Do pro-environmental attitudes affect the adoption of flying cars?

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Abstract. The decarbonization of the transportation sector requires the adoption of low-carbon power sources and technological progress in vehicles' energy efficiency. Flying cars constitute innovative transport modes that have exploited technological advancements such as electrification to provide a more sustainable urban and inter-urban landscape. Existing literature has focused on the technical characteristics, while few studies have investigated flying cars in terms of their environmental footprint. In tandem, research on the adoption of flying car and its relationship with their environmental aspects is still scarce. This paper aims at enhancing the current literature by investigating whether end-users environmental attitudes might affect their perception towards flying cars. To achieve this, a questionnaire survey was conducted gathering attitudes and perceptions regarding flying cars from 202 people. The collected data are used to estimate a regression model explaining the effect of their pro-environmental attitudes on their perception towards flying cars. Results indicate that flying cars' perceived environmental footprint and low income affect negatively the perception towars them, while females seem to be more positive with this concept.

Keywords: flying cars, air taxis, environmental attitudes, environmental footprint

1. Introduction

The decarbonization of the transportation sector requires the adoption of low-carbon power sources and technological progress in vehicles' energy efficiency (Sutherland, 2019). The aerial vehicles that are known as flying cars or air taxis, and also referred to as electric vertical landing and take-off vehicles (eVToLs), are innovative modes that could contribute to decarbonizing the transportation sector. Existing literature has focused on the technical characteristics of air taxis, while few studies have investigated them in terms of their environmental footprint. A recent study indicated that traveling a 100-km distance by flying cars would result in less than 52% greenhouse gas emissions than traditional ground vehicles and 6% less than ground electric battery vehicles (Kasliwal et al., 2019). Other than that, the literature includes studies that have focused on the technical characteristics of eVToLs (McCormick, 1967; Zhou et al., 2020), while some studies have investigated demand analysis for flying cars (Rajendran, and Shulman, 2020; Peeta et al., 2008) and factors affecting attitudes and perception towards them (Lee et al., 2019; Al Haddad et al., 2020). In addition, some researchers analyzed individuals' willingness to use (Rajendran and Srinivas, 2020) and pay (Eker et al., 2020) for air taxis as well as the future sustainable business models for their implementation (Price et al., 2020). Few researchers have studied the aerial vehicle concept in terms of the policy insights related to infrastructure requirements (Fadhil et al., 2019) and environmental footprint (Kasliwal et al., 2019), while the research field of safety and security issues regarding air taxis is under-researched (Garrow et al., 2019; Cokorilo, 2019).

As the technological development of air taxis evolves, it is of utmost importance to provide adequate information on the factors that affect their adoption by end-users. These might include end-users' socio-economic charasteristics, current habit and attitudes. For instance potential user's affinity to automation, usage of online services, social media and adoption of sharing activities have positive impact on the adoption, in contrast with data concerns, environmental and safety concerns which present negative influence. (Al Haddad et al., 2020). Pro-environmental attitudes have been documented as an important factor affecting end-users' adoption for innovative transport modes (Al Haddad et al., 2020). For example, a study conducted by Ahmed et al. (2021) indicates that people who are more aware of air taxis environmental benefits would be more willing to hire autonomous flying cars.

On these rounds, the aim of the paper is to explore individuals' attitudes and perceptions towards air taxis and examine whether perceived environmental attitudes related to air taxis as well as socio-economic characteristics could explain future adoption of flying cars.

2. Methodology and data

2.1. Survey design and data

This survey is part of a wider research that aims to investigate the implementation of flying cars in Greece, through the execution of end-users' surveys, as well as in-depth interviews with related stakeholders. This paper focuses on the questionnaire survey which was conducted to gather data on individuals' attitudes, perceptions and preferences towards flying cars. As part of the survey,

environmental attitudes and perceptions towards air taxis were collected. The study was designed in two languages, English (EN) and Greek (GR), to collect information from both Greek and foreign people. The questionnaire was distributed to potential participants through the social media and generated 202 individual responses, with 85.6% of the sample size residing in Greece (172 individuals), around 10% in other European countries (20 individuals), including France, Belgium, Spain, The Netherlands, the United Kingdom, Luxemburg, Slovenia, Germany, and Cyprus. The rest (10 responses) were scattered outside Europe between the US, Canada, Singapore, and Australia. Table 1 presents the descriptive statistics of the 202 individuals that participated in the survey. The sample is almost equally distributed in terms of gender with 53% females and 44.1% males, while the average age is 35.5 years old, with no difficulty to travel due to physical or health limitations (97.5%). Most of the participants hold a bachelor's degree (45%) or more (MSc and Ph.D. ~ 30.7%), while the majority of them are full-time employed (49%) or students (21.3%). Half of them are living in a city center, while most of them earn more than 9,100 euros per year before tax (49.9%). The majority live in a household with no children (86.1%), at least an adult (88.6%), and have access to at least a car (78.3%).

Table 1. Descriptive statistics of the sample (N=202 respondents)

Variable	Category	%
Age	*Mean age*	35.5 years
Gender	Female	53.0%
	Male	44.1%
	Another	1.5%
	I prefer not to answer	1.5%
Educational level	Less than high school	1.0%
	High school graduate	17.8%
	Vocational	5.4%
	BSc degree	45.0%
	MSc or Doctorate	30.7%
Employment Status	Full-time employed	49.0%
	Part-time employed	5.0%
	Student	21.3%
	On furlough	4.5%
	Retired	9.9%
	Unemployed	7.9%
	Other	2.5%
Annual income before tax	Less than 9,100	41.1%
	9,100 to 16,800	22.3%
	16,801 to 25,200	17.8%
	25,201 to 33,600	7.9%
	33,601 and more	10.9%
Difficulty to travel	No	97.5%
Area of residence	City center	51.0%
	Urban area	35.6%
	Suburban area	7.9%
	Rural area	1.5%
	Island	4.0%
Adults in household	No adult	11.4%
	One adult	27.2%
	Two adults	32.7%
	Three and more adults	28.8%
Children in household	No children	86.1%
	One and more children	13.9%
Available cars in household	No car	21.8%
	One car	41.1%
	Two and more cars	37.2%

2.2. Factor analysis and regression model

To explore how the individuals' perception towards air taxis is affected by their associated environmental impact, a linear regression is developed. First, factor analysis is conducted to construct the dependent and some of the independents variables based on the attitudinal questions. Using the exploratory factor analysis attitudes clustered to variables with high explanatory power. In particular, the dependent variable is contructed as the positive perception of people towards air taxis (POSPERC), based on the attitudinal questions: *"I believe that air taxi will benefit the society"*, *"I believe that air taxi will improve the accessibility of remote areas"* and "*I trust air taxi"*. The independent variables of the regression model include socio-economic variables such as age, income and gender, as well as a latent variable that represents people's perception towards air taxi's environmental footprint and eco-related beliefs (ENVFOOTPRINT). This variable is constructed by using the attitudes: *"Air taxis contribution to noise pollution concerns me"* and *"A sky with a lot of air taxis concerns me"*, *"I am worried about climate change"* and *"I am willing to change my mobility choices due to my environmental concerns"*. In addition the Kaiser-Meyer-Olkin Measure of Sampling Adequacy was test to estimate the proportion of variance in the chosen variables. Both latent variables, presented high values more than 0.5 (POSPERC = 0.632 and ENVFOOTPRINT = 0.565) which generally indicate that the factor analysis is useful.

3. Results

3.1. Descriptive analysis

The attitudinal questionas were presented to the respondents through specific statements and they were asked to score them in a 7-point Likert scale from 1 to 7, where 1 means that they Strongly Disagree with the statement and 7 mening that they Strongly Agree with it. Figure 1 depicts the nine pro- and related to air taxis environmental attitudes and the corresponding response statistics. Overall, individuals are worried about climate change (97%), while the majority of them accept the fact that modern society causes pollution (92.1%). Most of the participants seem to agree with the principle "the polluter pays" (75.3%), and are willing to change their mobility choices due to their environmental concerns (91.2%). Regarding the recycling actions, a large percentage of participants recycle (81.7%) and even more prefer recyclable products (84.7%). Focusing on the potential environmental drawbacks, the respondents agree that air taxis might contribute to noise pollution (71.8%), while

fewer people are concerned about the potential visual pollution caused by uncontrolled air taxis operations (59.3%). Furthermore, almost two-thirds (66.3%) consider that air taxis will benefit society. Finally, the respondents seem to be reluctant towards environmental concerns that could stimulate individual's to use air taxis, with less than a quarter of the sample being neutral, 14.8% negative, and the rest positive (61.3%).

3.2. Regression model results

The estimated results of the linear regression model are presented in Table 2. All coefficients are statistically significant (at 0.01 level) and the results (in terms of the signs of the coefficients) are in line with our expectations. More specifically, females seem to have a positive perception towards air taxis, while regarding the magnitude of the estimated coefficient of age, it was found that it plays a subtle role, indicating that older individuals are those you have positive perception towards flying cars. On the contrary less than 9,100 annual income seem to have a major negative contribution on the dependent variable. This could possible be explained since the mobility budget comes second in a row of basic human needs. Furthermore, as expected, the coefficient of the latent variable "ENVFOOTPRINT" indicates that people who generally are conscious about enviromentall footprint either with daily activities or mobility choices seem to be have negative influence on flying cars positive perception.

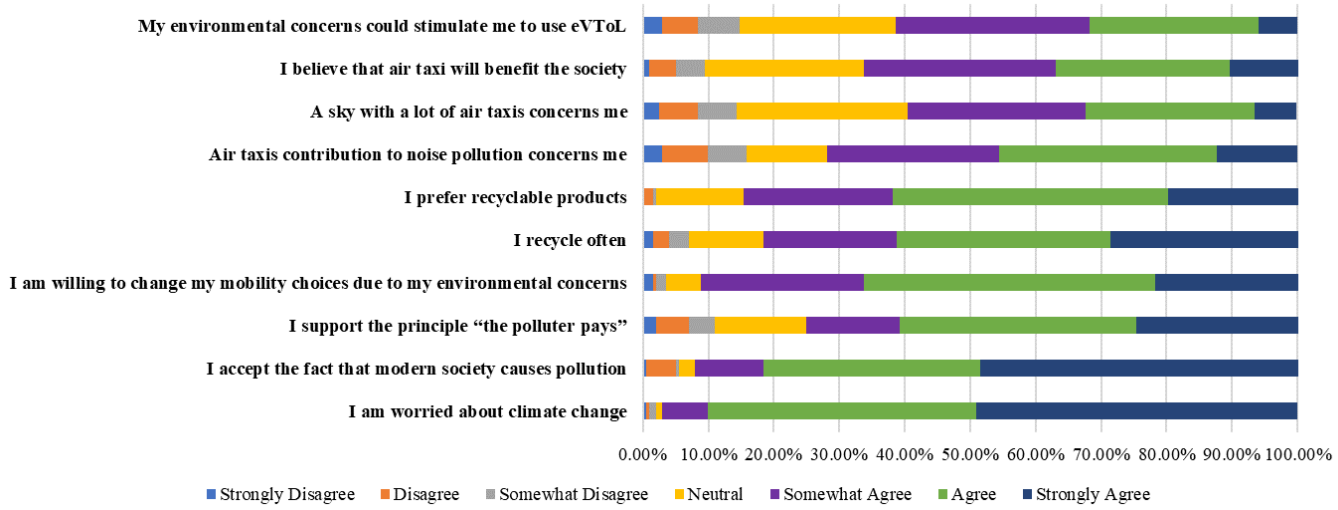

Figure 1. Pro- and related to air taxi attitudes.

Table 2. Regression estimation results

	Coefficients	*t Stat*
Intercept	-0.601	-2.632
Age (scale)	0.017	3.339
ENVFOOTPRINT (latent)	-0.312	-4.891
Female (dummy)	0.299	2.360
Income (dummy; 1 = less than 9,100 annualy)	-0.347	-2.408

4. Discussion

This paper explored end users' perception towardas flying cars through an online survey that gathered 202 respondents mostly from Greece. The data analysis highlighted specific socio-economic parameters and attitudes that play a major role in perception towards flying cars. Using the exploratory factor analysis some attitudes clustered to variables with high explanatory power, such as the positive perception towards taxis and air taxis' environmental footprint, and following a regression model was estimated to quantify their effect. The findings of this work might contribute to the overall challenge of promoting end-users trust and confidence in the use of these aircraft, while the industry moving from design to demonstration flights (Winter et al., 2020). Insights might also be useful for policymakers and actors that could be potential actors in the emerging technology ecosystem.

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