managerial implications, as well as limitations of our study with possible avenues for future research.

LITERATURE REVIEW

The Technology of Autonomous Vehicles

The global auto industry is on the brink of technological change that will prove revolutionary, accelerating, disruptive, and permanent (Kushma, 2017). The technology is being developed, in many cases cooperatively, by auto manufacturers, ride sharing firms, and technology giants (Bensinger and Dawson, 2018). Research initiatives are currently underway throughout the industry to move firms as quickly as possible through the levels of technological advancement necessary to reach the fully autonomous vehicle envisioned by both automotive executives and consumers (Baldwin, 2020). As Tesla CEO, Elon Musk stated, "Almost all [new] cars built will be capable of full autonomy in about 10 years" (Sabatini, 2017).

The evolutionary technological path that has taken us toward autonomous driving is now moving towards a truly revolutionary and disruptive technology. To understand the different levels of autonomous vehicle technology, we provide the following information from Planing and Dursun (2018), where SAV technology consists of a total of six levels of automation:

- Level 0 – No Automation.
- Level 1 – Driver Assistance (or the driving mode involving specific execution by a driver assistance system of either steering **or** acceleration/deceleration while the human driver performs all remaining tasks).
- Level 2 – Partial Automation (the driving mode-specific execution of both steering and acceleration/deceleration and the human driver performs all remaining tasks).
- Level 3 – Conditional Automation (the driving mode-specific performance by an automated driving system of all aspects of the driving task with the expectation that the driver will respond appropriately to a request to intervene).
- Level 4 – High Automation (the driving mode-specific performance by an automated driving system of all aspects, even if a human driver does not respond to a request to intervene).
- Level 5 – Full Automation (the full-time performance by an automated driving

system of all aspects of the dynamic driving task under all roadway and environment conditions that can be managed by a human driver).

Evolutionary technology includes advancements in which the driver is not physically operating the vehicle, but supervises the system to resume control at any time. Tesla's *Autopilot*, for example, takes Tesla to Level 2 by incorporating features that include: matching an auto's speed to that of the surrounding traffic (Traffic-Aware Cruise Control); assisting drivers in steering within marked lanes (Autosteer); moving to adjacent lanes on the highway automatically (Auto Lane Change), among others (Tesla.com, 2021). However, Tesla cars still fall short of being revolutionary enough to be deemed fully autonomous.

A *revolutionary* advancement in an automobile would be seen at Level 5 (full automation), where there is neither a human driver nor steering wheel (Nordhoff, *et al*., 2016). Such vehicle capability is a leap forward from the semi-autonomous evolutionary technology advancements, requiring a level of disruption that will be far more difficult to adopt. Nevertheless, investments in pursuit of fully autonomous vehicles are accelerating (CBInsights.com, 2020). Over 40 corporations have invested in autonomous vehicle technology; indeed, over $80 billion was invested between 2014 and 2017 and another $80 billion in 2018 alone (CBInsights.com, 2020).

At this level of investment, firms in the automotive, ride sharing, and technology sectors see the opportunity that autonomously driven vehicles will provide to society (CBInsights.com, 2020). Volkswagen alone has invested $54 billion in autonomous technology (Claypool, 2020), while other firms have formed partnerships to share technology (*Independent*, 2018). The presence of so many firms engaged in the development of autonomous driving vehicles in an interrelated fashion, combined with a market intrigued with inherent benefits of self-driving vehicles, might initially point to a market prime for development, expansion, and profit. However, despite the substantial financial investments being made, adoption of the enhanced technology and the required dramatic change to consumer transportation norms make total acceptance of autonomous transportation a serious challenge (Bensinger and Dawson, 2018).

Theoretical Background and Hypothesis Development

Technology Adoption Models (Davis, 1986; Davis, *et al.,* 1989) find evidence that perceived usefulness and perceived ease-of-use shape attitudes, buyer intention, and adoption of new technology. Later refinements to the technology adoption model – TAM2 (Venkatesh and Davis, 2000) extended the generalizability by including several antecedents, notably subjective norms and result demonstrability. Subsequently, Venkatesh, *et al.* (2003) proposed a Unified Theory of User Acceptance of Technology (UTUAT), including performance expectancy, effort expectancy, and social influence, as additional antecedents to adoption intention. A further refinement, UTUAT 2 (Venkatesh, *et al.,* 2012) provides evidence of hedonic influence as another antecedent. Additionally, the Venkatesh, *et. al.*, (2012) study also demonstrated the moderating influence of age, gender, and prior experience.

TAM models, noted above, studied the adoption of information technology in the context of computers. Technology applications have rapidly migrated into the mobile information technology domain in all walks of life, including health care (Nielsen and Mengiste, 2014), education (Koç, *et al.,* 2016), banking services (Shaikh and Karjaluoto, 2015), tourism (Hew, *et al.,* 2016) and smart homes (Nikou, 2019). Along these lines, we suggest that smartphones and mobile technology applications have acquired pervasive importance as an antecedent in defining information technology adoption. Therefore, consumers' technology-friendliness, as reflected by their reliance on smartphones for extensive use of potentially risky apps – such as for banking, filing taxes, and healthcare – is likely to be a leading indicator and a predictor of adoption-intention for futuristic technologies.

Whereas TAM models predict acceptance of information technology use, in general, autonomous vehicle usage relies extensively on smart technology that share characteristics, such as connectedness, big data, and use of applications (Bagloee et al., 2016). "*A smart object is a physical object in which a processor, a data storage system, a sensor system and network technology are embedded*" (Bajenescu, 2021). These features are also common to smartphones. Autonomous vehicles would use biometric data, such as fingerprints to open the doors just like fingerprints unlock smart phones (Tajik and Ganji, 2022). Autonomous taxis will navigate a safe drive using multiple sensors, such as feeds from cameras, radars, computer vision, and GPS to assess the nature and mix of the surrounding traffic patterns including the speed of the vehicles all around, speed limits, and other data. Similarly, *find-my-phone* applications on smartphone ecosystems use GPS data to track location (Biersdorfer, 2017). These autonomous vehicles will deploy cutting edge analytics, including AI and machine learning on Big Data and will drive themselves using algorithms. Likewise, machine learning algorithms are now employed to detect malware affecting smartphone operating systems (Talal et al., 2019). In addition, these taxis will use software similar to rideshare technologies, so they can be hailed by customers. Taxi riders can accept or refuse a ride based on other economic parameters and share their ride details, such as location and destination with friends and relatives. Consumers who are comfortable with the use of technology, particularly smartphones, are more likely to appreciate the reliability of such technological applications, to be less fearful of the unknown, and more likely to adopt autonomous taxis.

In summary, drawing from the past research on technology adoption of information technology and noting the recent increase of mobile technology adoption in myriad spheres of consumer life, the present study proposes a summary construct, *technology-friendliness,* as an antecedent to acceptance of new technology. Formally, we define technology-friendliness as a *consumer's favorable attitude to explore and embrace new technology*. We propose that those exhibiting greater technology-friendliness are more likely to use smartphones extensively in several areas of their life, ranging from communication (email, social media) to tourism (GPS applications), and electronic banking. Along these lines we develop the *technology-friendliness* construct (Appendix 1) and propose that technology-friendliness will be a main-effect antecedent to adoption intention for autonomous taxis. Formally,

H_1: The greater the technology-friendliness, the higher the intention to adopt shared autonomous taxis.

Mediating Role of Rogers's Innovation Adoption Attributes

Rogers (2003) describes adoption of new innovations as a diffusion of innovation through a social system. In his 2003 book, Rogers suggests that the perceptions of five specific attributes of the new innovation – relative advantage, compatibility, complexity, trialability, and observability – drive the adoption rates of innovations. A meta-analysis on Rogersian attributes (Kapoor, *et al.*, 2014) across 226 publications focusing on adoption as the dependent variable, reports statistical significance for only three of these factors: relative advantage, compatibility, and complexity. Accordingly, the present study evaluates the mediational role of these three Rogersian variables. In addition, since autonomous taxis are not yet available for measuring the other two Rogersian variables of trialability and observability, we focus on the primary three variables or relative advantage, compatibility, and complexity.

Relative advantage of an innovation refers to the ability of an innovative product to provide the same or higher level of benefits that a present version provides at a lower cost or effort. Starting with the principle of loss aversion (Tversky and Kahneman, 1979) that losses loom larger, Kahneman's theory of endowment effect suggests that people tend to overweight what they currently own. This phenomenon plays an important role in adoption of innovations for one must give up (a loss) the conventional taxi service to acquire the autonomous taxi service (gain). Since losses loom larger, what one currently uses is perceived more valuable than it really is and Gourville (2006) estimates that the relative advantage of the innovation must be three times the current product for the swap (i.e., adoption) to materialize. Because consumers will use smartphone applications to hail autonomous taxis and these taxis will deploy data analytics for safe navigation, it is likely that the perceived relative advantage will be higher among technology-friendly consumers. Formally,

H_2: The influence of technology-friendliness on adoption-intention of autonomous taxis will be mediated by the perceived relative advantage of the innovation.

The second attribute, compatibility, refers to the extent of perceived overlap in anticipated behavior from the consumers when using the innovation in comparison to the present solution. An innovation that requires new behavior or a drastic change in behavior is likely to meet with resistance to adoption (Gourville, 2006). For instance, technology-friendly customers are already using applications (apps) on their phone to hail a ride, pay bills online, use mobile wallets, etc. Thus, many behaviors anticipated in using an autonomous taxi are already part of their lives. It is likely that these consumers show a pattern of compatible behaviors, such as use of cruise control, lane assist, toll transponders, rideshare apps, etc. Alternatively, other consumers might find certain behaviors (e.g., using the rear-view camera to reverse the car) as being incompatible and resist the innovative technology (Claudy, Garcia and O'Driscoll, 2015). Thus, the degree of compatibility (or incompatibility) should mediate the influence of technology-friendliness on intention to adopt. Formally,

H_3: The influence of technology-friendliness on adoption-intention of shared autonomous taxis will be mediated by the perceived compatibility of the innovation.

The third Rogersian attribute influencing adoption-intention is the degree of complexity. It is easy to assume that the higher the complexity, the less the intent to adopt innovations. Individuals who are reluctant to use technology due to perceived complexity will prefer to walk to the bank to deposit checks instead of using an app or will use the check-in counter at the airport instead of using the check -in kiosk. However, prior research shows that consumers demonstrate higher levels of adoption intention for innovations that are more complex, but actually adopt innovations with lower complexity (Arts, Frambach and Bijmolt, 2011). Thus, the influence of perceived complexity on eventual adoption is an empirical question; although, we anticipate perceived complexity to mediate the adoption intention. Formally,

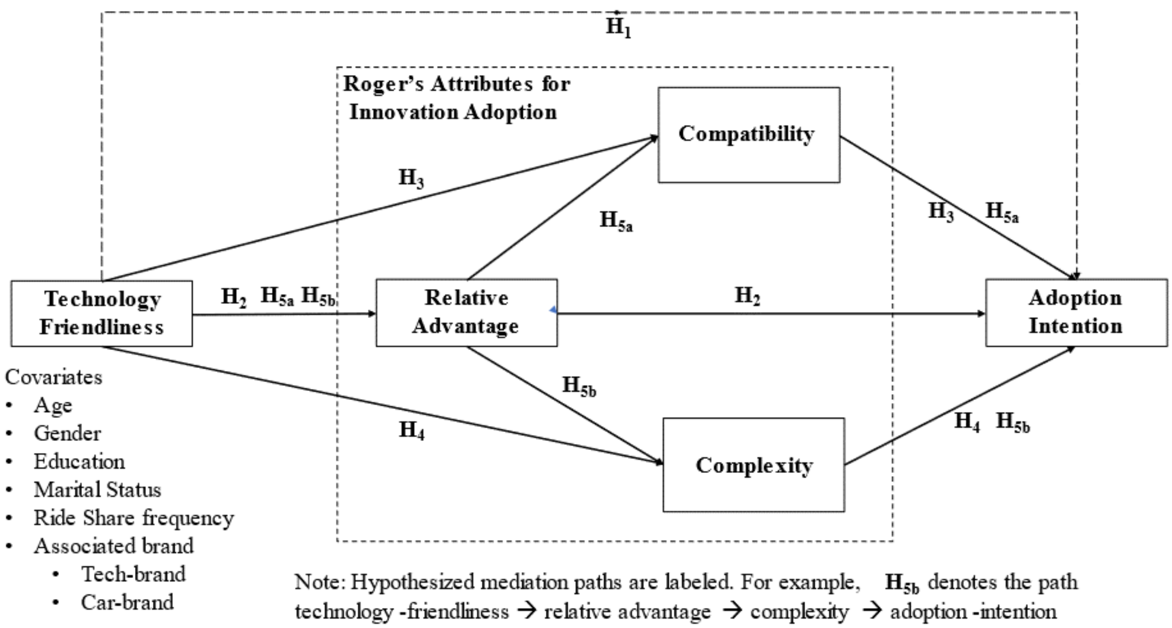
H_4: The influence of technology-friendliness on adoption-intention of autonomous taxis will be mediated by the perceived complexity of the innovation.

Unpacking the Mediation Process

In addition to these hypotheses on the mediational roles, it is important to unpack the order of the influence of these mediators. Extant literature assumes that the Rogersian adoption attributes are independent of each other and influence adoption-intention in an *additive* manner. Based on the literature on stages of innovation adoption (Hage and Aiken, 1970; Zaltman, *et al.*, 1973; Kwon and Zmud, 1987; Angle and Van de Ven, 2000) and adoption under uncertainty (Kalish, 1985), we argue for a *serial mediation path* (Figure 1) led by relative advantage, impacting compatibility and complexity downstream and, in turn, influencing the intention to adopt.

Broadly, the stages of adoption models converge on five generic sequential steps comprising awareness, interest, evaluation, trial, and adoption (Sheth, 1971; Damanpour and Scneider, 2006). Beyond awareness and interest, when consumers start considering an autonomous taxi ride, perhaps the first thought they have is that it saves on a driver's cost of wages, and therefore, it should be economical. Perhaps there is no social obligation to 'chit-chat' with the driver. Therefore, the ride is likely going to be peaceful. Another thought could be that riding with a stranger is an uncomfortable experience. As they think about the relative advantages of an autonomous taxi over a conventional taxi, they are likely to engage in a vicarious experience imagining how compatible this interaction might be. Some aspects may be compatible ("I can use an app to hail this taxi the same way I hail a rideshare today"). Other aspects may be less compatible ("I think I will feel queasy sitting in the taxi and

FIGURE 1:
Conceptualized Mediation Model for Autonomous Taxi Adoption (Study 2)



seeing the steering wheel move by itself"). That is, the question of compatibility would arise downstream of considering relative advantages. As consumers consider the relative advantage of an autonomous taxi, counterarguments about the complexity ("I am concerned I don't know a whole lot about autonomous taxis"; "I wonder how it can assess the surroundings by using cameras?"; "What if it snows and the cameras can't see?") of the innovation will likely emerge.

Another way to think about adoption stages is in terms of action identification theory (Vallacher and Wegner, 1989) which suggests that an action can be construed at a high level in "why" terms (e.g., "Why should I adopt an autonomous taxi?") or at a lower level in terms of "how" (e.g., "How will autonomous taxis be compatible with my life? The whole idea of autonomous taxis seems too complex to me. How will I deal with it?"). Liberman and Trope (2014) suggest that when a construal is distant in time, space, or psychologically away from self, people frame questions at a higher construal level on 'why' terms. However, when the decision comes closer, the questions and concerns switch to lower construal levels on 'how' terms. Along these lines, we argue that when assessing relative advantage, the consumer takes a more distant objective and a cognitive approach. Here the consumer is thinking about *why* she should adopt autonomous taxi rides. That is, relative advantage is evaluated at a higher-level construal. In consumer psychology terms, the consumer is still evaluating the merits of the proposition of the autonomous taxi. However, as one starts to consider it for personal use, the psychological distance narrows and leads to compatibility and complexity questions. These questions revolve around imagining vicariously an autonomous taxi ride and attempting to answer questions on *how* the experience might unfold. Along these lines, we suggest a serial mediation hypothesis. Formally,

H_5: The influence of technology-friendliness on adoption-intention of autonomous taxis will be:
- Serially-mediated by the relative advantage of the innovation and by its perceived compatibility, and,
- Serially-mediated by the relative advantage of the innovation and by its complexity.

Beyond the general expectation that relative advantage is a stronger mediator, whether these serial mediations will partially or fully attenuate the one-step mediational influences of compatibility and complexity, is an empirical question.

Moderating influence of regulatory focus

Higgins (1997) defines regulatory focus as a goal orientation a person adopts when pursuing a goal or when thinking about alternative choices.Prior research (e.g., Aaker and Lee, 2001; Monga and Zhu, 2005; Pham and Chang, 2010) has shown that consumer choices can be influenced by prevention and promotion self-regulation systems. A specific regulatory focus in a person – prevention-focus or promotion-focus – may be induced situationally or be a persistent trait (Herzenstein, *et al.*, 2007). Whereas prevention-focused individuals are risk minimizers, promotion-focused individuals are reward-maximizers. Although both traits are seen in every individual, either one may be dominant. Those with a dominant promotion focus play to win and those with a prevention focus play not to lose. Nevertheless, the two constructs have been shown to be independent and uncorrelated (Higgins, *et al.*, 2001; Ouschan, *et al.*, 2007) and sometimes even weakly positively correlated (Haws, *et al.*, 2010; Lockwood, *et al.*, 2002).

Autonomous taxis potentially provide several advantages of convenience, privacy, and cost. Therefore, they may appeal to individuals with a dominant promotion-focus. Equally, those with dominant prevention-focus may shy away because a new technology also poses several risks. Ram and Sheth (1989) enumerate four kinds of perceived risks in new product adoptions – functional risk, economic risk, social consequences risk, and physical risk. These risks characterize autonomous taxi rides. Previous research has shown that promotion-focused individuals are more likely than prevention-focused individuals in adoption of new-to-the-world products (Herzenstein *et al.*, 2007).

In this study, we are investigating whether consumers' regulation systems will interact in a complex, but systematic manner – and, in the presence of technology-friendliness – to shape consumer adoption-intention for autonomous taxis. For example, consumers with a high promotion-focus are willing to take risks, look for new experiences, and play-to-win. Indeed, they might weigh the advantages of being able to work during the ride, enjoy a movie, take a nap, or even enjoy a drink without the fear of being pulled over for driving under the influence. Perhaps they can attend a video conference meeting or an online class during the ride? With the elimination of human errors in autonomous vehicles, driving will become safer, even as speed limits go up, and consumers can live farther out and afford bigger homes. With gains seeming larger, these consumers are likely to discount their technology-friendliness in determining their adoption-intention for autonomous taxis. Rather, their (high) promotion-focus is likely to shape their adoption-intention for autonomous taxis. However, those low on promotion-focus are not overly upbeat about possible gains, and consequently, are more likely to recruit their technology-friendliness to assess the gains.

In contrast, "losses loom larger than gains" (Tversky and Kahneman, 1979) for consumers with a high prevention-focus. They are risk averse and unwilling to change; preferring status quo to change owing to the endowment effect (Thaler, 1980). For instance, they are likely to compare subjective utility estimates of advantages of privacy and convenience of an autonomous taxi ride with privacy concerns of their personal data being compromised when they hail the taxi using their phones. These consumers may even contemplate using their smartphones during rides to estimate the speed at which the autonomous taxi is moving or whether it is following the most optimal and safe path. Very concerned consumers may think of coping actions should malware lead to "taxi-jacking" or taxi hacking. That is, consumers with a high prevention-focus may simulate possible losses and consider whether to mitigate these possible losses by drawing from their technology-friendliness. In a lonely autonomous taxi ride, their only connectivity with the outside world is through their mobile device. Along these lines, they are likely to recruit and overweigh their technology-friendliness to evaluate the risks and advantages of the autonomous taxi rides, thus, shaping their adoption-intention. However, those low on prevention-focus are not overly preoccupied with losses, and consequently, are less likely to recruit their technology-friendliness. We, therefore, anticipate a three-way interaction effect among technology-friendliness, promotion focus, and prevention focus. Formally,

H_6: Technology-friendliness, promotion-focus, and prevention-focus of a consumer will influence adoption-intention of autonomous taxis such that:

Technology-friendliness will influence the adoption-intention for consumers with a low promotion-focus but not for consumers with a high promotion-focus; and,

Technology-friendliness will influence the adoption-intention for consumers with a high prevention-focus but not for consumers with a low prevention-focus

METHODOLOGY

In a program of three studies, this paper tests for the *main effect* of technology-friendliness on intention to adopt autonomous taxis (Study 1), the *mediating role* of Rogers's innovation adoption variables—relative advantage, compatibility, and complexity (Study 2), and the *moderating role* of regulatory (promotion and prevention) focus that may qualify these relationships (Study 3). Informed by past research on technology adoption discussed earlier (Venkatesh, *et. al.,* 2012), we include several covariates, including participants' gender, age, education, and marital status and previous related experience, notably, the frequency of their rideshares. Additionally, given the extent of information technology surrounding autonomous taxis with either technology brands (e.g., Google, Microsoft) or auto brands (e.g., Ford, GM) or both (e.g., Tesla), we consider that the brand may affect consumer intention for autonomous taxi adoption. Select consumers may find autonomous taxis offered from one or another brand's category more credible and reliable. Accordingly, their indicated preferences for technology brands and car brands were also included as covariates.

Study 1 Overview

In the first study, we conducted a survey in Qualtrics™ with 137 participants from a midwestern university in the USA (108 undergraduates, 29 graduates; 31.4% women, 68.6% men; median age 23, range 20-74; 86.1% unmarried). First, participants, in exchange for class credit (~1% of overall course grade), were shown a video (82 seconds long and publicly available on YouTube, https://youtu.be/9cfEAEatzTs), describing a proposed autonomous taxi service. Next, participants rated their intention to adopt autonomous taxi rides, along with their own level of technology-friendliness. Finally, demographic data were collected. The survey took approximately 10 minutes.

Study 1 Measures

Adoption-intention was measured using a ten-item measure as specified in Appendix 1 (Cronbach's alpha = .89). Technology-friendliness was measured using a seven-item measure (also provided in Appendix 1; Cronbach's alpha = .60). An Exploratory Factor Analysis revealed unidimensionality for adoption-intention (61% variance extracted) and for unidimensionality for technology-friendliness (41% variance extracted).

Results

To test H_1, we conducted a linear regression analysis with adoption-intention as the dependent variable and technology-friendliness as the independent variable, including participants' gender (women=0, men=1), age, education, and marital status as covariates. Results revealed overall significance ($F(5, 131) = 3.53$, $p < .005$) for the regression model; a significant technology-friendliness influence (B = .595, , $t = 2.27$, $p < .025$); a significant participant gender influence (B = 4.405, $t = 2.11$, $p < .037$), such that men exhibit four times greater adoption intention for autonomous taxis; and, no other effects. Thus, the data support H_1.

Study 1 Discussion

Study 1 provides initial evidence that technology-friendliness may lead to autonomous taxi adoption. We also found that men appear more likely to adopt the use of autonomous taxis than are women. This finding is in line with previous industry studies on autonomous vehicle use (Galeon, 2018). Please note that the variance extracted, along with the Cronbach's alpha, are low for technology-friendliness in this study. We remedy this in Studies 2 and 3. Churchill (1979, p. 68) cites Nunnally (1967) by noting that for initial studies, it is reasonable to have a scale reliability of 0.5 to 0.6, if one refines the scale in subsequent studies and the studies replicate results. Following Churchill's paradigm on scale development (Churchill, 1979) we refine this construct in the second study by dropping one-item.

Study 2 Overview

While the results from Study 1 offer initial evidence that technology-friendliness influences adoption-intention of autonomous taxis, we are compelled to unpack the mechanism that mediates adoption-intention for autonomous taxis. To test the hypothesized mediation (Figure 1) model, we conducted a Qualtrics^{TM} survey (approximately 10 minutes), in which 173 participants (142 undergraduates, 30 graduates, 1 missing; 43.9% women, 56.1% men; median age 23, range 20-76; 87.3% unmarried) participated in exchange for class credit. First, they were shown the same video as in Study 1. Next, participants rated their intention to adopt autonomous taxi rides, along with their assessment as to the relative-advantage, compatibility, and complexity of the autonomous taxi service. Participants then provided their ride-share frequency and their preferences on various brand names for the taxis. Finally, demographic data were collected.

Study 2 Measures

The technology-friendliness measure from Study 1 was refined by dropping one item resulting in a Cronbach's alpha = .787; see Appendix 1 for all measures. Adoption-intention was measured using a ten-item scale developed by the authors (as in Study 1; Cronbach's alpha = .926). Relative advantage was measured using an eight-item scale (Cronbach's alpha = .870). Compatibility was measured using a five-item scale (Cronbach's alpha = .754). Complexity was measured using a six-item scale (Cronbach's alpha = .882). Brand category for the autonomous taxi was included to determine whether a technology brand (e.g., Google, Microsoft) or a conventional automobile brand (e.g., Ford, Volkswagen) would be preferred and was measured using "*I will ride sooner if the self-driving taxi is from* ________ for eight technology brands (Cronbach's alpha = .918) and for eight car brands (Cronbach's alpha = .932). As discussed earlier, we included a brand covariate to determine if a technology brand or an automotive brand would be more likely to be adopted. Rideshare frequency was measured using a single-item on a five-point scale: *Tell us about your use of ridesharing taxi services such as Uber, Lyft etc., in the last six months* (never, 1-5 rides, 6-10 rides, 11-15 rides, 16 or more rides). All the constructs demonstrated unidimensionality with variance extracted greater than 50%.

Study 2 Results

To re-test H_1, we conducted a linear regression analysis with adoption-intention as the dependent variable and technology-friendliness as the independent variable. We included participants' gender, age, education, marital status, frequency of their rideshares, and their indicated preferences for technology brands and car brands as covariates. Results revealed overall significance ($F(8,160) = 3.09$, $p < .003$) for the regression model; a significant technology-brand influence (B = .563, $t = 2.54$, $p < .012$); a significant participant gender influence (B = 5.00, $t = 2.41$, $p < .017$); and, no other effects. Thus, data replicate and provide support for H_1.

Next, to test the conceptualized mediation model (Figure 1), we conducted a mediation analysis using process Model 81 (Hayes, 2018) with adoption-intention as the dependent variable (Y); technology-friendliness as the independent variable (X); relative advantage, compatibility, and complexity as mediators; and, participants' gender, age, education, marital status, frequency of their rideshares, and preferences for technology brands and car brands as covariates.

As expected, results (5,000 iterations, 95% confidence) show an overall significance ($F(11,156) = 13.43$, $p < .001$; $R^2 = .49$) for the conceptualized moderation model; a non-significant direct influence of technology-friendliness on adoption-intention (Model 81: B = .18, 95% CI = [-.17, .54]); a significant indirect influence of relative advantage (Model

81: B = .24, 95% CI = [.06, .43]) supporting H_2; a significant indirect influence of serial mediation by relative advantage followed by compatibility (Model 81: B = .08, 95% CI = [.01, .22]) supporting H_{5a}; and, a significant indirect influence of serial mediation by relative advantage followed by complexity (Model 81: B = .06, 95% CI = [.01, .17]) supporting H_{5b}. This pattern of results supports the mediation model with the direct influence of technology-friendliness (H_1) being completely mediated. The mediation paths within the conceptualized model, compatibility (H_3) (Model 81: B = .05, 95% CI = [-.07, .14]) and complexity (H_4) were not supported (Model 81: B = -.04, 95% CI = [-.17, .09]). All results are displayed in Figure 2.

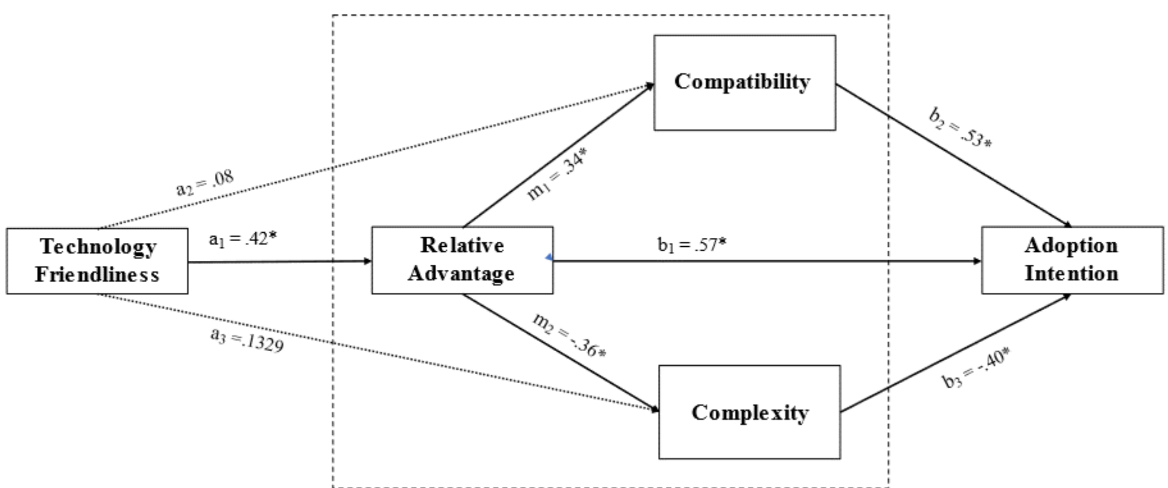
Study 2 Discussion

It is interesting to note that even after controlling for several covariates, technology-friendliness retained a significant main effect influence as a predictor of adoption intention. However, its influence was completely mediated by the Rogersian drivers of innovation adoption, including: relative advantage, compatibility, and complexity. Interestingly, relative advantage is a leading mediator as both serial mediation paths, one followed by compatibility and the other followed by complexity, showed significant mediation. Although both relative advantage and compatibility exhibited residual significant mediation beyond the serial paths, complexity did not contribute to mediation independently beyond its participation in the serial path. This is counterintuitive because autonomous taxis invoke managerial concerns about adoption-intention primarily due to the complexity. The present research allays some of those concerns and suggests that if relative advantage and compatibility are addressed, the influence of complexity should recede. Next, we explore the moderating boundary conditions for these findings.

Study 3 Overview

To test the hypothesized moderation (Figure 3) model concerning the influence of technology-friendliness on adoption-intention for autonomous taxis, we followed a similar protocol as in the previous two studies and conducted a 10-minute survey in Qualtrics™, in which 153 participants (121 undergraduates, 32 graduates; 40.5% women, 59.5% men; median age 22, range 20-82; 87.6% unmarried) who participated in exchange for class credit (~1% of overall course grade) were shown the video as in Studies 1 and 2. Next, participants rated their intention to adopt autonomous taxi rides, its relative-advantages, compatibility, and

FIGURE 2:
Results for the Mediation Model for Autonomous Taxi Adoption



95% CI → $.06 < a_1b_1 = .24^* < .43$ $-.07 < a_2b_2 = .05 < .14$ $-.17 < a_3b_3 = -.04 < .09$
$.02 < a_2m_1b_2 = .08^* < .22$ $.01 < a_3m_2b_3 = .06^* < .17$

complexity following which they rated their ride-share frequency, a scale measuring prevention and promotion regulatory focus, and their preferences on various brand names for the taxis. Finally, demographic data were collected.

Study 3 Measures

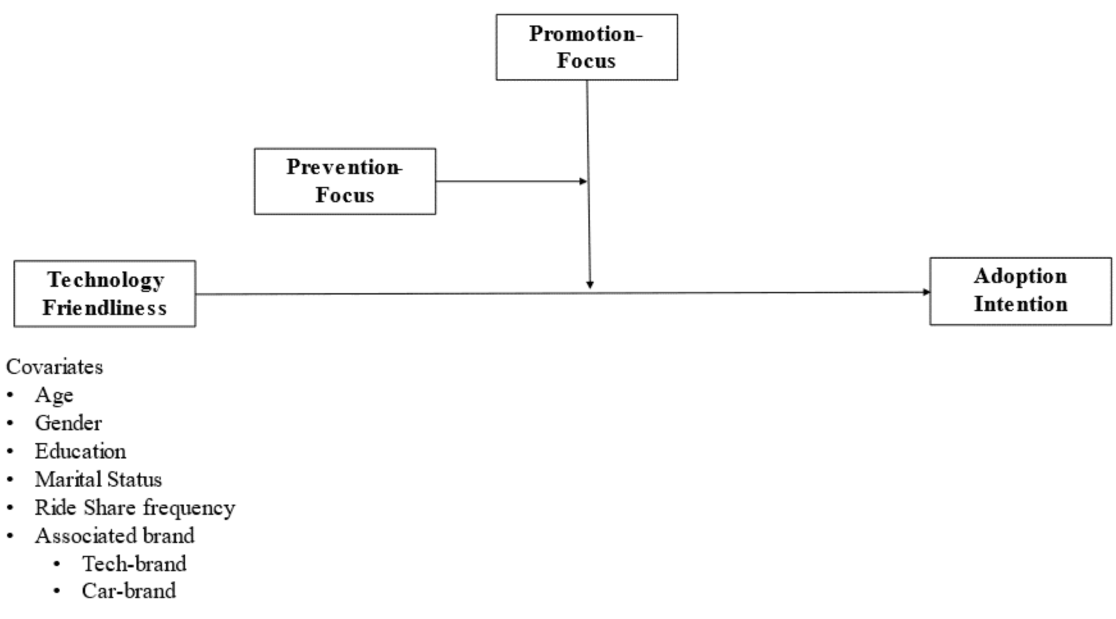
Adoption-intention was measured using a 10-item measure as in previous studies (Cronbach's alpha = .913). Technology-friendliness was measured using a 6-item measure as before (Cronbach's alpha = .708). Regulatory focus was measured using the instrument developed by Higgins, *et al.* (2001). Brand category preference for the autonomous taxi – whether a technology brand (Cronbach's alpha = .916) or a car brand (Cronbach's alpha = .934) – was measured as before. Rideshare frequency was measured as in Study 2. Appendix 1 has details of the measures. All the constructs demonstrated unidimensionality with variance extracted greater than 50%.

Study 3 Results and Discussion

To test the conceptualized moderation model (Figure 3), we conducted a moderation analysis using process Model 3 (Hayes, 2018) with adoption-intention as the dependent variable (Y), technology-friendliness as the independent variable (X), and promotion-focus (W) and prevention-focus (Z) as moderators; plus, we included participants' gender, age, education, marital status, frequency of their rideshares, and their indicated preferences for technology brands and car brands as covariates.

Results (5,000 iterations, 95% confidence) show an overall significance ($F(14,136) = 7.17$, $p < .001$) for the regression model; a significant three-way interactive influence of technology-friendliness X promotion-focus X prevention-focus on adoption-intention ($F(1,136) = 6.67$, $p < .01$); a significant two-way interactive influence of technology-friendliness X promotion-focus on adoption-intention ($F(1,136) = 4.28$, $p < .04$); a significant two-way interactive influence of technology-friendliness X prevention-focus on adoption-intention ($F(1,136) = 12.10$, $p < .001$); a significant two-way interactive influence of promotion-focus X prevention-focus ($F(1,136) = 4.90$, $p < .029$) on adoption-intention; a significant main effect influence of technology-friendliness on adoption-intention ($F(1,136) = 7.83$, $p < .004$); a significant main effect influence of prevention -focus on adoption-intention ($F(1,136) = 10.18$, $p < .002$); a significant main effect influence of

FIGURE 3:
Conceptualized Moderation Model for Autonomous Taxi Adoption (Study 3)



gender on adoption-intention ($F(1,136) = 5.78$, $p < .018$); and a significant main effect influence of technology-brands ($F(1,136) = 9.76$, $p < .002$).

A follow-up moderation analysis using process Model 1 (Hayes, 2018) with adoption-intention as the dependent variable (Y), technology-friendliness as the independent variable (X), promotion-focus (W) as a moderator, and all covariates as before shows a significant two-way interactive influence of technology-friendliness X promotion-focus ($F(1,140) = 11.55$, $p < .001$) with a significant conditional effect of technology-friendliness on adoption-intention at low (-1σ) promotion-focus ($B_L = .68$, $t= 2.42$, $p < .017$) and a non-significant conditional effect of technology-friendliness on adoption-intention at high ($+1\sigma$) promotion-focus ($B\text{-}_H = -.52$, $t= -1.58$, $p > .12$). This pattern of results supports H_{6a}.

Finally, a follow-up moderation analysis using process Model 1 (Hayes, 2018) with adoption-intention as the dependent variable (Y), technology-friendliness as the independent variable (X), prevention-focus (W) as a moderator, and all covariates as before shows a significant two-way interactive influence of technology-friendliness X prevention-focus ($F(1,140) = 18.73$, $p < .001$) with a significant conditional effect of technology-friendliness on adoption-intention at low (-1σ) prevention-focus ($B_L = -.89$, $t= -2.34$, $p < .02$) and a significant conditional effect of technology-friendliness on adoption-intention at high ($+1\sigma$) prevention-focus ($B_H =1.12$, $t= 3.80$, $p < .001$). This pattern of results supports H_{6b} (see Figure 4).

GENERAL DISCUSSION AND RESEARCH IMPLICATIONS

Our overall findings suggest that consumers' technology-friendliness does lead to new technology adoption, as predicted; however, technology-friendliness is found to be completely mediated by three components of Rogers' Theory of Diffusion: relative advantage, compatibility, and complexity. Furthermore, results show a three-way moderation, such that the influence of technology-friendliness on adoption-intention is amplified for consumers with a low promotion-focus but not for consumers with a high promotion-focus; and for consumers with a high prevention-focus but not for consumers with a low prevention-focus. Table 1 summarizes the hypothesized results from all three studies.

Theoretical Implications

The primary objective of this article was to unpack the adoption-intention for autonomous taxis. Findings provide many insights that inform consumer adoption-intention in a granular fashion (see Table 1). Technology-

FIGURE 4:
Results for the Moderation Model for Autonomous Taxi Adoption

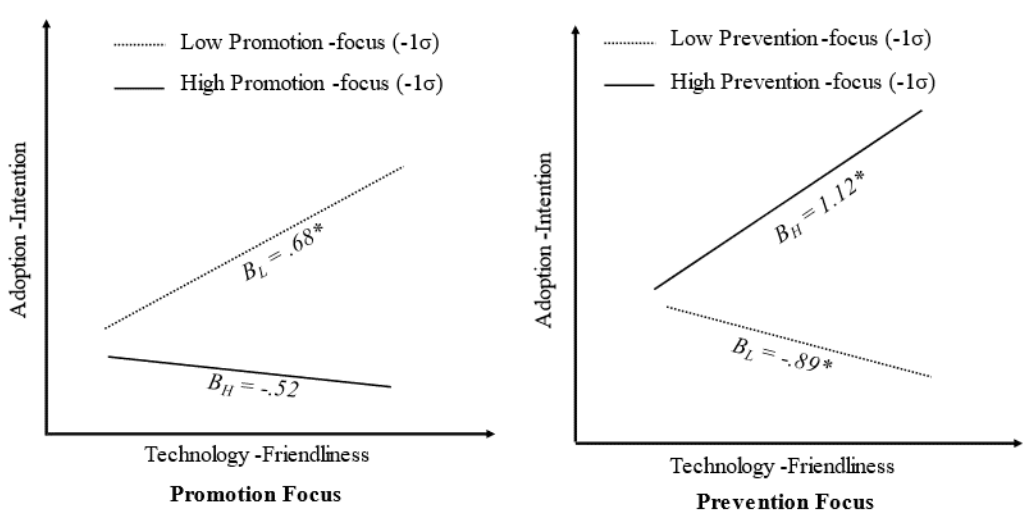


TABLE 1:
Hypotheses Results

	Hypothesis	Support
H_1:	The greater a user's technology-friendliness, the higher the intention to adopt autonomous taxis	Supported
H_2:	The influence of technology-friendliness on adoption-intention of autonomous taxis will be mediated by the perceived relative advantage of the innovation.	Supported
H_3:	The influence of technology-friendliness on adoption-intention of autonomous taxis will be mediated by the perceived compatibility of the innovation.	Not Supported
H_4:	The influence of technology-friendliness on adoption-intention of autonomous taxis will be mediated by the perceived complexity of the innovation.	Not Supported
H_5:	The influence of technology-friendliness on adoption-intention of autonomous taxis will be:	
	serially mediated by their relative advantage and by their compatibility	Supported
	serially mediated by their relative advantage and by their complexity	Supported
H_6:	Technology-friendliness, promotion-focus, and prevention-focus of a consumer will influence adoption-intention of autonomous taxis such that:	
	Technology-friendliness will influence the adoption-intention for consumers with a low promotion-focus but not for consumers with a high promotion-focus	Supported
	Technology-friendliness will influence the adoption-intention for consumers with a high prevention-focus but not for consumers with a low prevention-focus	Supported

friendliness is a leading indicator for autonomous taxi adoption. Even after controlling for several covariates, notably, gender and possible brand association categories (car brand, technology brand), technology-friendliness retained a main effect influence as a significant predictor of autonomous taxi adoption-intention. However, its influence was completely mediated by three of the Rogersian drivers of innovation: relative advantage, compatibility, and complexity. This finding extends the adoption intention literature in demonstrating that when relative advantage is present with compatibility, complexity – as a concern about adoption – recedes in importance.

The individuals' regulatory prevention and promotion focuses showed a significant three-way interaction along expected lines. This provides additional insights on boundary conditions for the influence of technology-friendliness on adoption intention: that it only works for people low on promotion focus and high on prevention focus. The literature on regulatory focus is extended in that we demonstrated where these two key constructs make a difference on a consumer's intention to adopt new technologies.

While not hypothesized, the aversion for the technology brands covariate is counterintuitive. Nevertheless, the result is in line with a heightened influence of complexity on adoption -intention. Our expectation was that technology brands inspire confidence among respondents insofar as complexity is a pivotal concern. The pattern of results indicates that complexity is not a leading mediator with only a subsidiary contribution in a serial mediation path. Finally, our anticipation was that rideshare experience, a covariate in the models, should foster adoption-intention. However, it did not attain significance. Perhaps previous ridesharing is only incidental rather than central to potential use of an autonomous taxi.

Managerial Implications

As Bob Lutz (2017), former Vice Chairman and Head of Product Development at General Motors stated, "*The auto industry is on an accelerating change curve…. The end state will be the fully autonomous module with no capability for the driver to exercise command. You will call for it, it will arrive at your location, you'll get in, input your destination and go to the freeway…. This transition will be largely complete in 20 years.*" The business model in which automobile sales to private individuals has provided billions of dollars in revenue to some of the world's largest corporations, is itself in the final stage of its own life cycle. Today, autonomous vehicle technology and the sharing economy together will likely usher in an entirely new transportation paradigm and business model.

Aware of the perils associated with marketing myopia (Levitt, 1960), the transportation industry is embracing both the autonomous vehicle technology and sharing economy trends. Witness the recent purchase by one of Toyota's subsidiaries of Lyft's autonomous car business for $550 million (Hawkins, 2021). Automotive companies will soon no longer be "manufacturers of personal transportation vehicles," but instead manufacturers of autonomous taxis that provide ride hailing services. To compete successfully, auto manufacturers and the firms providing autonomous taxi services must understand the intricacies involving the diffusion of innovation surrounding autonomous taxis and their services. In so doing, management must uncover and understand the unique characteristics and commonalities of the innovators within their new target markets, along with the roles they play in communicating or convincing the benefits associated with the technology surrounding autonomous vehicles and autonomous taxi services (Dedehayir, *et al.*, 2019).

The findings of the three studies detailed above provide insights into who the early adopters might be. Technology-friendly individuals are likely to exhibit higher adoption-intention and, therefore, are early target segments. Younger generational cohorts literally live on their mobile phones: one-in-three identify social media as the preferred channel for communicating with businesses and they check their phones over 150 times a day (Snedeker, *et al.*, 2019). Further, numerous research findings indicate that younger consumers embrace the sharing economy (Godelnik, 2017), prefer shared transportation over owned transportation (Klein and Smart, 2017), and have been identified as the drivers of the shared economy (Maycotte, 2015).

The conventional car brands are competing for the mindshare against the technology brand names in this futuristic world of self-driving vehicles. For instance, Alphabet, the parent company of Google, alone has spent over $3.5 billion on research of its own AV, branded Waymo (Baldwin, 2020). Surely, these big investments warrant serious and urgent insights on which segments would be the early adopters, including which consumers with what types of psychological mindsets would exhibit greater affinity towards the technology? Thus, the technology-friendliness construct that was tested in this study, correlates and identifies with Gen Z as the primary target segment for autonomous taxis.

The mediation analysis indicates that relative advantage of autonomous taxis to be a key mediator. In a more nuanced way, the present study shows that the influence of technology-friendliness on adoption-intention is amplified for consumers with a high prevention-focus. The framing of the communication messages in promoting autonomous taxis should simultaneously highlight the relative advantages (e.g., "Be driven. Don't drive to work") and safety (e.g., "autonomous taxis are 95% more safe").

Along these lines, firms attempting to enter this sector of the sharing economy must convince innovators and early adopters that the advantages offered by autonomous taxis far outweigh the consequences of 1) not using one's own vehicle; and 2) not having control over the vehicle. Simply put, companies must be able to successfully highlight benefits, such as the enhanced level of socializing (via mobile technology) that passengers could enjoy while riding in the taxi. This could also be strengthened by reinforcing the benefit of not having to own the vehicle outright and instead focusing on enjoying life without the burden of car payments and other requirements of vehicle ownership (e.g., insurance payments, maintenance, repairs, fuel costs, etc.). The cost-benefit, multi-tasking abilities, rider convenience, privacy, etc. must be foremost in the initial marketing initiatives employed and presented to autonomous taxi service users. If the relative advantage and compatibility are adequately addressed, negative influences associated with complexity should recede.

As the reality of autonomous taxi services becomes more evident and the sharing economy grows in prominence, auto manufacturers and providers of ridesharing services will be faced with *how* to market autonomous taxi services, not *whether* to market them. By better understanding the unique characteristics associated with innovators and early adopters, who will ultimately be responsible for "communicating or convincing the benefits of the innovation and its uses to the remainder of the population" (Dedehayir, 2019), and by avoiding the marketing myopia that has inflicted so many industries (Levitt, 1960), auto manufacturers and ridesharing service providers will enhance diffusion and adoption of the autonomous taxi to their primary target markets.

LIMITATIONS AND FUTURE RESEARCH

While providing insightful evidence as to the adoption of autonomous taxis, this paper still experienced limitations. For example, the three-study sample consisted of a total of 339 college students enrolled at a midwestern university. Even as the sample size is considered acceptable, perceptions of autonomous taxi technology and services could vary significantly among potential customers at universities in different geographical regions of the United States, outside of the United States, or those outside of the university setting altogether. The sample also consisted of students relatively comfortable with the basic levels of technology. A study focusing primarily upon the more technologically advanced consumers, quite possibly the initial target market for autonomous taxis, could yield different results. Along these same lines, the study sample included participants who, even by their own definition, would be neither innovators nor early adopters. The advanced technology required to make autonomous taxi services possible would likely be embraced almost exclusively by those who are far less risk averse, and it would be these individuals initially targeted by firms introducing SAV services.

The studies also looked only at autonomous taxi services, or *Shared* Autonomous Vehicles, and not autonomous vehicles sold to individual consumers for their own personal use. The consumer who hails a taxi may have significantly different perceptions of automobile transportation than one who purchases an automobile for his/her own personal transportation needs. The mindsets of those who borrow/share versus those who own may be quite different. Even as we progress toward a more shared economy, the mindset of those who still purchase for personal consumption cannot be overlooked.

Future Research

The inherent limitations associated with studies of this nature, as well as other research questions surrounding SAVs can readily be addressed in future research. A larger sample size alone might provide unique insights as a broader spectrum of views could be included in the analysis. In addition, a study focusing primarily upon those who self-identify as innovators or early adopters, may offer different, yet better focused insights surrounding those whom the industry will depend upon to purchase initial SAV offerings. Since they consider themselves early adopters or innovators, they may embrace the new technology offered by SAVs and may be less concerned with complexity. Along these same lines, a distinction needs to be clearly made between those who would be targeted to purchase *shared autonomous vehicle services*, as opposed to those who would buy *autonomous vehicles* for their personal use. Differentiating the interests and concerns of those who are interested in owning an autonomous vehicle as opposed to simply riding in such a vehicle may vary dramatically.

The industry would also benefit from learning more about market perceptions surrounding the actual driving experience, so embraced by some and dismissed by others, but totally absent in a SAV. These opinions would obviously impact the purchase of an autonomous vehicle or sharing of SAV services.

A better understanding of why individuals may want to leave their current means of transportation consisting of the personal ownership and driving of an automobile would also be of interest not only to the academy but the automobile industry as well. The marketing of technologically enabled autonomous vehicles will only be successful if said vehicles and associated services prove superior in existing vehicles and services in some manner. In other words, garnering a better understanding of what drivers of personally owned vehicles dislike about their existing means of transportation may serve to better position the introduction of SAV services and the sale of AVs.

The introduction of the revolutionary technology surrounding autonomous vehicles will have a dramatic impact upon global transportation. A great deal of research surrounding the adoption of such services, and vehicles, has yet to be conducted and will prove essential in the successful launch of the new products and services. Autonomous taxis are closer than they appear in the rear-view mirror.

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APPENDIX 1:
Constructs and Measures

Construct	Item	Reliability Cronbach's Alpha
Adoption-intention (1 Strongly Disagree 7 Strongly agree)	Self-driving taxis would be my first choice among taxi rides	**.892** (Study 1) **.926** (Study 2) **.913** (Study 3)
	I will try self-driving taxis as soon as they are launched in my city	
	I will consider riding self-driving taxis within the next two years	
	I will actively explore more information on self-driving taxis	
	I will recommend self-driving taxi rides to my friends	
	I will consider riding self-driving taxis if a backup driver is sitting in the driver's seat	
	I will try self-driving taxi rides even if a back-up driver is not present	
	I will consider riding self-driving taxis if another colleague/friend shares the ride with me	
	I will consider riding self-driving taxis if regular taxis are not available	
	I will not ride self-driving taxis any time soon*	
Relative advantage (1 Strongly Disagree 7 Strongly agree)	Self-driving taxis would be less expensive rides	**.848**
	Self-driving taxis would be more convenient rides	
	Self-driving taxis would be more private rides	
	Self-driving taxis would be more peaceful rides	
	Self-driving taxis would be easier to request	
	Self-driving taxis would not require any tipping	
	Self-driving taxis are good for the environment	
	Overall, self-driving taxis are a good idea	
Compatibility (1 Strongly Disagree 7 Strongly agree)	I expect to request self-driving taxis the same way I would request a taxi today.	**.768**
	I expect my riding experience in a self-driving taxi to be similar to a taxi experience today.	
	I expect the self-driving taxis to look similar to the taxis I see today	
	Self-driving taxis are compatible with my lifestyle	
	People like me will readily ride self-driving taxis	
Complexity (1 Strongly Disagree 7 Strongly agree)	I find it hard to believe that a taxi can drive itself	**.877**
	The whole self-driving taxi idea appears too complex to me	
	I think that the cameras attached on the taxis must have very complicated technology	
	I am concerned that an self-driving taxi might not come to a stop	
	I am concerned that a self-driving taxi may not be able to control its speed	
	I am concerned that I don't know a whole lot about self-driving taxis	
Technology-friendliness (1 Strongly Disagree 7 Strongly agree	I use my smartphone to check email	**.600 (S**tudy 1) **.787** (Study 2) **.708** (Study 3) *This item was dropped in Studies 2 and 3
	I use my smartphone as a GPS	
	I use my smartphone as a remote thermostat for my home*	
	I use my smartphone to access social media	
	I use my smartphone calendar app to schedule my appointments	
	I use my smartphone to deposit checks into my bank account	
	I constantly use apps on my smartphone	