MODE SHIFT INTENTIONS TO HIGH-SPEED RAIL IN THE US – MEDIATION AND MODERATION ANALYSES

FINAL REPORT

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16. Abstract

While the US lags behind other nations in high-speed rail (HSR) development, it has seen growing interest in integrating HSR into its transportation network. Existing HSR literature focuses primarily on policies, advantages, and disadvantages of HSR development in the US, leaving a research gap in users' intentions toward HSR. With the predominant use of air and cars in the US, it is imperative to understand mode shift intentions to HSR once it becomes a viable option for domestic travel. This study examined travelers' mode shift intentions toward HSR in the US, focusing on important determinants of such intentions and the inter-relationships between key factors. Data was collected on Amazon Mechanical Turk (MTurk) using a structured questionnaire to form two mode shift groups for analysis – from air to HSR (n=637) and cars to HSR (n=250). To capture the complexity of the decision-making process, mediation, moderation, and moderated mediation analyses were performed on both mode shift groups. Results indicated that (1) intrinsic factors especially pro-environmental attitudes and pro-environmental personal values significantly mediated the normative influence on mode shift intentions toward HSR, (2) while HSR prices, travel time and service frequency were important in the mode shift decisions, their effect was enhanced by travelers' motivation to try out new ridership experiences and (3) HSR information significantly moderated the mediating effect of pro-environmental attitudes in the relationship between HSR characteristics (especially HSR prices) and the intention to shift from air or cars to HSR. The findings contributed to the understanding of travelers' mode shift intentions toward HSR and informed policymaking for successful HSR entry into the US market.

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1. Introduction

While high-speed rail emerged in the early 1960s and has since expanded in Asia and Europe, it is still a new phenomenon in the US. Only certain segments of Amtrak Acela Express running along the Northeast Corridor (NEC) can reach speeds up to 150 mph, making it arguably the only HSR service in the US (Ashiabor & Wei, 2013). The lack of train transport in general and HSR service in particular in the US has historical reasons. Over the decades, the US has focused predominantly on highways and aviation in building its transportation system, forming a unique car and air culture (Kamga & Yazici, 2014). With the growing population and transport needs, the reliance almost entirely on car and air transportation has become problematic. With limited space to expand the highways and airports, along with environmental challenges, the US has explored electrified HSR as a possible way to rebalance the transport ecosystem in the country.

With more countries adopting HSR, mode shift toward HSR has been witnessed, especially from air transport to HSR. This has been observed in high-demand markets where HSR competes directly with air on short- and medium-distance routes (Zhang et al., 2018). There was extensive literature on choosing HSR over other transport modes, suggesting important factors such as travel time, convenience, safety, attitudes, and social norms in the intermodal choice (Celikkol-Kocak et al., 2017; Chan & Yuan., 2017; Jing & Juan., 2013). However, mode shift intentions and underlying factors - switching from air or cars to HSR – have not received much attention. Environmental benefits could be an important factor, but its impact has been studied primarily at the market and policy levels. Some studies compared CO2 emissions before and after the introduction of HSR to estimate the mode substitution effect of HSR. The findings generally

supported reduced CO2 emissions due to the mode shift from cars and air to HSR (Robertan, 2016; Zanin et al., 2012). At the micro level, few studies examined the role of environmental considerations in travelers' decisions to switch from cars and air to HSR. While Rajendran and Popfinger (2022) evaluated the current HSR system in major European markets, considering environmental benefits and different levels of expected willingness to use HSR, it did not focus on environmental considerations as an impact factor in travelers' mode shift decisions, indicating a research gap in the literature.

Furthermore, the indirect impact of environmental considerations on mode shift decisions needs to be understood better. Transport markets present a complex situation. This means that decision-making is a complex process involving travelers processing information available and evaluating different factors to determine the best option or course of action to meet their travel needs. In this process, some factors may directly impact the decision while others may demonstrate a hidden impact, in the form of mediating and moderating the relationship between key factors and the travel decision. Likely for this reason, mediation (a third variable mediating the effect of an independent variable on the outcome) analysis and moderation (the combined effect of the independent variable and a third variable on the outcome) analysis have been utilized to gain deeper insights into the complexity of intermodal choice in the transport market (Hu et al., 2019). However, there is scarce literature on mediating and moderating effects in the decision to switch from other transport modes to HSR when HSR enters a new market, especially when the mediation and moderation analyses involve environmentally related factors, which is another research gap this study attempts to bridge.

This study aimed to understand the direct and indirect impact of HSR characteristics and environmentally related factors on the mode shift intention of US travelers. Both intrinsic factors (pro-environmental attitudes, pro-environmental habits, and pro-environmental personal values) and extrinsic factors (HSR characteristics, normative influence, and HSR information) and their mediating or moderating effects were examined. This study is important as it fills the missing piece in the literature on HSR use, especially in the US where HSR is new and travelers' intentions to switch from their familiar air and car transportation to HSR are understudied. Three research questions were used to guide the study regarding US travelers including (1) what is the mediating effect of pro-environmental attitudes, habits, and values in the relationship between normative influence and mode shift intentions toward HSR, (2) what is the moderating effect of HSR safety and convenience and HSR stimulus in the relationship between HSR factors and mode shift intentions toward HSR, and (3) what is the moderated mediating effect involving pro-environmental attitudes and HSR information in the relationship between HSR factors and mode shift intentions toward HSR.

2. Literature Review

2.1. HSR in the US

While major countries in Asia and Europe have expanded their HSR network, the US continues to underperform its counterparts in HSR development. Only part of the train operation between Boston and Washington can be qualified as an HSR operation (Kamga, 2015), which makes the train service on this route the only HSR service in the US. For decades, the US relied heavily on

automobiles and airplanes, creating a unique air and car culture (Kamga & Yazici, 2014). In recent years, there has been renewed discussion of HSR in the US, signaling a potential need to accelerate HSR development. Several reasons may explain this new trend. Increasingly, states across the US have faced challenges in expanding their highways, interstates, and airports, resulting in ground and airspace congestion. This threatens the health of the country's transportation system and affects travelers' experience significantly. A modernized rail system may provide the needed solution, as rail transport, especially HSR, can mitigate the pressure on ground and air transportation, a pattern observed in many mature HSR countries worldwide. Indeed, the HSR literature indicated changing competition dynamics following HSR entry into busy transport markets and mode shift from air transport to HSR (Mizutani & Sakai, 2021; Zhang et al., 2017; Zhang et al., 2019). The social benefits associated with HSR development, such as travel time and safety, may also drive the interest in HSR. As population and urbanization continue to grow, the US needs more capable public transportation, for which HSR can play an important role. As major cities in the US continue to expand, demand for fast and safe mobility increases. The accelerated speeds of HSR allow for efficient connection between populated areas in the US, and such spatial-temporal compression effect has already been seen in other countries (Li et al., 2022). Another important factor in HSR development in the US is the government's long-term vision of sustainable transportation, which involves "technological optimism" to shift traffic from fossil-fuel-dependent cars and planes to more energy-efficient transport modes, which include HSR (Kamga & Yazici, 2014).

2.2. HSR and Green Transportation

As HSR relies on clean and renewable energy (electrically powered), it is often considered an eco-friendly solution to decarbonize the transportation network. For this reason, the European Commission has adopted the HSR strategy, aiming to reduce 90% of greenhouse emissions generated by transportation by 2025 compared to the 1990 levels (Avogadro et al., 2021). This could be achieved partially by the interaction and substitution between air and HSR in short-distance markets, where HSR can be an efficient and environmental-friendly alternative to air transport. Many studies supported the environmental benefits of HSR (Avogadro et al., 2021; Bueno et al., 2018; Liu et al., 2022; Sun & Lin, 2018; Zhang et al., 2023). Avogadro et al. (2021) assessed the intermodal substitution between air and other transport modes (mainly HSR) on short- to medium-haul routes and its impact on the European markets at the macro- and micro-levels regarding emission savings. The findings indicated that the environmental benefits were not equally distributed across Europe; however, such benefits occurred primarily in domestic markets where air-HSR interactions were observed, and they can lead to potential emission savings in the long term. HSR-related carbon emission reduction was also observed in China, the largest HSR market in the world. HSR contributed significantly to “green development” based on the analysis of 276 cities in China (Zhang et al., 2022). This was supported by the green total factor productivity (GTFP) estimation, indicating that HSR-connected cities outperformed non-HSR-connected cities by 12.8% in GTFP values. Another study yielded similar findings regarding HSR’s ability to reduce urban carbon emissions at the city level. Further, the study highlighted the direct environmental impact (HSR replacing highway passenger traffic) and indirect environmental impact (reducing emissions through technological innovation). However, there is still some debate on the environmental benefits of HSR, especially when multiple stages

of HSR development are considered (Givoni & Dobruszkes, 2013). Some studies used the Life Cycle Assessment (LCA) method to estimate the environmental cost of HSR. For example, Kortazar et al. (2021) integrated the construction, maintenance, and operation phases for environmental impact assessment on the HSR lines built on multiple corridors in Spain. The results showed that HSR construction on several corridors cannot be justified regarding energy saving and emission reduction due to low travel demand.

2.3. HSR Studies – Travelers' Perspective

While substantial research examined market accessibility, economic growth, environmental impact, and pricing strategy related to HSR (Button, 2017; Wang et al., 2020; Yao et al., 2013; Zhao & Yu, 2018), little attention has been given to travelers' mode shift intentions toward HSR. Several studies examined the choice between air travel and HSR in high-demand markets, suggesting that travel time, price, demographics, and travel-related factors were important in the intermodal decision (Chantruthai et al., 2014; Lee et al., 2016; Shi et al., 2022). Direct and indirect relationships were examined, often using established theoretical models (Borhan et al., 2019; Hou et al., 2021). Sagoe et al. (2021) partially adopted the theory of planned behavior (TPB) model, focusing on the direct impact of external factors on the intention to use HSR. They found that attitude, convenience, travel time reliability, and safety were directly related to the intention to use HSR, with safety being the most important determinant. The mediating effect of key factors was also examined. According to Barhan et al. (2019), trust toward HSR positively influenced the three TPB factors, while novelty seeking indirectly influenced the intention to use HSR via attitude. Similarly, Hou et al. (2021) showed that the TPB factors significantly mediated the relationship between perceived service quality and the intention to use HSR in China. Surprisingly, while environmental benefits of HSR have been widely studied, there is limited research examining the role of pro-environmental factors in the decision to use HSR, especially in the US, where HSR remains a new phenomenon. Pan (2024) modeled US travelers' perceived sustainability and intentions to use HSR based on the three-pillar theory and found a significant, direct impact of environmental factors on the intention to use HSR, suggesting a relatively high level of green travel awareness among US travelers.

The review of the literature pointed to the knowledge gaps regarding HSR. First, while HSR has been a research interest for decades, most literature has focused on the technological, operational, and economic aspects of HSR, leaving the intention to use HSR understudied, especially in the US. The ongoing urbanization, growing traffic, and acceptance of sustainable transport have stimulated interest in passenger dedicated HSR transportation. Research on HSR in the US needs to incorporate the impact of these important changes. Second, more research is needed to understand the role of pro-environmental factors in the intention to use HSR in the US. Pan (2024) identified a significant environmental impact on the use of HSR, which disagreed with the finding of Ashiabor and Wei (2023) indicating that environmental impacts may be difficult for average travelers to perceive, and US travelers are more likely to base their mode decisions on cost and time factors. Pan (2024), however, only focused on environmental impact at a higher level. More study involving environmental impact is needed at the micro-levels to understand internal and external factors in HSR intentions. Lastly, mediation and moderation analyses, while often examined in studies based on well-established attitudinal and behavioral

models, had limited application in HSR studies that examine environmental factors and the intention to use HSR. Especially, how and to what extent internal environmental factors would mediate the relationship between external forces and the mode shift intention toward HSR has remained untested. Answers to these important questions can fill the research gap in the literature and provide support for HSR integration into the current transport system in the US.

2.4. Theoretical Frameworks and Factor Selection

This study was built on two well-established theories - the theory of planned behavior and intrinsic and extrinsic motivation - to examine the direct and indirect relationship between selected factors and the intention to shift from air and cars to HSR when available in the US. The original TPB model was proposed by Azjen (1991), positing that behavioral intention is shaped by three factors – an attitude that represents the favorableness and unfavorableness toward the behavior, subjective norms that describe the pressure from important others for an individual to engage in the behavior, and perceived behavioral control (PBC) that refers to an individual's perceived control on conducting the behavior. In the transport domain, studies applied the TPB model to examine travelers' intentions and behaviors, including the use of HSR (Borhan et al., 2019; Hsiao & Yang, 2010; Hou et al., 2021; Sagoe et al., 2021). The present study included three types of constructs related to the TPB – attitudes, social norms (subjective and descriptive norms), and intentions, emphasizing the pro-environmental element in these constructs. As this study investigated the internal and external factors that affected the mode shift intention, the intrinsic and extrinsic motivational theory was utilized, again incorporating the pro-environmental element. In this study, *intrinsic factors* were defined as factors that motivate people to do an activity for its inherent satisfactions rather than for some separable consequence, and *extrinsic factors* are those that motivate people to do things to attain some separable outcome (Ryan & Deci, 2000). Pro-environmental attitudes, habits, and values were intrinsic, while social norms, HSR information, and HSR characteristics were extrinsic. This study aimed to examine the direct, mediating, and moderating effects of these factors on the mode shift intention toward HSR. The remainder of Section 2.4 justifies the selection of the factors for developing the theoretical models.

2.4.1. Intrinsic Factors

Human experience - both real and perceived – shapes the attitude toward a particular behavior. In the HSR literature, researchers often found attitudes toward HSR significantly and directly influenced the intention to use HSR, making it an important factor in the HSR context (Borhan et al., 2019; Hsiao & Yang, 2010; Hou et al., 2021; Sagoe et al., 2021). A few studies examined pro-environmental travel attitudes, behaviors, and intrinsic and extrinsic factors (Ma et al., 2018; Silvi & Padilla, 2021). Ma et al. (2018) explored the association between Chinese visitors' motivations and pro-environmentally attitudes and behaviors. They found that intrinsic and extrinsic motivational factors were related to visitors' environmental attitudes and pro-environmental behaviors. Studies also showed a positive relationship between pro-environmental attitudes and the desire to maintain high-quality environmental conditions when traveling (Kiatkawsin & Han, 2017). Some studies examined the mediating effect of attitudinal factors (Koning et al., 2011; Wang et al., 2019; Wood et al., 2014). Fallah Zavareh et al. (2020) found no mediating effect of environmental attitudes towards transportation in the relationship between motives and active mode use. Their study, however, did not focus on the use of HSR. Indeed,

there is a lack of research on the mediating effect of pro-environmental attitudes in the HSR literature.

Habits are formed through the repetition of behaviors. Rooted deeply in experience, habits can be a more important determinant of intentions and behaviors than the TPB factors (Connor & Armitage, 1998). Only limited studies examined the role of habits in HSR intentions and behaviors. Jing and Juan (2013) expanded the TPB model with habits and descriptive norms to investigate the intermodal choice involving HSR. Habits significantly influenced the intention to use HSR, and the inclusion of the habit factor led to the biggest increase in explained variance in the choice model. The relationship between habits and pro-environmental behaviors was also examined. Studies revealed that habits can significantly explain the consistency between pro-environmental behaviors (Bilynets & Cvelbar, 2022; MacInnes et al., 2022). In comparing pro-environmental behaviors between people's daily lives and the destination they recently visited, Bilynets and Cvelbar (2022) suggested that being more diligent in daily pro-environmental behavior is the strongest positive predictor of the same behavior at the tourist destination. The mediating effect of habits was also identified in the relationship between intrinsic exercise rewards and engaging in exercise (Phillips et al., 2016). However, whether or not habit mediates the relationship involving the HSR intention remains untested.

Pro-environmental value is complex and multidimensional. It can be part of the personal value, defined as a desirable trans-situational goal that can vary in importance and be used as a guiding principle in a person's life (Schwartz, 1992). Studies indicated that pro-environmental behaviors stem from personal values towards the environment (Kiatkawsin & Han, 2017). In the tourism literature, relationships were found between the values, beliefs, and personal norms of tourists, and these factors predicted pro-environmental behaviors and supported sustainable tourism (Park et al., 2022). The value factor can be important in accepting comprehensive green transport policies and engaging in pro-environmental behaviors (Zhang et al., 2020). The choice of environmentally friendly modes of transportation is often based on a sense of moral obligation to act sustainably (Lind et al., 2015). While many believe that personal values can influence behaviors indirectly, more research is needed to investigate the mediating effect of pro-environmental values on intentions and behaviors, especially in the HSR context.
In this study, pro-environmental attitudes, habits, and values were treated as three intrinsic factors that could mediate the relationship between social norms (subjective and descriptive norms) and the intention to shift to HSR. The hypotheses stated that pro-environmental attitudes (habits, values) mediated the relationship between social norms (subjective and descriptive norms) and mode shift intentions toward HSR.

2.4.2. Extrinsic Factors

Social norms may come from social expectations (subjective norms) and actual behaviors of other people (descriptive norms), which influence individuals' intentions and behaviors. In this study, subjective norms were defined as approval from important others for travelers to adopt pro-environmental behaviors, and descriptive norms referred to other people's actual pro-environmental behaviors; both could encourage mode shift intentions toward HSR. Fallah Zavareh et al. (2020) found that subjective norms significantly influenced car use for university routes, while personal environmental norms and attitudes towards transportation were not important factors. The role model effect has been studied in pro-environmental intentions and

behaviors. Its impact was found in car use, indicating descriptive social norms can encourage commuters to consciously evaluate their mode choice and increase sustainable transport behaviors related to private vehicle use for commuting purposes (Kormos et al., 2015), and it was a powerful predictor of pro-environmental behaviors, both directly and indirectly, through its influence on perceived behavioral control (Fornara et al., 2011). Bissing-Olson et al. (2016) examined the relationship between pro-environmental behaviors and experiences of pride and guilt that people experience, with pro-environmental descriptive norms as a moderator. A moderating effect was found, meaning participants were more likely to engage in pro-environmental behaviors when they perceived more positive pro-environmental descriptive norms. The moderating effect of descriptive norms has not been examined in the HSR context, which the present study aimed to address.

Information can be important in driving environmental awareness and pro-environmental behaviors. Information intervention has been widely studied in consumer behaviors such as purchasing organic food products (Chang & Wu, 2015; Schöll et al., 2015; Singh & Verma; 2017), travelers' intention to accept travel information (Xu et al., 2010), and the effect of information from various sources on COVID-19 vaccination intentions (Gehrau et al., 2021). In the transport domain, Xu et al. (2010) examined travelers' acceptance or refusal of travel information provided by the advanced traveler information system. The study indicated the importance of trust in travel information, among other information-related factors, in travelers' intention to accept travel information. However, the impact of information on HSR travelers is understudied, especially when information is used as a moderator.

Human beings are motivated to learn new things and gain new experiences. The desire to respond to new stimuli (Hirschman, 1980) often serves as an inner force driving people to explore the world around them. Research of novelty seeking has been conducted in the HSR context (Hsiao & Yang, 2010; Borhana et al., 2019), suggesting the importance of novelty seeking in HSR intentions and behaviors. As HSR is still a new phenomenon in the US, US travelers generally lack HSR experience. When HSR starts operations in the US, travelers may be curious about HSR and motivated to try HSR as a new ridership experience. Therefore, the entry of HSR into the US is framed as an extrinsic motivational factor, or HSR stimuli, in the present study. The focus was on how this external stimulus moderated or enhanced the effect of HSR-related factors on the intention to shift from air or cars to HSR in the US.

This study treated subjective norms, descriptive norms, HSR information, and HSR stimuli as extrinsic factors that can motivate travelers to shift from air or cars to HSR. For the moderation analysis, the hypothesis stated that HSR stimulus (safety, convenience) significantly moderated the relationship between the price (travel time, service frequency) of HSR and the mode shift intention toward HSR. Another hypothesis stated that there is a moderated mediating effect of HSR information and pro-environmental attitudes in the relationship between HSR price (travel time, service frequency) and the mode shift intention toward HSR when it becomes available in the US.

2.4.3. HSR Characteristics

Speed acceleration allows HSR to compete directly with air transport in short- and medium-haul markets (Ashiabor & Wei, 2013; Chou et al., 2018). With the high speed, time-space

compression can be achieved, which significantly reduces travel time between cities (Yao et al., 2020). Travel time is key in choosing a transport mode (Sinha & Labi, 2007) and increasing HSR ridership (Ngoc & Nishiuchi, 2022; Shi et al., 2022). In the context of HSR, travel time is significant for travelers to choose HSR over other transport modes, especially among high-income travelers (Lee et al., 2016; Yao et al.,2013). As such, the travel time factor was included in this study.

A major advantage of HSR is the ability to move large amounts of travelers safely and reliably (Ureña et al., 2009). Since its commencement in the 1960s, HSR has been considered one of the safest travel methods (Chou et al., 2018). The safety record of HSR attracts travelers, and it has become one of the major reasons for the increase in HSR ridership (Ngoc & Nishiuchi, 2022). Safety was the most important factor affecting the intention to use HSR in African countries, demonstrating that safety, among other factors, had a robust influence on behavioral intentions toward HSR in developing countries (Sagoe et al., 2021). The impact of safety on HSR use may vary across different passenger groups. In predicting the choice between air transport and HSR, Lee et al. (2016) identified much higher values of safety for business passengers than leisure passengers. However, more research is needed to understand how HSR safety is related to mode shift intentions toward HSR, especially in a new HSR country.

While some studies examined HSR accessibility at the regional level (which cities provide HSR service), the interest in the present study was the convenience of HSR service within the city and how it could influence travelers' intentions to shift to HSR. Accessing HSR is often easy because railway stations, compared to airports, are generally conveniently located near the city center with well-connected surface transport, allowing travelers to arrive at the train station relatively quickly (Zhao & Yu, 2018). The convenience factor can be important in the US, as young and senior populations in the US increasingly choose to settle in urban areas for easy access to numerous facilities, including transportation. These travelers could find the convenient location of HSR facilities important in meeting their travel needs and therefore intend to shift from other transport modes, particularly air transport, to HSR.

Ticket price is a critical factor in the competitiveness of a transportation mode (Chou et al., 2018). In high-demand markets where HSR competes with air transport, airlines frequently lowered prices to maintain market share (Shi et al., 2022). Price is also a key factor in the competition between HSR and low-cost carriers (LCCs), and a small fare difference of USD 0.03/km can be significant in making travelers change from LCCs to HSR (Chantruthai et al., 2014). Studies found an inverse relationship between HSR prices and occupancy rates, citing high HSR prices as the major factor in low occupancy rates (Yao et al., 2013). Hortelano et al. (2016) further concluded that price, travel time, comfort, frequency, and punctuality were the most important reasons for choosing HSR. Earlier studies in the US suggested that price and travel time were essential for the success of HSR in the US (Williams et al., 2013). Therefore, the price factor was included in this study.

The present study analyzed the direct effect of HSR price, travel time, and service frequency in the mode shift intention toward HSR. Furthermore, the moderating effect of safety and convenience in the relationship between price, travel time, frequency, and the intention to shift toward HSR were examined.

3. Method

3.1. Sampling and Data Collection

This study used a non-experimental survey design to collect data from Amazon Mechanical Turk (MTurk). The convenience sample was selected from the sampling frame of MTurkers (US travelers registered to MTurk and eligible for participating in the survey). Measures taken to ensure the quality of the survey data included (1) participants having completed 100 or more MTurk tasks, (2) participants receiving an approval rate of 98% or more, and (3) participants completing the same survey in the pilot study being excluded from the main survey. The sample size was an important consideration in testing the mediation effect. Fritz and MacKinnon (2007) estimated empirical sample sizes needed for a power of 0.8 to test the mediation effect. The required sample sizes for bootstrap tests ranged from 34 to 462, depending on the study conditions. Furthermore, a literature survey of 166 mediation studies indicated that the median sample sizes for testing indirect effect and causal steps using non-structural-equation-modeling (SEM) were 142.5 and 159.5, respectively. Hence, the sample sizes used in this study - 637 for shifting from air to HSR and 250 for shifting from cars to HSR - were considered acceptable for the mediation analyses.

Data collection was completed in the fall of 2023. The time coincided with the growing attention to HSR in the US, driven largely by the desire to upgrade the public transport system to achieve efficient and eco-friendly transportation. Noticeably, HSR will likely enjoy new opportunities in the post-pandemic era given the higher demand for customer experience regarding reliability, quality, service frequency, and sanitization safety. US travelers are likely to be interested in learning about HSR and its future operations, which can influence their intentions to use HSR. Since this study focused on travelers' intentions to shift to HSR when it becomes available, especially from predominantly utilized air and cars, the data collected at this time can capture US travelers' opinions of switching to HSR.

3.2. Data Collection instrument

The survey questionnaire provided a Los Angeles - San Francisco market scenario and asked the participants to indicate their mode shift intentions in two steps. Compared to a single question of mode shift intentions to all participants, the two-step method considered the complexity of mode use and intermodal competition in the busy transport market. Participants were first asked to consider the current market competition and choose from either air or cars for travel between LA and SF. Once the two groups were created (choosing air or choosing cars), participants were asked to indicate their intention to switch to HSR if it becomes available. The two-step data collection, depicted in Figure 1, allowed the data to represent the mode shift intentions more accurately. There were 637 respondents choosing air over cars and further indicated their intention to shift from air to HSR when it becomes available, and 250 selected cars over air and further indicated the intention to switch to HSR. These two groups (n=637 and n=250) became the samples for the data analyses in this study.

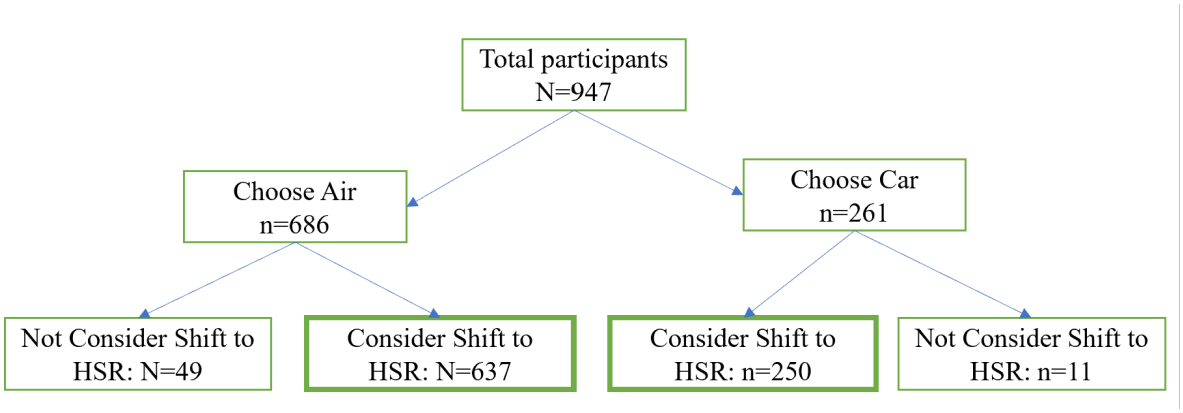

Figure 1: Two-Step Data Collection of Mode Shift Intentions to HSR

3.3. Data Treatment

Using the survey data, the researcher performed three sets of analysis: mediation, moderation, and moderated mediation analyses, using PROCESS macro for SPSS. PROCESS is a computational tool for path analysis-based mediation and moderation analysis and their integration as a conditional process model (Hayes, 2018). The mediation analysis examined three intrinsic factors (pro-environmental attitudes, pro-environmental habits, and pro-environmental personal values) and their mediating effect on the relationship between social norms and mode shift intentions. The moderation analysis focused on extrinsic factors and their interaction with HSR characteristics to influence the mode shift intentions. Finally, in the conditional analysis integrating mediation and moderation, the study examined the factor of HSR information and how it moderated the mediating effect of pro-environmental attitudes in the relationship between HSR characteristics and mode shift intentions.

4. Results

Of the total participants (N=947), 72% (n=686) preferred traveling by air between LA and SF while the remaining 28% (n=261) would prefer cars. Of those who chose air, 93% (n=637) would consider shifting to HSR when it becomes available in the LA-SF market. Of those who chose a car, 96% (n=250) indicated the intention to shift to HSR. For the purpose of this study, those who selected air and considered shifting to HSR when it becomes available (n=637) and those who selected cars and considered shifting to HSR when it becomes available (n=250) were used for the comparative analysis.

Mediating effect, moderating effect, and moderated mediating effect were examined for both air-HSR and car-HSR groups. SPSS PROCESS Macro v4.2 was used for the data analyses. Appendix 1 shows the thirteen factors used in these analyses and intercorrelations between the factors. The factors were mostly moderately correlated. Six of these factors – pro-environmental attitudes (AT), pro-environmental personal values (VA), pro-environmental habits (HA), descriptive norms (DN), subjective norms (SN), and HSR information (IN) - were measured by a 5-point Likert scale ranging from 1 (Strongly Disagree) to 5 (Strong Agree). Appendix 2 shows

the scale items measuring each factor and the corresponding Cronbach Alpha score. All the Cronbach Alpha scores were greater than 0.7, indicating reliable measurement of these factors.

4.1. Mediation Analyses

To answer the first research question, mediation analyses were performed to examine the direct effect of SN and DN on mode shift intentions toward HSR and whether the effect was mediated by a third variable, namely AT, VA, and HA, individually. The independent variables – SN and DN – represented the external, normative influence on the intention to switch to HSR, while the three mediators represented intrinsic, personal factors. The focus was on whether and to what extent each internal factor intervened (mediate) the influence of external factors (IV) on mode shift intentions toward HSR (DV). The theoretical framework for the mediation analyses is illustrated in Figure 2. The effects examined in the analyses included (1) Direct Effect represented by the direct impact of DN and SN on SI, respectively, (2) Indirect Effect represented by the impact of DN and SN on SI through each mediator, respectively, and (3) Total Effect which is the sum of Direct Effect and Indirect Effect. The mediation analyses were performed for air-HSR and car-HSR groups, with two covariates – gender and age.

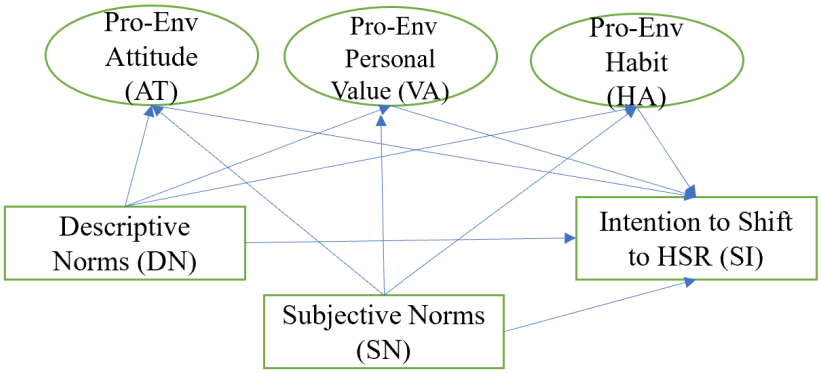

Figure 2: Theoretical Framework for the Mediation Analyses

Table 1 shows the mediation results. The three mediators (AT, HA, VA) were tested separately in the relationship between normative factors and mode shift intentions. For participants who preferred air but intended to switch to HSR when it becomes available, the models produced positive coefficients, indicating that an increase in other people's pro-environmental acts (descriptive norms) and approval from important others (subjective norms) would increase travelers' intentions to shift from air to HSR. The regression model with each mediator explained similar variances in mode shift intentions as indicated by the R^2 values (43%-46%). Both subjective and descriptive norms had a significant direct effect on mode shift intentions to HSR.

Table 1: Mediation Analyses Results – Air-HSR and Car-HSR Groups.

Mediator	Relation	R^2	Total Effect	Direct Effect	Indirect Effect	CI(L)	CI(H)	Result
Air-HSR								
AT	DN→ SI	.4533	.7362***	.4669***	.2692	.1715	.3628	Partial mediation
	Cov1					-.350	.1302	No effect
	Cov2					-.0276	.0637	No effect
	SN → SI	.431	.7095***	.4075***	.302	.1919	.4083	Partial mediation
	Cov1					-.0553	.1134	No effect
	Cov2					-.0340	.0591	No effect
HA	DN→ SI	.4427	.7362***	.4819***	.2543	.1308	.3742	Partial mediation
	Cov1					-.0385	.1284	No effect
	Cov2					.0132	.1043	With effect
	SN → SI	.4304	.7095***	.4233***	.2862	.1657	.4078	Partial mediation
	Cov1					-.0606	.183	No effect
	Cov2					.0094	.1019	With effect
VA	DN→ SI	.4594	.7362***	0.3761***	0.36	.2319	.484	Partial mediation
	Cov1					-. .0323	.1319	No effect
	Cov2					- .0034	.0859	No effect
	SN → SI	.4426	.7095***	.2848***	0.4247	.2872	.5468	Partial mediation
	Cov1					-.0470	.1202	No effect
	Cov2					-.0065	.0844	No effect
Car-HSR								
AT	DN→ SI	.6728	0.8715***	.6047***	.2668	.1456	.4277	Partial mediation
	Cov1					-.0407	.0923	No effect
	Cov2					-.1627	.1062	No effect
	SN → SI	.653	.8866***	.6021***	.2845	.1448	.4451	Partial mediation
	Cov1					-.0365	.1155	No effect
	Cov2					-.1615	.1155	No effect
HA	DN→ SI	.6314	.8715***	.7677***	.1038	-.0200	.2764	No mediation
	Cov1					.0095	.1458	With effect
	Cov2					-.1116	.1682	No effect
	SN → SI	.6168	.8866***	.8412***	.0454	-.1311	.2512	No mediation
	Cov1					.0115	.1516	With effect
	Cov2					-.1115	.1761	No effect
VA	DN→ SI	.6633	.8715***	.6072***	.2643	.11	.5183	Partial mediation
	Cov1					- .0069	.1244	No effect
	Cov2					-.1083	.1614	No effect
	SN → SI	.6362	.8866***	.6205***	.2661	.0485	.5318	Partial mediation
	Cov1					-.0013	.1351	No effect
	Cov2					-.1068	.1734	No effect

Notes: AT=Pro-environmental Attitudes; VA= Pro-environmental Personal Values; HA= Pro-environmental Habits; DN=Descriptive Norms; SN=Subjective Norms; SI=Mode Shift Intentions to HSR; Cov1=Gender; Cov2=Age.

The indirect effect, or mediating effect of AT, HA, and VA, was tested using the non-parametric bootstrapping technique, which produced the confidence interval (CI) information. As the range for the upper and lower bound estimates do not cross over zero, as shown in Table 1, the indirect effect is considered significant. Therefore, AT, HA, and VA significantly and partially mediated the prediction between DN and SI, CI [.1719, .3628], [13.08, .3742], [.2319, .4840], and between the prediction of SN on SI, CI [.1919, .4083], [1657, .4078], [.2872, .5468]. It indicated that social norms significantly influence travelers' intention to shift from air to HSR when it becomes available in the US. However, this external influence was accounted for by intrinsic and personal factors, specifically AT, VA, and HA. Of the three mediators, HA was the weakest mediator, while VA was the strongest mediator, as indicated by the coefficients in Table 1. This means pro-environmental personal values most strongly intervened the normative influence in the intention to switch from air to HSR, while pro-environmental habits intervened the least.
For participants who preferred cars but intended to switch to HSR when it becomes available, the regression models produced positive coefficients for all variables, explaining between 62% and 67% of the variance in the mode shift intention. Both subjective and descriptive norms had a significant direct effect on mode shift intentions. The indirect effect was significant in four of the six paths, DN-AT-SI: CI [.1456, .4277]; SN-AT-SI; CI [.1448, .4451], DN-VA-SI, CI [.1100, .5183], and SN-VA-SI, CI [.0485, .5318]. This indicated that social norms significantly influence travelers' intentions to shift from cars to HSR when it becomes available. However, this external influence was mediated by internal and personal factors. Noticeably, the indirect effect involving HA was not significant, suggesting that the influence of social norms on intentions to switch from cars to HSR was not mediated by pro-environmental habits. Pro-environmental attitudes were a stronger mediator than pro-environmental values, albeit only slightly in magnitude. Both air-HSR and car-HSR analyses controlled the gender and age factors. The covariates showed generally similar patterns in their influence in the outcome variables.

4.2. Moderation Analyses

Moderation analysis differs from mediation analysis in that moderation examines if the direct influence of an IV on an DV is altered because of a third variable (a moderator) while mediation is concerned about if the influence between two factors may take an indirect path through a third variable (Collier, 2020). The interest in moderation analysis is the combined effect, or interaction effect, of the IV and the moderator on the outcome. For the moderation analysis in this study, the IVs were HSR characteristics – Price (PR), Time of Travel (TT), and Frequency (FR), the DV was the mode shift intention to HSR when it became available, and the moderators were HSR stimulus (HS), Safety (SA), and Convenience (CO). The focus was on whether and how the moderators would interact with the IVs to influence the DV. The PROCESS Macro tool automatically mean-centers the variables, transforming the IV and the moderator around a fixed point (mean). The approach of -1SD, Mean, and +1SD for Low, Average, and High levels of the moderator was used for interpreting the interaction effect of the moderator. Figure 3 illustrates the theoretical framework for the moderation analysis in this study. Table 2 shows the results of the moderation analysis for both groups – shifting from air to HSR and shifting from cars to HSR.

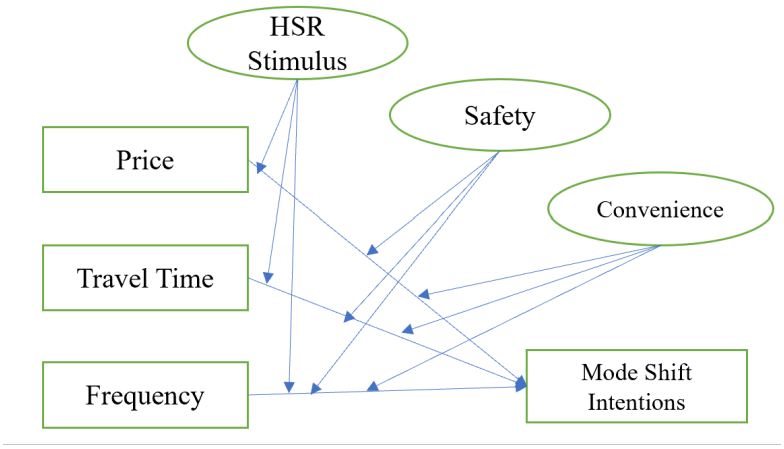

Figure 3: Theoretical Framework for the Moderation Analyses

Table 2: Moderation Analyses Results – Air-HSR and Car-HSR Groups.

Moderator (M)	Factors	X→Y	M→Y	X*M	Conditional Effect	Cov1	Cov2	Moderation Effect
Air - HSR								
HSR	X=PR, Y=SI	9.18***	5.07***	p=.2674	No Effect	No	No	No
Stimulus	X=TT, Y=SI	9.97***	5.88***	p=.003	L: .1246	Yes	No	Yes
(HS)					M: .1543			
					H: .1841			
	X=FR, Y=SI	9.24***	5.13***	p=.024	L: .1298	No	Yes	Yes
					M: .1520			
					H:.1742			
Safety	X=PR, Y=SI	6.80***	5.27***	p=.004	L:.1013	No	No	Yes
(SA)					M: .1314			
					H: .1616			
	X=TT, Y=SI	6.62***	5.23***	p=.011	L: .1088	No	No	Yes
					M: .1375			
					H: .1663			
	X=FR, Y=SI	6.53***	6.01***	p=.033	L: .1043	No	Yes	Yes
					M: .1270			
					H: .1489			
Convenience	X=PR, Y=SI	7.11***	7.28***	p=.005	L: .0910	No	No	Yes
(CO)					M: .1192			
					H: .1474			
	X=TT, Y=SI	6.69***	6.8***	p=.006	L: .0943	Yes	No	Yes
					M: .1225			
					H: .1507			
	X=FR, Y=SI	6.24***	6.89***	p=.049	L: .0947	No	Yes	Yes
					M: .1147			
					H: .1346			

Car - HSR								
HSR Stimulus (HS)	X=PR, Y=SI	9.37***	3.6**	p=.0009	L: .1347 N: .1876 H: .2405	No	No	Yes
	X=TT, Y=SI	8.67***	3.16**	p=.0027	L: .1372 M: .1937 H: .2502	No	No	Yes
	X=FR, Y=SI	9.28***	2.54**	p=.018	L: .1532 M: .1934 H: .2335	No	No	Yes
Safety (SA)	X=PR, Y=SI	3.47**	3.86**	p=.972	No effect	No	No	No
	X=TT, Y=SI	2.64**	4.25***	p=.217	No effect	No	No	No
	X=FR, Y=SI	4.17***	4.19***	p=.099	No effect	No	Yes	No
Convenience (CO)	X=PR, Y=SI	3.96**	3.59**	p=.785	No effect	No	No	No
	X=TT, Y=SI	2.73**	3.62**	p=.725	No effect	No	No	No
	X=FR, Y=SI	4.31***	3.44**	p=.148	No effect	No	No	No

Notes: PR=Prices; TT=Travel Time; FR=Service Frequency.

For those who preferred air in the LA-SF market and intended to switch to HSR when it becomes available, all the three IVs (PR, TT, FR) and the three moderators (HS, SA, CO) significantly affected the mode shift intention. Except for the PR and HS pair, a significant interaction effect was observed between all the IVs and the moderators ($p < .05$). This showed that, while travelers considered HSR price, travel time, and service frequency as important factors to switch from air to HSR, other factors like trying out new ridership experience, safety, and convenience of HSR can significantly alter the effect of price, time, and frequency on mode shift intentions. To explore the significant moderation effect further, three different regressions for each IV combined with each moderator were examined. Take travel time (one IV) and HSR stimulus (one moderator) for example, the researcher examined the regressions for travel time as the predictor of mode shift intentions when the HSR stimulus is low, at the mean value, and at a high level. These regressions are shown in the column of Conditional Effect in Table 2. The low, mean, and high values of HSR stimulus were .1246, .1543, and .1841, respectively, and they were statistically significant. This indicated that HSR stimulus positively moderated the relationship between travel time and mode shift intentions. In other words, as HSR stimulus increased in levels (becoming more attractive as a new experience), it enhanced the effect of travel time on mode shift intentions more. The similar pattern was observed in all the significant moderation effects, namely TT*HS, FR*HS, PR*SA, TT*SA, FR*SA, PR*CO, TT*CO, and FR*CO.

For participants who preferred cars in the LA-SA market and intended to shift to HSR when it becomes available, the findings were very different. Safety and convenience did not show significant moderating effect in the relationship between the three IVs – price, travel time, and service frequency – and mode shift intentions to HSR, suggesting that safety and convenience of HSR would not alter the effect of price, travel time, and service frequency on the decision to switch to HSR. HSR stimulus was the only significant moderator in the car-HSR moderation analysis, moderating the relationship between price, travel time, frequency, and mode shift intentions. This means that the relationships between price, travel time, frequency, and mode

shift intention were dependent on the motivation to try out a new transport mode. The regression coefficient for each significant moderating effect – PR*NS, TT*NS, and FR*NS - indicated that HSR stimulus positively affected the relationship between the individual IVs - price, travel time, and frequency - and mode shift intentions. As HSR stimulus increased in levels (become more attractive as a new transport mode), its moderating effect became greater. Take price for example, as HSR stimulus moved along low, medium, and high levels, there was a positive, significant enhancement in the relationship between price and the intention to switch to HSR (.1347, .1876, .2405).

4.3. Moderated Mediating Effect Analysis

The third analysis in this study combined moderation and mediation analyses to gain deeper insights into the relationship between HSR characteristics and the intention to shift to HSR when it becomes available in the US. The reason for this combination was twofold. First, given the complexity of mode shift decisions, it is likely that the decision to shift to HSR is influenced by both mediating and moderating effects. A moderated mediation analysis can handle complicated relationships like mode shift decisions. Second, the factor of HSR information and its possible moderating effect were the focus of this analysis given that HSR is still a relatively new phenomenon in the US. In the moderated mediation analysis, HSR information and pro-environmental attitudes were used as the moderator and the mediator, respectively. The focus was on their effects in the relationship between three HSR factors (price, travel time, and service frequency) and the intention to shift to HSR. The option of Model 7 of PROCESS Macro allows for inclusion of a mediation model that also has a moderator on one of the indirect paths, which was used for this analysis. Figure 4 depicts the theoretical framework for the moderated mediation analysis for this study.

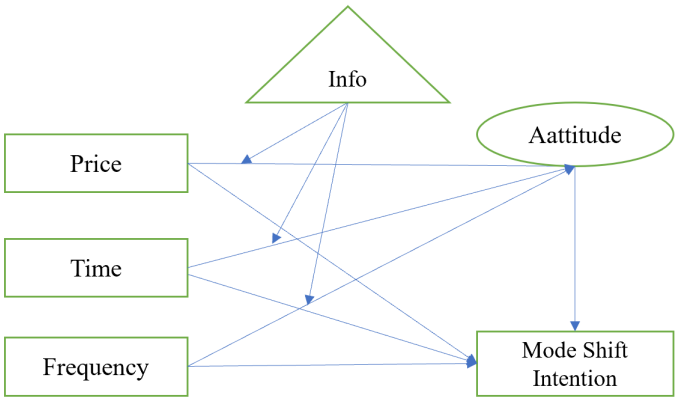

Figure 4: Framework for the Moderated Mediation Analysis

Table 3 shows the results of the indirect effect of the three HSR factors (price, travel time, and service frequency) on intentions to switch to HSR via the proposed mediator of pro-environmental attitudes, with the mediating effect being moderated by HSR information. For travelers who selected air travel in the current market and intended to switch to HSR when it becomes available, the three HSR factors had significant direct impact on the pro-environmental attitudes and mode shift intentions. There was a significant interaction effect between the three

HSR factors and HSR information in affecting pro-environmental attitudes. However, when the moderator of HSR information and the mediator of pro-environmental attitudes were considered simultaneously, a significant moderated mediating effect was observed only in the relationship between price and mode shift intentions, as indicated by the lower and upper bounds of the CIs (-.0046, -.0029). This indicated that HSR information not only altered the effect of HSR price on pro-environmental attitudes, but also influenced how pro-environmental attitudes mediated the relationship between HSR price and intentions to switch to HSR. The mean centered conditional effect showed a decrease in moderated mediating effect (.0708, .0555, .0401) when the HSR information factor changed in the order of low, medium, and high. This indicated that, as the level of HSR information increased, the mediating effect of pro-environmental attitudes in the relationship between HSR price and mode shift intentions would decrease.

Table 3: Moderated Mediation Analysis - Air-HSR and Car-HSR Groups.

ME	MO	Relation	Moderating Effect		Direct Effect	Moderated Mediating Effect		
Air to HSR								
AT	IN	IV/DV	IV-AT	IV*IN	IV-SI	CI(L)	CI(H)	Conditional Effect
		PR-SI	9.14***	p=.0002	4.14***	-.0466	-.0029	L: .0708
								M: .0555
								H: .0401
		TT-SI	8.44***	p=.013	3.88**	-.0404	.0074	No effect
		FR-SI	7.10***	P=.333	4.93***	-.0289	.0143	No effect
Car to HSR								
AT	IN	PR-SI	6.03***	p=.0002	2.45**	-.072	-.0107	L: .1044
								M: .0715
								H: .0387
		TT-SI	4.95***	p=.0017	3.67**	-.0703	-.0048	L:.0876
								M: .0592
								H:.0308
		FR-SI	5.26***	p=.0076	3.48**	-.0632	.0042	No effect

Notes: Moderated Mediation Analyses Results – Air-HSR and Car-HSR participants. Notes: IV=Independent Variable; DV=Dependent Variable; PR=Price; TT=Travel time; FR=Frequency service; ME=Mediator; MO=Moderator.

For travelers who selected cars in the LA-SF market and intended to change to HSR when it becomes available, a significant direct impact was observed in the three HSR factors on pro-environmental attitudes and mode shift intentions. There was a significant moderated mediation effect of HSR information (moderator) and pro-environmental attitudes (mediator) in the relationship between HSR price and mode shift intentions toward HSR. Different from the findings of air-HSR analysis, the car-HSR analysis also showed a significant moderated mediating effect of HSR information and pro-environmental attitude in the relationship between travel time and mode shift intentions to HSR. The results indicated that HSR information may be

more important in the decision to switch from cars to HSR, as it significantly altered the effect of both price and travel time on pro-environmental attitudes as well as how pro-environmental attitudes mediated the relationship between HSR factors and mode shift intentions. The mean-centered conditional effect again demonstrated decreasing scores (.1044, .0715, .0387 and .0876, .0592, .0308 for HSR price and travel time, respectively) as the information factor increased in the order of low, medium, and high levels. The interpretation was that an increase in HSR information reduced the mediating effect of pro-environmental attitudes in the relationship between price, travel time, and mode shift intentions toward HSR.

5. Discussion

Over half of the survey respondents fell between the ages of 20 and 40 years, indicating relatively young travelers in this study. Participants generally were well-educated (most received a bachelor's degree or higher), with incomes in the low to medium ranges (below $75,000 annually). An uneven distribution was observed in gender (slightly more males than females) and ethnicity (more Whites than participants from other ethnic groups). The respondents were frequent travelers, with 4-5 times being the most selected frequency for air-HSR and car-HSR groups. For both groups, more travelers traveled for business purposes than non-business purposes. Overall, the respondents in this study were younger, more educated, and earned lower incomes than the general population in the US.

5.1. Mediation Analysis

The mediation analysis revealed significant mediating effect of three intrinsic factors (pro-environmental attitudes, habits, and personal values) in the relationship between two extrinsic factors (pro-environmental subjective norms and descriptive norms) and mode shift intentions toward HSR. For travelers who intended to shift from air to HSR, total effects, direct effects, and indirect effects involving all factors were significant. This indicated that approval from important ones to behave pro-environmentally (subjective norms) and other people's pro-environmental behaviors (descriptive norms) significantly affected travelers' intentions to shift from air to HSR, which aligned with previous findings of the importance of the external, normative influence in pro-environmental intentions and behaviors (Kormos et al., 2015). The significance of the indirect effect further showed that a considerable portion of the influence of descriptive norms and subjective norms on mode shift intentions was carried by the mediators of pro-environmental attitudes, habits, and personal values. This indicated that for complex intentions like mode shift intentions, both extrinsic factors (what other people say or do) and intrinsic factors (traveler's attitudes, habits, and personal values toward eco-friendly travel) play a significant role in driving the intention. Pro-environmental personal values were the strongest mediator, indicating that when a traveler feels a sense of obligation and personal responsibility to help the environment when traveling, this moral awareness most strongly mediates the effect of normative factors on mode shift from air to HSR. The finding was consistent with the literature that showed values were good predictors of pro-environmental behavior, often more stable than the factor of attitude (Gatersleben et al., 2014). The habit was the weakest mediator, suggesting that travelers' pro-environmental habits, compared to their pro-environmental attitudes and personal values, had less effect in mediating the relationship between normative factors and mode shift from air to HSR.

For travelers who intended to shift from cars to HSR, pro-environmental attitudes and personal values were significant mediators between normative factors and mode shift intentions. Again, descriptive and subjective norms directly affected the mode shift from cars to HSR. However, their influence was transmitted through the intrinsic factors of pro-environmental attitudes and personal values. Different from the air-HSR group, travelers in the car-HSR group saw a slightly stronger mediating effect of pro-environmental attitudes, indicating that pro-environmental attitudes as the mediator was able to explain more variance in the intention to shift from cars to HSR than can be explained by pro-environmental personal values. Noticeably, pro-environmental habits had a marginal mediating effect between subjective norms and mode shift intentions and no mediating effect between descriptive norms and mode shift intentions. This suggests the insignificant role of pro-environmental habits in explaining the normative influence on the intention to shift from cars to HSR.

While both pro-environmental attitudes and personal values were significant mediators in the air-HSR and car-HSR analyses, they differed in the magnitude of importance, which can be reasonably explained. Both car and air transport emit large amounts of greenhouse gas (GHG), but car emissions have slowed since the 1990s, while emissions from air transport have increased due to the growth in air travel demand (Mattioli et al., 2023; Rajendran & Popfinger, 2022). Travelers may perceive air travel as a "higher emitter" than car travel and being responsible for a larger portion of transport-related GHG emission. With this perception, travelers may be more likely to associate mode shift from air to HSR (presumably more polluted) with personal obligations and values, making pro-environmental personal values a more important mediator. For those shifting from cars to HSR, the decision may be more straightforward based on their pro-environmental attitudes instead of moral principles of environmental protection. In both analyses, pro-environmental habits showed a neglectable mediating effect, indicating whether or not travelers have pro-environmental habits has little influence on their intentions to switch from air or cars to HSR in the US.

5.2. Moderation Analysis

The moderation analysis, with HSR price, travel time, and service frequency as the IVs, mode shift intentions from air or cars to HSR as the DV, and HSR stimulus, safety, and convenience as the moderators, yielded different findings for the air-HSR and car-HSR groups. For those intended to switch from air to HSR, price, travel time, and service frequency significantly influenced the mode shift intention, which was supported by the literature on the importance of these factors in the intention toward HSR (Chantruthai et al., 2014; Lee et al., 2016). Safety and convenience factors affected the mode shift intention directly and moderated the relationship between HSR price, travel time, frequency, and mode shift intentions. In other words, the effect of HSR prices, travel time, and service frequency on mode shift intentions was dependent upon travelers' perceived safety and convenience of HSR. When the perceived safety and convenience increased, the effect of price, travel time, and service frequency on the intention to shift from air to HSR would increase. This means that while price, travel time, and service frequency are important characteristics that drive the decision to switch from air to HSR, travelers would consider HSR safety and convenience in conjunction with these factors to form the decision to shift from air to HSR. HSR stimulus was a significant moderator in the relationship between travel time, service frequency, and mode shift intention, indicating that motivation to try new

things played an important role when travelers evaluated the time and service frequency of HSR in their mode shift decisions. However, HSR stimulus did not moderate the relationship between HSR price and mode shift intentions, likely due to the lack of HSR service and pricing information in the US. For travelers who intended to switch from cars to HSR, safety and convenience were not significant moderators. This indicated that those who preferred to use cars to travel between LA and SF would rely mainly on the price, travel time, or service frequency information to decide whether or not to switch from cars to HSR, and the decision was not affected by the safety and convenience factors of HSR. HSR stimulus was the only significant moderator for the car-HSR group, indicating that car users in the LA-SF market intended to switch to HSR not only because of price, travel time, and service frequency of HSR but also because they were curious about HSR and wanted to try out a new ridership experience.

There were interesting findings when comparing the moderation analyses between air-HSR and car-HSR travelers. Safety and convenience significantly altered the effect of price, travel time, and service frequency on mode shift decisions for the air-HSR group but not for the car-HSR group. This is likely due to the different perceptions of air and car travel. Travelers often perceive air travel as inconvenient (e.g., congested airports, delays, and hassles) and pay more attention to safety when traveling by air. As HSR presents a safer and more convenient travel option, travelers will likely consider safety and convenience when evaluating the effect of price, travel time, and service frequency on switching from air to HSR. The car users on the LA-SF corridor, on the other hand, may perceive car travel to be equally convenient and safe as HSR and, therefore, would not consider safety and convenience when assessing the effect of price, travel time, and service frequency on their decisions to switch from cars to HSR. Noticeably, HSR stimulus was the important moderator for both airline users and car users to form their mode shift decisions. This indicates that the intention to shift from air and cars to HSR in the US was partially driven by the motivation to try out a new ridership experience.

5.3. Moderated Mediation Analysis

The focus of the moderated mediating analysis was on whether pro-environmental attitudes mediated the relationship between HSR price, travel time, service frequency, and mode shift intentions toward HSR, whether HSR information created a combined effect with HSR price, travel time, and service frequency, and more importantly, whether the mediating effect of pro-environmental attitudes depends on different levels of HSR information travelers received. For airline travelers who intended to shift to HSR, the mediator of pro-environmental attitudes and the moderator of HSR information were both significant, indicating that HSR prices, travel time, and service frequency affected mode shift intentions through pro-environmental attitudes, and HSR information can change the effect of HSR price, travel time, and service frequency on pro-environmental attitudes toward HSR. The moderated mediating effect of HSR information was significant only for the relationship between HSR price, pro-environmental attitudes, and mode shift intentions. In other words, to what extent travelers' pro-environmental attitudes mediated the effect of HSR price on mode shift intentions was dependent on the levels of HSR information they received. The more HSR information air travelers receive, the smaller role pro-environmental attitudes would play in mediating the influence of HSR price on the decision to switch to HSR. Again, this may be explained by the lack of information on HSR prices in the US. For car users, a significant moderated mediating effect was observed regarding HSR price

and travel time. Compared to air travelers, car users appear to require more HSR information in forming their pro-environmental attitudes and mode shift decisions toward HSR.

In this analysis, HSR information significantly moderated the mediating effect of pro-environmental attitudes toward HSR, supported by the literature on the importance of information in intentions and behaviors (Schöll et al., 2015; Singh & Verma; 2017). Its importance, however, was observed mainly in HSR prices for both air and car users in forming their mode shift intentions to HSR, suggesting a need for providing HSR pricing information in the US.

6. Conclusions

Mediation, moderation, and moderated mediation analyses were performed to understand the effect of intrinsic and extrinsic factors and HSR characteristics on the intention to shift from air or cars to HSR in the US. Three major conclusions can be drawn from the study. First, intrinsic factors of pro-environmental attitudes, habits, and personal values significantly mediated the relationship between extrinsic, normative influence and mode shift intentions, with pro-environmental personal values and attitudes being the strongest mediators for travelers switching from air to HSR and from cars to HSR, respectively. Pro-environmental habits had little mediating effect on mode shift intentions for both traveler groups. Second, the effect of HSR price, travel time, and service frequency on mode shift intentions toward HSR was enhanced by the safety and convenience consideration only for those who intended to switch from air to HSR. However, motivation to try out a new ridership experience was a significant moderator for both air and car users. Thirdly, while pro-environmental attitudes mediated the relationship between HSR characteristics and intentions to switch from air or cars to HSR, its mediating effect depends upon the level of HSR information available to travelers in the US, especially when HSR price is involved.

This study made three theoretical contributions. First, while key factors influencing HSR intentions have been widely studied, environmental-related factors' impact has received limited academic attention. By incorporating pro-environmental, intrinsic, and extrinsic factors, the findings of this study can provide deeper understanding of travelers' intentions toward HSR. Second, most studies examined the direct influence of key factors on HSR intentions and behaviors, which oversimplified the decision process in using HSR. The forming of HSR intentions is complex, often driven by multiple factors interacting with one another. This study adds to the knowledge of travelers' intentions toward HSR by incorporating mediation, moderation, and moderated mediation analyses. Lastly, while extensive literature examined mode choice behaviors involving HSR, there needs to be more research focusing on mode shift toward HSR especially in the new HSR markets. The present study focused on travelers who preferred air or cars in the current market and their decisions to switch to HSR, which expanded the HSR literature in the US, where HSR is still a new phenomenon.

At the practical level, the findings can inform policy-making for HSR in the US. First, this study found that social norms influence travelers’ decisions to shift from air or cars to HSR and further indicated that part of the normative influence was operated via intrinsic factors, especially travelers’ pro-environmental attitudes and personal values. Thus, positive social norms should be developed to promote eco-friendly transportation by enhancing the awareness of green travel and

providing role models for moving away from polluted air and car transport to eco-friendly transportation modes. Knowing the strong mediating effect of pro-environmental attitudes and personal values, efforts should be made to foster positive attitudes toward green travel and relate personal values closely to eco-friendly transportation. Changing personal values is more challenging but could be achieved through environmental education to integrate environmental consciousness and responsibility into the travelers' value system. Second, the findings indicated that air and car users in the US intend to shift to HSR not only because of the price, travel time, and service frequency considerations but also because they were curious to try a transport mode newly introduced to the market. Whether or not this curiosity-motivated mode shift would slowly fade, disappear, or change into something different is unknown. The finding is particularly important given the lack of HSR ridership experience in the US. It is necessary to monitor public interest in HSR continuously. More importantly, effort should be made to improve and promote HSR prices, safety, and service frequency to achieve long-term success of HSR in the US. Lastly, the finding indicated that HSR information moderated the mediating effect of pro-environmental attitudes in the relationship between HSR characteristics and mode shift intentions, highlighting the need to increase HSR information in the US. The price information is particularly important as it can drive mode shift intentions of both air and car users in the current market. The US can learn from international experience in developing its HSR pricing system and communicate the information with the public to prepare for the upcoming HSR operations in the US.

This study has some limitations. The convenience sampling, although allowing for quick data collection, made it difficult to generalize the results to a larger population in the US. Another limitation was related to the model development. The mediation, moderation, and moderated mediation analyses were performed on the relationship between a single IV and the DV, representing a simplified scenario of mode shift intentions in the US. Several future research directions can be explored. One avenue involves delving into more complex model building, incorporating multiple factors into the model to examine not only the effect of a single IV on the DV but also interactions of multiple IVs and the mediation and moderation analyses involving these factors collectively. Additionally, a longitudinal study can be conducted to test the mode shift intention of US travelers toward HSR at multiple points in time following the commencement of HSR operation in the US. The comparison can provide deeper insights into the mode shift intentions in the busy transport market in the US, incorporating the time factor to identify useful patterns and trends.

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Appendix 1

Correlation between Factors.

Mode shift from air to HSR:

	AT	HA	VA	SN	DN	SI	HS	PR	TT	SA	FR	CO	IN
AT	1												
HA	.674**	1											
VA	.802**	.802**	1										
SN	.797**	.777**	.852**	1									
DN	.759**	.786**	.824**	.873**	1								
SI	.615**	.598**	.643**	.616**	.635**	1							
HS	.521**	.442**	.475**	.497**	.475**	.378**	1						
PR	.594**	.482**	.546**	.535**	.516**	.476**	.501**	1					
TT	.600**	.439**	.527**	.537**	.530**	.478**	.462**	.698**	1				
SA	.604**	.473**	.533**	.532**	.503**	.459**	.498**	.710**	.707**	1			
FR	.543**	.459**	.520**	.544**	.506**	.469**	.511**	.669**	.710**	.670**	1		
CO	.530**	.448**	.497**	.502**	.484**	.482**	.485**	.623**	.664**	.720**	.661**	1	
IN	.699**	.817**	.801**	.813**	.843**	.616**	.455**	.486**	.493**	.491**	.487**	.453**	1

Notes: **=significant at p< 0.05. AT=Pro-environmental Attitudes; HA= Pro-environmental Habits; VA=Pro-environmental Personal Values; SN=Subjective Norms; DN=Descriptive Norms, SI=Mode Shift Intention to HSR; HS=HSR Stimulus; PR=HSR Prices; TT=Travel Time; SA=Safety; FR=Service Frequency; CO=Convenience; IN=HSR Information.

Mode shift from cars to HSR

	AT	HA	VA	SN	DN	SI	HS	PR	TT	SA	FR	CO	IN
AT	1												
HA	.717**	1											
VA	.746**	.839**	1										
SN	.786**	.820**	.852**	1									
DN	.761**	.766**	.800**	.848**	1								
SI	.743**	.651**	.743**	.780**	.791**	1							
HS	.315**	.325**	.299**	.295**	.259**	.244**	1						
PR	.662**	.476**	.516**	.546**	.584**	.570**	.198**	1					
TT	.589**	.405**	.439**	.452**	.493**	.554**	.254**	.755**	1				
SA	.667**	.450**	.476**	.521**	.556**	.578**	.233**	.784**	.773**	1			
FR	.632**	.495**	.509**	.532**	.569**	.579**	.292**	.794**	.800**	.783**	1		
CO	.631**	.462**	.493**	.513**	.563**	.550**	.233**	.762**	.783**	.797**	.778**	1	
IN	.708**	.782**	.730**	.802**	.875**	.704**	.306**	.544**	.462**	.513**	.546**	.527**	1

Notes: **=significant at p< 0.05. AT=Pro-environmental Attitudes; HA= Pro-environmental Habits; VA=Pro-environmental Personal Values; SN=Subjective Norms; DN=Descriptive Norms, SI=Mode Shift Intention to HSR; HS=HSR Stimulus; PR=HSR Prices; TT=Travel Time; SA=Safety; FR=Service Frequency; CO=Convenience.

Appendix 2

Likert Scale Items Measuring AT, VA, HA, DN, IN, and SN and Reliability Testing.

Factor			α (Air-HSR)	α (Car-HSR)
AT	AT1	Eco-friendly travel is a wise thing to do	.785	.852
	AT2	Eco-friendly travel is beneficial		
	AT3	Eco-friendly travel is a pleasant experience		
	AT4	Eco-friendly travel contributes to better environment		
	AT5	AT5. Engaging in eco-friendly travel makes me happy		
	AT6	Eco-friendly travel gives me peace of mind		
	AT7	I'm in favor of eco-friendly travel		
HA	HA1	I engage in eco-friendly travel without having to consciously remember	.796	.822
	HA2	During a trip, I engage in eco-friendly behaviors without thinking		
	HA3	I have developed a habit of driving less and using public transport more		
	HA4	It makes me feel weird if I do not use eco-friendly travel		
	HA5	Eco-friendly commuting is my daily routine.		
	HA6	I use eco-friendly travel regularly for a long time		
VA	VA1	I feel morally obliged to do whatever I can to minimize my environmental footprint	.781	.846
	VA2	Damaging the environment is against my values		
	VA3	Protecting environment when traveling is anchored in my value system		
	VA4	Choosing eco-friendly travel is my responsibility based on my values		
	VA5	I will choose eco-friendly travel no matter what others would do		
	VA6	I become a better person if I engage in eco-friendly travel		
DN	DN1	My selection of eco-friendly traveling options is influenced by others' actions.	.780	.860
	DN2	People who are important to me take care of the environment when traveling		
	DN3	Many of my friends choose eco-friendly travel		

	DN4	I follow other people's eco-friendly acts in a trip		
	DN5	People around me make concrete efforts in reducing carbon footprint		
	DN6	Those who take solid environmental actions are a good role model for me		
SN	SN1	People who are important to me think I should choose eco-friendly travel	.791	.830
	SN2	People whose opinion I value think I should choose eco-friendly travel		
	SN3	People who impact my behaviors think I should choose eco-friendly travel		
	SN4	The discussion of low-carbon travel has a great influence on me		
	SN5	I'm constantly reminded to be environmentally conscious while traveling		
	SN6	I will choose eco-friendly travel if my friends encourage me to do so.		
IN	IN1	HSR information is frequently updated in the US	.809	.861
	IN2	Information of HSR is well-communicated in the US		
	IN3	I often obtain HSR information from government releases		
	IN4	Public information of HSR is easy to find		
	IN5	I often obtain HSR information from interpersonal network (such as family, friends, co-workers and classmates)		
	IN6	I often obtain HSR information from social media platforms		