Are air travellers willing to pay for reducing or offsetting carbon emissions? Evidence from Italy

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ABSTRACT

The aviation industry is one of the fastest-growing sectors in producing carbon emissions. In order to reduce its carbon footprint and to respond to the increasing number of people concerned about the impact caused by air transport on climate change, the International Civil Aviation Organization (ICAO) has recently passed the "carbon neutral growth from 2020" resolution requiring that the global net CO_2 emissions from international aviation do not exceed the 2019–2020 levels. Airlines, however, can act beyond their obligations under the ICAO resolution investing in projects aimed at reducing or offsetting all the emissions produced not only by their international flights but also by their domestic flights. The aim of this paper is to test whether Italian air travellers would be willing to donate a contribution to finance these projects and whether the willingness to pay depends on the projects' type and on the projects' effectiveness. To this aim we performed a stated-choice experiment involving a sample of 1228 Italians who travelled by plane at least once in the last 3 years. We find that their willingness to pay ranges from €12 to €38 per ton and from €14 to €66 per flight. The description of the project type to be financed via the passengers' donations is one of the most important factors influencing their willingness to pay. Other key factors are the quantity of CO_2 reduced or offset via the project and the respondents' gender, education degree, occupational status, environmental consciousness and travel habits. Our results are useful for airlines to design the donation proposals and improve the corporate image and for policy makers to support air travellers' environmental conscious behaviour and airlines' environmental sustainable strategies.

1. Introduction

Civil aviation accounts for 4–5 per cent of global total greenhouse gas emissions (Lee et al., 2010; Peeters and Williams, 2012; Larsson et al., 2018), 65 per cent of which are due to international aviation (Sims et al., 2014). Although the absolute value is relatively small compared to other transport modes (e.g. road transport), the emissions per passenger km are much higher, 170 g CO_2eq by plane vs. 50 g CO_2eq for a long-distance trip by car (Kamb and Larsson, 2019). Moreover, although only a very small number of people participates in air travel, in the last decade the aviation contribution to CO_2 emissions has grown at an annual rate of 1.8 per cent. Cames et al. (2015) forecast that aviation share in global CO_2 emissions may rise to 22 per cent by 2050 if action to combat climate change is postponed.

These trends have several consequences. On the one side, the number of air travellers concerned with the environmental impact of

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their transport choice is growing, as well as their support for policies increasing the cost of flying, incentivizing airlines to cut air emissions and to reduce subsidies (Gössling et al., 2020). On the other side, some European policy makers have turned their attention to the environmental sustainability of the air transport sector and have started taking action. In Sweden, since April 2018, a new ticket tax has been levied both for short-distance (€6) and for medium- (€25) and long-distance (€40) flights, while in the Netherlands the government has recently voted to re-introduce, starting from 2021, a €7 tax on all air tickets. The Dutch government has also proposed the introduction of a Europe-wide tax on flying to reduce the environmental impacts of air travel while avoiding competition distortions among European airports.

Within this context of increasing environmental consciousness shared not only by air travellers and policy makers, but also by airlines, the International Civil Aviation Organization (ICAO) approved the "carbon neutral growth from 2020" resolution, which aims at limiting the global net CO_2 emissions from international aviation within the 2019–2020 levels. In March 2017, ICAO adopted a new aircraft CO_2 emissions standard (Volume III to Annex 16 of the Chicago Convention) that defines the measures to be implemented to achieve this goal, including alternative fuels, operational improvements and energy efficient aircraft technologies (Becken and Pant, 2019; ICAO, 2019). These measures, however, will not suffice, at least in the short and medium run, since aircraft fuel efficiency increases annually at 1 to 2 per cent, while traffic is forecasted to grow at 5 per cent per year (ICAO, 2018). Therefore, to complement airlines' commitment to technological, operational and infrastructural improvements, ICAO has also introduced a mandatory market-based offsetting mechanism, the Carbon Offsetting and Reduction Scheme for International Aviation (CORSIA). According to CORSIA, airlines can compensate the emissions that exceed their 2019–2020 baseline levels by purchasing a quantity of eligible emissions units certifying an equivalent reduction, avoidance, or sequestration of carbon emissions produced outside the international aviation sector. The effectiveness of this mechanism, however, is controversial due to the information asymmetry between project participants and regulators. Another debated issue is that it could incentivise policy makers in host countries not to implement policies or regulations to address CO_2 emissions or to credit activities that are not additional but implemented due to policies or regulations. There is also uncertainty on the quantity of emission reductions and on how long the projects will reduce emissions (Cames et al., 2016). To deal with these problems and select the eligible programmes a Technical Advisory Body has been appointed.[1]

Nevertheless, the "carbon neutral growth from 2020" resolution limits the global net CO_2 emissions only with respect to international aviation and only with reference to the 2019–2020 base levels. To go beyond these mandatory obligations pursuing on a voluntary basis the goal of net-zero carbon emission flights, airlines could also propose air travellers to donate a contribution to further reduce or compensate the emissions produced. The studies published so far on the willingness to pay of air travellers to reduce or offset carbon emissions have provided estimates that span over such a large range of values to be of little help for airlines willing to design the donation proposals for their customers. Several reasons explain such a high variability. The samples selected frequently do not include only air travellers. No studies, except Brouwer et al. (2008) and Lu and Shon (2012), are pivoted around the last flight type taken by the respondents, amplifying the hypothetical bias problem. Most studies analyse the preferences with respect to a hypothetical flight that is fixed either in the distance travelled or in the origin and destination of the flight, limiting the transferability and the comparability of the results obtained. Most of the choice experiments do not include the "no choice" option, a methodological weakness which might lead to unrealistic responses (Dhar and Simonson, 2003; Beck et al., 2016). An additional source of heterogeneity deals with the methodology used to collect the data, online vs. via face-to face surveys.[2] Moreover, few papers explicitly analyse whether the willingness to pay is influenced by the type of project to be financed.[3] Finally, almost all studies are based on at least 5 year-old surveys, whereas the awareness of the environmental impact caused by air transport has significantly increased during the last few years, potentially changing air travellers' willingness to pay.

To overcome these shortcomings and to provide an update to the existing estimates, we deemed it worthwhile to investigate the willingness to pay of Italian air travellers, whom, to the best of our knowledge, have never been studied before. To this aim, we interviewed face-to-face 1228 Italian air travellers and we studied which factors influence their willingness to pay. We focused on the type of project (aimed at reducing rather than at offsetting carbon emissions), the effectiveness of the project (expressed in terms of percentage of CO_2 emissions reduced or offset), the respondents' travel behaviour (travel purpose, distance travelled, and frequency), their socio-demographic characteristics and their environmental consciousness. The results expressed in terms of willingness to pay per ton and per flight type (domestic, continental and intercontinental) will help airlines designing the donation proposals.

Although our research builds on the existing literature, it adopts a mix of methodological measures that was never used before in a single research focused on this topic. With reference to the sample selection, we have interviewed only air travellers. Moreover, our

[1] According to the criteria set by the Technical Advisory Body the emissions units are eligible if they are additional; based on a realistic and credible baseline; quantified, monitored, reported, and verified; have a clear and transparent chain of custody; represent permanent emissions reductions; assess and mitigate against potential increase in emissions elsewhere; are only counted once towards a mitigation obligation; do no net harm. In March 2020 the Technical Advisory Body approved six eligible programmes, the second programme call ended April 2020.

[2] Both methodologies have pros and cons. Online surveys allow respondents more time to think about the proposed items and are particularly appropriate for those segments of the population that are increasingly purchasing airline tickets online. Face-to-face surveys allow the interviewer to reach also those segments of the population that would not respond to an online survey, however some bias could be introduced in the survey if the respondents do not get the same type and quantity of information. Therefore, it is important to use a structured questionnaire and to train the interviewers to provide standardized information if requested by participants (Emans, 2019; Saloniki et al., 2019).

[3] Among these papers, only Choi (2015) and Choi and Ritchie (2014) compare projects aimed at reducing carbon emissions and projects aimed at offsetting carbon emissions. Both papers, however, are based on data collected in 2012 from a convenience sample of students and staff of an Australian University, limiting the transferability of the results.

sample includes all age segments and is highly heterogeneous, enabling to detect how the willingness to pay is influenced not only by the socio-demographic characteristics of the respondents, but also by their travel behaviour and their environmental consciousness. With respect to the methodology used to elicit the stated preferences, we perform a choice experiment that includes not only the donation amount, but also the type of project to be financed and its effectiveness in reducing the quantity of emissions produced. Moreover, the hypothetical choice experiments are pivoted around the last flight type taken by each respondent (domestic, continental, intercontinental) increasing the realism of the task but also the transferability of the results obtained. In the literature, there are only two studies adopting such an adaptive approach, but the stated preferences are collected using a contingent valuation experiment. The choice tasks include the "no choice" option increasing the reliability of the results obtained.

The paper is organized as follows: Section 2 reviews the literature. Section 3 describes the questionnaire and the sample interviewed. Section 4 illustrates the econometric strategy and the results obtained. Section 5 discusses the results' implications for the air transport sector, including airlines and policy makers, draws some conclusions and presents some directions for future research.

2. Literature review

The number of papers focusing on air travellers' willingness to pay to reduce or offset the carbon emissions produced is not particularly large because only few airlines actually offer their customers the possibility of donating a voluntary contribution and this market is still in its initial phase (Table 1). The majority of the studies are in Europe, four in Australia and three in Asian countries (Taiwan and Malaysia). Surprisingly there are no studies for the USA. The most recent paper is based on data collected in 2017 (Sonnenschein and Smedby, 2018), while all the other studies were performed before 2015. A minority of the surveys interviewed only air travellers performing face-to-face interviews at an airport, with the exception of MacKerron et al. (2009) and Hinnen et al. (2015) who interviewed air travellers using an online survey. All the other studies are based on convenience samples (e.g. students and staff of universities, government employees) or panels of the national population and are carried out via online surveys.

Only Sonnenschein and Smedby (2018) and Brouwer et al. (2008) analyse the willingness to pay for a mandatory contribution, all the others study the willingness to pay for a voluntary contribution. Half of the papers focus on the willingness to pay per flight, while the other half analyse the willingness to pay per ton. Among the former, Araghi et al. (2016) ask the respondents to imagine booking an economy class return flight from Amsterdam to New York. Also Jou and Chen (2015) frame the experiment with reference to a specific hypothetical flight, that is an economy class flight from Taiwan to Hong Kong. Hinnen et al. (2015), instead, refer to a four-hour flight in economy class with a ticket of CHF 500 without mentioning the origin and destination of the flight. Choi (2015) and van Birgelen et al. (2011) broadly distinguish between short- and long-haul flights, while Cheung et al. (2015) refer to a flight producing 3 ton of CO_2 without mentioning the distance travelled or the flight type (domestic, continental, intercontinental). Fatihah and Rahim (2017) do not give any details on the distance, the travel time or the quantity of CO_2 produced by the flight. None of the studies estimating the willingness to pay per flight pivots the experiment around the last flight type taken by the respondent. In all the studies analysing the willingness to pay per flight the values proposed are additional to the ticket price except for Araghi et al. (2016) who use ticket price values including the offsetting cost. In the experiments we have reviewed, the values proposed to the respondents to offset the carbon emissions produced per flight range from €0.1 (Jou and Chen, 2015) to €45 (Choi, 2015).

Among the papers analysing the willingness to pay per ton, only the study by Brouwer et al. (2008) and by Lu and Shon (2012) frame the contingent valuation experiment with reference to the last flight taken by the respondent. MacKerron et al. (2009) ask the respondents to imagine booking a flight from New York to London but do not mention the quantity of CO_2 produced. Blasch and Farsi (2014, 2012) ask the respondents to imagine booking a flight producing 3.6 ton of CO_2 but omit the description of the origin and the destination of the flight or the distance travelled. Choi et al. (2018) use two versions of the questionnaire, one focused on hypothetical domestic flights and the other one on international flights, while Choi and Ritchie (2014) use both flight types in each choice task. In both cases, the quantity of CO_2 produced by each flight type is depicted; however, no mention is made of the origin and destination of the flight. Sonnenschein and Smedby (2018) broadly distinguish between short- and long-haul flights but do not mention the quantity of CO_2 produced. Schwirplies et al. (2017) do not give any details on the distance, the travel time or the quantity of CO_2 produced. MacKerron et al. (2009), Blasch and Farsi (2014, 2012), Schwirplies et al. (2017) and Sonnenschein and Smedby (2018) propose values per ton, while all the others propose values per flight. All these studies express the values as additional to the ticket price. The values proposed per ton range from €2 (Lu and Shon, 2012) to €95 (Sonnenschein and Smedby, 2018).

The criteria chosen to select the values proposed significantly differ among the studies. Sometimes they are based on the price of the specific flight analysed in the experiment (Araghi et al., 2016; Jou and Chen, 2015) or on the real offset payments offered by airlines (Choi, 2015; MacKerron et al., 2009), with the drawback of anchoring the values proposed during the experiment to reference values which might significantly differ from the willingness to pay of the respondents. In other cases, the values are derived from the market prices of voluntary carbon offsets (Blasch and Farsi, 2014, 2012) or from the CO_2 transaction price per ton (Lu and Shon, 2012; Sonnenschein and Smedby, 2018), a methodological approach which is more consistent with the value to be estimated. In some other papers the description of the criteria used is not provided.

Only one study (MacKerron et al., 2009) uses both choice and contingent valuation experiments, all the others use only one of the two methodologies. There is an equivalent number of papers using each methodology; however, most of the choice experiments are carried out via online surveys. The contingent valuation experiments describe only the bids that are proposed to the respondents, with the exception of Choi (2015), who mentions also the project type and location, and MacKerron et al. (2009), who describe also the project co-benefits including conservation and biodiversity and technology and market development. In the choice experiments the description of the alternatives proposed to the respondents includes also other attributes including the location of the project (Schwirplies et al., 2017), the type of organization implementing the project (Blasch and Farsi, 2012, 2014), the type of airline eco-

Table 1
Literature review methodology.

Authors	Country	Period	Sample selection	Methodology	Attributes and values proposed
Araghi et al. (2016)	NL	2013	Air travelers at Schiphol and Rotterdam airports	Face-to-face; CE: nine choice tasks; three alternatives per task; unlabeled flight type	Flight ticket price (€505; €525; €545); Carbon reduction (0%, 50%, or 100%); Luggage allowance (10, 15, and 20 kg); Airline eco-efficiency label (green airline; fuel-efficient airline; gray airline)
Blasch and Farsi (2014, 2012)	CH	2011	Panel of Swiss aged 14 or older	Online survey; CE: eight choice tasks; three alternatives per task plus no choice option	Price €/ton (5; 11; 17; 22; 28; 34); Project type (renewable energy; re-/afforestation; energy efficiency); Location (developing; industrializing); Carbon offset (3.6 ton for air travel); Provider type (for-profit; non-profit); Certification (Swiss gov.; NGO; UN; no certification); Activity (air travel; space heating; hotel stay; car rental)
Brouwer et al. (2008)	NL	2006	Air travelers at Schiphol Airport	Face-to-face; CV: double-bounded dichotomous choice	Bids proposed ranging from €5 to €100 per flight
Cheung et al. (2015)	AU	2014	Panel proportional to the national population in Australia	Online survey; CE: six choice tasks; three alternatives per task plus no choice option	Price (€7; €17; €34; €52; €69); Project type (renewable energy; forest protection; reforestation); Location (Own state – Australia; another state – Australia; overseas); Protecting native wildlife (yes; no)
Choi and Ritchie (2014)	AU	2012	Students and staff members of the University of Queensland	Online survey; CE: eight choice tasks differentiated for domestic and international flights	Price €/per flight (4; 11; 22; 43); Project type (renewable energy; forest management); Location (domestic; overseas); Carbon offset in ton (0.1; 0.33; 1; 2); Legal effect (reduce carbon tax legal liability); Measures by Airlines (use of biofuels; more efficient technology; more efficient operational practices)
Choi (2015)	AU	2012	Students and staff members of one Australian university	Online survey; CV: 3 questions for each individual; payment ladder	Price (€0; €0.7; €3.7; €7.4; €11; €22; €45); Carbon offset (0.3 ton; 2 ton); Project type (renewable energy; forest management); Location (domestic; overseas); Legal effect (reduce legal liability under the carbon tax policy); Airlines' measures (use of biofuels; more efficient technology; more efficient operational practices)
Choi et al. (2018)	AU	2013	Representative sample of Australian population.	Online survey; CE: six choice tasks differentiated for domestic and international flights	Price €/per flight (0; 1; 4; 7; 11; 22; 43); Project type (renewable energy; forest management); Location (domestic; overseas); Carbon offset in ton (0.1; 0.33; 1; 2); Legal effect (reduce carbon tax legal liability)
Fatihah and Rahim (2017)	MY	2014	Government employees living in Putrajaya (Federal Territory of Malaysia)	Face-to-face; CV: double-bounded dichotomous choice	Flight ticket increased by 3%; 5%; 7%; 9% (value randomly selected for each respondent)
Hinnen et al. (2015)	CH	2014	Swiss air travelers	Online survey; CE (n. tasks unknown); three alternatives per task	Price (€37; €55, €73); Location (not mentioned; India; Switzerland); Meal (standard; premium; organic premium); Hotel transfer (not available; by minivan; by electric minivan); Travel pack (not available; travel pack; green travel pack)
Jou and Chen (2015)	TW	2011	Airline travelers of Taiwan's Int. Airport	Paper-and-pencil; CV: triple-bounded dichotomous choice	Price (€0.1; €0.2; €0.3; €0.6; €0.7; €0.9; €1)
Lu and Shon (2012)	TW	2011	International travelers at Taoyuan Int. Airport	Face-to-face; CV: double-bounded dichotomous choice	Bids ranging from €2 to €68 per flight according to the distance travelled and the estimated carbon emissions.
MacKerron et al. (2009)	UK	2007	International air travelers	Online survey; CV: one dichotomous-choice question; CE: six choice tasks	Price €/ton (5; 11; 16; 22; 27); Project co-benefits (Human development; Conservation and biodiversity; Technology and market development), Certification (present; absent)
Schwirplies et al. (2017)	DE	2014	Representative panel of German consumers	Online survey; CE: six choice tasks; three alternatives per task plus no choice option	Price €/ton (10; 20; 30; 40; 50); Project type (renewable energy; re-/afforestation; energy efficiency); Location (Germany; Europe outside Germany; developing country); Additional provider's contribution (0%; 33%; 100%)
Sonnenschein and Smedby (2018)	SE	2017	Random sample of Swedish adults	Online survey; CV: triple-bounded dichotomous choice	Bids proposed ranging from €9 to €95 per ton
van Birgelen et al. (2011)	NL	n.a.	Students and staff Maastricht University	Online survey; CV: open ended question	Open ended question

Note: CV: contingent valuation; CE: choice experiment.

efficiency label (Araghi et al., 2016). Only few studies, in particular Blasch and Farsi (2012, 2014), Cheung et al. (2015), Choi et al. (2018), Choi and Ritchie (2014), and Schwirplies et al. (2017), specify also the type of project to be financed via the voluntary contribution. The availability of this information, however, critically determines not only the preferences stated by the respondents, but also the usefulness of the results obtained in order to properly design the contribution proposals to be offered to air travellers. Among these few studies only Choi (2015) and Choi and Ritchie (2014) specifically compare projects aimed at improving the aircraft technology or at increasing the use of alternative fuels and projects aimed at forest management. A limited number of papers describe also the quantity of emissions reduced or offset via the donation which is expressed either in percentage terms, from 50 per cent up to 100 per cent (Araghi et al., 2016), or in tons, from 0.1 (Choi and Ritchie, 2014) to 3.6 (Blasch and Farsi, 2014, 2012). Omitting this information limits the transferability of the results and could bias the estimates obtained since the effectiveness of the project and the quantity of emissions reduced or offset could significantly influence the willingness to pay.

In Table 2 we summarize the estimates of the willingness to pay reported in the literature (in 2018 PPP-adjusted values, €). Since the values are based on data collected via different methodologies and refer to different types of flights, projects and samples, they are not directly comparable. All the values reported in the literature, except for the lower bound found by Choi et al. (2018), are positive, showing that air travellers are willing to pay to offset or reduce carbon emissions. The values, however, vary considerably both among the papers and within each research. The estimates of the willingness to pay per flight are as low as €1 for Asian countries (Jou and Chen, 2015; Fatihah and Rahim, 2017) and as high as €113 or €94 for Australia (Cheung et al., 2015) and Switzerland (Hinnen et al., 2015), respectively. Also the estimates of the willingness to pay per ton are highly heterogeneous, with values up to €97 for Germany (Schwirplies et al., 2017) but even negative for Australia (Choi et al., 2018). Only Brouwer et al. (2008) and Sonnenschein and Smedby (2018) study the willingness to pay for a mandatory contribution, obtaining values that are higher than the average.

The socio-demographic characteristics of the respondents are important factors influencing the willingness to pay. Having a higher income level (Akter et al., 2009; Araghi et al., 2016; Blasch and Farsi, 2012, 2014; Brouwer et al., 2008; Cheung et al., 2015; Choi, 2015; Fatihah and Rahim, 2017; 2012;; Schwirplies et al., 2017) and being more educated (Cheung et al., 2015) are positively related to the willingness to pay. Also being female (Choi and Ritchie, 2014; MacKerron et al., 2009; Sonnenschein and Smedby, 2018) and being younger (Blasch and Farsi, 2012, 2014; Fatihah and Rahim, 2017; Lu and Shon, 2012; Schwirplies et al., 2017) are positively linked to the willingness to pay. Travel behaviour plays an important role too, since for short-haul flights the estimated willingness to pay is on average higher (Akter et al., 2009; Brouwer et al., 2008; Choi, 2015; Choi and Ritchie, 2014). The empirical evidence with respect to travel frequency, instead, is mixed: some research studies report a positive relationship (Akter et al., 2009; Araghi et al.,

Table 2
Literature review results.

Authors	N. interviews	WTP per flight	Environmental Consciousness	Travel frequency	Age	Income	Education
Araghi et al. (2016)	261	Average €18		+		+	
Cheung et al. (2015)	527	€6–€112 varying by project, location and respondent type	+			+	+
Choi (2015)	349	€7 with protest bidders; €10 without protest bidders	+			+	
Fatihah and Rahim (2017)	250	Average €1			+	+	
Hinnen et al. (2015)	811	€5–€94 varying by project, location and respondent type					
Jou and Chen (2015)	477	Average €1	+	+			
van Birgelen et al. (2011)	128	€24 short-haul flight; €55 long-haul flight	+				
Authors	**N. interviews**	**WTP per ton**	**Environmental Consciousness**	**Travel frequency**	**Age**	**Income**	**Gender (male)**
Blasch and Farsi (2012, 2014)	1010	€7 (occasional offsetters)–€76 (habitual offsetters)	+	–	–	+	
Brouwer et al. (2008)	400	Average €30 (€12 Asian, €21 Americans, €50 Europeans) [€20–€33 per flight]	+	+		+	
Choi and Ritchie (2014)	349	Average €16		+			–
Choi et al. (2018)	2000	€-1.5–€20 varying by flight distance and respondent type	+				
Lu and Shon (2012)	1339	€ 5–€ 27 varying by flight destination	+		–	+	
MacKerron et al. (2009)	321	€17–€53 varying by certification and project type [€33 per flight]					–
Schwirplies et al. (2017)	1005	Average €42, leisure trip €60, business trip €97	+		–	+	
Sonnenschein and Smedby (2018)	500	€30 (long-haul flight)–€50 (short-haul flight)	+	–			–

Note: values in year 2018 €; Empty cells: estimates not available or insignificant effect; symbol + (−) means a positive (negative) relationship between WTP and individuals' sociodemographic characteristics.

2016; Brouwer et al., 2008; Choi and Ritchie, 2014; Jou and Chen, 2015), while other studies find the opposite result (Blasch and Farsi, 2012, 2014; Sonnenschein and Smedby, 2018). Finally, having a sense of responsibility for the emissions produced travelling by plane, believing that offsetting makes a high contribution to climate protection or being environmental conscious are positively related with the estimates obtained in all the studies that have controlled for these factors. It is also found that the willingness to pay is higher if the project is aimed at reforestation (Akter et al., 2009; Schwirplies et al., 2017) and at increasing the use of renewable energy (Cheung et al., 2015; Choi et al., 2018; Choi and Ritchie, 2014). Higher values of the willingness to pay are found also if the project is certified (Blasch and Farsi, 2012, 2014; MacKerron et al., 2009), is co-financed by airlines (Schwirplies et al., 2017) and is implemented in the respondent's home country (Cheung et al., 2015; Choi et al., 2018; Hinnen et al., 2015; Schwirplies et al., 2017).

3. The questionnaire and the sample interviewed

The survey was conducted in May 2018 with 1228 respondents. All the interviews were administered face-to-face in order to increase the representativeness of the sample, enhance the response rate and better control the quality of the data collected. A team of researchers trained to guarantee the homogeneity of the procedure used to collect the data carried out the interviews. The interviewers used printed questionnaires. The questionnaires differed according to the distance travelled in the last flight taken by the respondents. The choice tasks were printed in cards that were shown to the respondents during the interview. Respondents were selected randomly using a counting design according to which each fortieth person passing in front of the interviewer was asked to participate to the survey (Bell et al., 2019). Only people who had travelled by plane within the last three years were interviewed. The interviews were performed in Friuli Venezia Giulia, a northeastern region of Italy and took place at the Friuli Venezia Giulia airport and at railway and bus stations.

3.1. The questionnaire

We structured the questionnaire into four parts. The first part focused on the respondents' beliefs about climate change, in line with the methodology proposed by Sonnenschein and Smedby (2018), Choi (2015), Hinnen et al. (2015), Jou and Chen (2015), Choi and Ritchie (2014), van Birgelen et al. (2011), Akter et al. (2009) and Brouwer et al. (2008). We asked the respondent to state if s/he believes that climate change is going on and to what extent it is caused by human activities. Previous research (Drews and Van den Bergh, 2016) demonstrated that social-psychological factors and climate change perception, such as environmental values, climate change knowledge, and opinions about climate change increase the propensity to adopt environmentally friendly measures[4]. At the end of the interview, we also asked if the respondent has ever joined an environmental association or if s/he has ever participated in environmental protests seeking to bring recognition of how people, companies, or governments impact the environment. The second part of the questionnaire collected information on the respondent's travel behaviour and asked about the air travel frequency in the last three years, the purpose and destination (domestic, continental or intercontinental) of the last journey travelled by plane, the number of family members accompanying the respondent in the last journey travelled and the chosen airline. In the third part of the questionnaire, six hypothetical choice scenarios were administered to each respondent.

The respondent was invited to imagine that s/he had to take the same type of flight s/he took the last time s/he travelled by plane (domestic, continental or intercontinental) and that s/he was offered the possibility of making a donation aimed at reducing or offsetting the quantity of CO_2 emissions produced during the flight. The values proposed in the choice tasks differed according to the flight type and are described in Table 3. To increase the realism of the hypothetical exercise, we presented to the respondent the average quantity of CO_2 emitted per flight (round trip) per person. Such a quantity is 0.22 tons for a domestic flight, 0.6 tons for a continental flight and 3.3 tons for an intercontinental flight. The quantity of CO_2 reduced or offset could be "small (10%)", "half the quantity produced (50%)" or "large (100%)". The respondents were also informed about the type of projects their donation would be invested in. The funds could be used to finance projects aimed at improving the energy efficiency of the aircraft technology and at enhancing the use of alternative fuels, or to finance afforestation, reforestation and forests protection. We chose these specific types of projects because we wanted to find whether air travellers are more willing to support airlines in their effort to reduce their emissions, or if they prefer to finance projects aimed at offsetting the emissions produced. In some alternatives of the choice tasks, we omitted on purpose the description of the project in order to detect if and to which extent knowing how the donations are used is important for the donors.

We selected the values of the donation to be proposed during the experiment using as a reference value an amount equal to €42 per ton, which is twice the value we obtained in a previous research we conducted on the willingness to pay for a carbon tax in Italy (Rotaris and Danielis, 2019). We assumed that the distance travelled (round trip) is 2000 km for a domestic flight, 5000 km for a continental flight, and 34,000 km for an intercontinental flight. Using the ICAO carbon emission calculator (https://applications.icao.int/icec), we estimated the quantity of CO_2 produced per each flight type by each traveller, which is equal to 0.22 ton, 0.6 ton, and 3.3 ton, respectively. We calculated the quantity of CO_2 corresponding to each percentage of carbon reduction or carbon offset that is: 0.022 ton (10%), 0.11 ton (50%) and 0.22 ton (100%) for a domestic flight, 0.06 ton (10%), 0.3 ton (50%) and 0.6 ton (100%) for a continental flight, and 0.33 ton (10%), 1.65 ton (50%) and 3.3 ton (100%) for an intercontinental flight. Finally, we multiplied each quantity by €42.

[4] As pointed out by an anonymous reviewer it would had been preferable to ask this question after the choice tasks avoiding the risk of influencing the stated preferences and of overestimating the willingness to pay to reduce or offset the emissions produced.

Table 3
Attributes and levels used to describe the hypothetical alternatives proposed during the choice task.

Attributes	Levels
Donation for domestic flights (0.22 ton)	€ 0; € 1; € 5; € 9
Donation for continental flights (0.6 ton)	€ 0; € 3; € 13; €26
Donation for intercontinental flights (3.3 ton)	€ 0; € 14; € 69; €139
Description of quantity of carbon emissions reduced or offset	• small (10%) • half (50%) • large (100%)
Description of the project	• Improvement of aircraft technology and use of alternative fuels • Afforestation, reforestation and forests protection • The description is not provided

The choice tasks were generated using the Ngene software according to the theory of efficient design (ChoiceMetrics, 2018).[5] Efficient designs, unlike orthogonal ones, minimise the asymptotic variance and allow the analyst to obtain robust estimates even with small samples (Bliemer and Rose, 2011). The priors of the variables describing the value of the contribution and of the quantity of CO_2 reduced or offset were set equal to 1 and 21, respectively. We chose these priors because their ratio is consistent with the willingness to pay for one ton of CO_2 we obtained in a previous research on the willingness to pay for a carbon tax in Italy (Rotaris and Danielis, 2019). The prior of the variable describing the projects aimed at technological improvements and alternative fuesl was half the positive value chosen for the attribute describing the projects aimed at afforestation, reforestation and forest protection. This *a-priori* derives from the results obtained by Akter et al. (2009), Jou and Chen (2015), Lu and Shon (2012), Schwirplies et al. (2017) and Sonnenschein and Smedby (2018). According to these authors, the willingness to pay is higher if the project aim is explicitly mentioned and for projects with environmental rather than technological aims. Finally, in order to increase the realism of the hypothetical choice tasks, we included the "no choice" option. We also asked those respondents who always chose the "no choice" option why they were systematically refusing to pay for the projects proposed.

An example of the choice tasks administered during the interviews is illustrated in Fig. 1.

Finally, in the fourth and last part of the questionnaire, we collected data on the socio-demographic characteristics of the respondents, including gender, age, occupational status, educational degree, residential location and family income level. We performed a pilot test to check if the questions were properly asked and to test for a clear understanding of the items proposed. We tested a questionnaire draft with a sample of 30 individuals. After the pilot test, we added a more detailed description of the projects to be financed and a question on the number of family members traveling with the respondent during the last flight taken. Each interview took on average 20 min.

3.2. *The sample*

The sample, comprising 1228 individuals, is representative of the Italian population aged between 18 and 75 with respect to gender and residential location, although younger and more educated people are slightly overrepresented (Table 4). The difference is most probably due to the fact that air travellers are mostly working-age individuals, as reported by the statistics published by the International Air Transport Association (Pearce, 2014); however, since no descriptive statistics are available on the socio-demographic characteristics of Italian air travellers, we cannot further comment on the representativeness of the sample we selected.

Half of the respondents (51 per cent) had flown 1 to 3 times within the last three years, 34 per cent 4 to 9 times and 15 per cent more than 9 times. The majority of the respondents (83 per cent) stated that they already planned to travel by air within the next year. Leisure is the prevailing trip purpose (79 per cent), followed by business (21 per cent). The majority of the sample includes unaccompanied travellers (40 per cent) or individuals travelling with one (29 per cent) or two (14 per cent) other people. Ryanair is the

	Alternative 1	**Alternative 2**	
Voluntary contribution	€ 1	€ 9	
% of CO_2 reduced or offset	Small (10%)	Half the quantity produced (50%)	**None of the two alternatives proposed**
Aim of the project financed with the traveler's' contribution	Improvement of aircraft technology and use of alternative fuels	Afforestation, reforestation and forests protection	

Fig. 1. Example of the hypothetical choice tasks proposed for a domestic flight.

[5] http://www.choice-metrics.com/features.html.

Table 4
Socio-demographic characteristics of the sample and of the Italian population.

	Sample	Italian population
Gender	Male: 51%; Female: 49%	Male: 50%; Female: 50%
Age group	Age 18–25: 18%; Age 26–45: 34%; Age 46–65: 35%; Age 66–75: 13%	Age 18–25: 11%; Age 26–45: 38%; Age 46–65: 37%; Age 66–75: 14%
Education	Middle school: 9%; High school: 47%; Bachelor or Master: 37%; PHD: 7%	Elementary or Middle school: 49%; High school: 37%; Bachelor or Master or PhD 15%
Family income	<= €20,000: 19%; €20,001–€40,000: 44%; €40,001–€100,000: 30%; >= €100,001: 7%	Average family income: € 31,400
Residential location	Urban: 82%; Rural: 18%	Urban: 83%; Rural: 17%

Source: Italian National Institute of Statistics (http://dati-censimentopopolazione.istat.it and https://www.istat.it/it/files/2019/12/Asi-2019.pdf).

mostly used airline (34 per cent), followed by Alitalia (18 per cent) and EasyJet (13 per cent). The destination of the last flight travelled for the majority of the sample is a European city (54 per cent), followed by Italian (24 per cent) and extra-European (22 per cent) destinations. Most of the respondents (91 per cent) believe that climate change is actually taking place and that human activities are the main cause of this phenomenon (86 per cent). Only 8 per cent of the sample (110 people out of 1228) stated that they were not willing to pay for the carbon offset programmes independently from the projects' aim. Half of these so called "protest bidders" justified their refusal by saying that the projects should be financed by the airline companies since they are primary responsible for the pollution emitted.

4. Econometric results and discussion

An econometric analysis of the sample's stated choices has been performed to assess whether and how the sociodemographic characteristics of the respondents, their air travel behaviour, their environmental consciousness and the type of offset project proposed influence their willingness to pay. We initially estimated a Multinomial Logit model (MNL, Table 9, in the Appendix) then, having tested for the parameters' variability, we estimated a Random Parameter Logit model (RPL_1, Table 9, in the Appendix). Afterwards, to better take into account and explain the preference heterogeneity of the respondents, we allowed the means of all the random parameters to differ according to some socio-demographic characteristics and the travel behaviour of our sample (RPL_2, Table 9, in the Appendix). Finally, we relaxed the assumption that the deterministic part of the utility function is linear in the variables describing the choice tasks since it implicitly constrains the variables to have a constant substitutability ratio (Rotaris, et al., 2012). To this aim, we tested and found that the marginal utility of the quantity of CO_2 reduced or offset is smaller for quantities larger than 1.2 tons, and we used for this variable a piecewise linear specification that better suits our data (RPL_3, Table 5). The measurement units and the coding of the variables used to specify the models are described in detail in the Appendix (Table 8). We specified also few interaction terms between the alternative specific constant and the variables representing the respondent's gender, her/his occupational status, the distance travelled during the last flight and the respondent's beliefs about climate change and environmental activism.

For the Random Parameter Logit models the parameters of all the variables describing the choice tasks proposed have been specified as having a random triangular distribution. The triangular distribution has been chosen since it allows to better control for the parameter range and avoids behaviourally unacceptable parameter estimates. Moreover, only for the parameter describing the quantity of CO_2 reduced or offset we used a symmetric constrained triangular distribution in order to keep the entire distribution within the positive range and to simplify the interpretation of the mean of the distribution (as suggested in Scarpa and Alberini, 2005).

Based on the AIC and BIC goodness of fit measures, model RPL_3 fits our data best confirming the need of taking into account the heterogeneity of the sample's preferences and the decreasing marginal utility of the emissions quantity, although this last feature refers only to the RPL_3 model.

With reference to the results reported in Table 5, we find that all the parameters of the variables describing the choice tasks have the expected sign, negative for the donation and positive for the other variables, and are statistically significant. In addition, the range of the parameters' distribution are statistically significant, proving the heterogeneity of the preferences with respect to these variables. For all the random parameters, we specified also some interaction terms capturing the sources of the preferences' heterogeneity. We find that the sensitivity to the value of the donation ("Price" in Table 5) is smaller for the unemployed (compared to students, employed or retired), for people travelling for business (rather than for leisure) and for frequent flyers (travelling more than 9 times in the last three years). The sensitivity to the quantity of CO_2 reduced or offset up to a maximum of 1.2 ton is smaller for men (in line with the results obtained by Sonnenschein and Smedby, 2018, Choi and Ritchie, 2014, and MacKerron et al., 2009). It is also smaller for less educated respondents (similarly to the results of Cheung et al., 2015), for the unemployed, for people travelling for business (similarly with the results of Lu and Shon, 2012), and for frequent flyers (in line with the evidence reported by Sonnenschein and Smedby, 2018, and Blasch and Farsi, 2012, 2014). For quantities of CO_2 over 1.2 ton the value of the parameter is much smaller and is influenced only by the respondent's gender, being smaller for men.

Providing the description of the purpose of the project significantly increases the willingness to pay, in line with our *a-priori*, particularly so if the project is aimed at forest protection and restoration rather than at improving the aircraft technology or at increasing the use of alternative fuels. Men and the unemployed are less sensitive to the description of the project aim if it deals with forestation and reforestation, while respondents having a lower education degree, that is a Middle school certificate, are less sensitive

Table 5
Estimates of the final Logit model (standard errors in brackets).

Description of the explanatory variables and of the estimated parameters	RPL_3
Price (€)	−0.26*** (0.01)
range of Price	0.50*** (0.02)
Price _Unemployed	0.13*** (0.03)
Price _Business traveler	0.03*** (0.01)
Price _High frequent flyer	0.05*** (0.01)
Quantity of CO_2 up to 1.2 ton. (ton)	3.76*** (0.23)
range of Quantity of CO2 up to 1.2 ton.	3.76*** (0.23)
Quantity of CO_2 up to 1.2 ton._Male	−1.36*** (0.23)
Quantity of CO_2 up to 1.2 ton._Middle school certificate	−1.47*** (0.37)
Quantity of CO_2 up to 1.2 ton._Unemployed	−3.07*** (0.48)
Quantity of CO_2 up to 1.2 ton._Business traveler	−0.96*** (0.25)
Quantity of CO_2 up to 1.2 ton._High frequent flyer	−0.64** (0.28)
Quantity of CO_2 over 1.2 ton. (ton)	1.26*** (0.17)
range of Quantity of CO2 over to 1.2 ton.	1.26*** (0.17)
Quantity of CO_2 over 1.2 ton._Male	−0.52*** (0.16)
Forest (vs. no mention of the purpose)	1.68*** (0.13)
range of Forest	3.87*** (0.24)
Forest _Male	−0.27* (0.16)
Forest _Middle school certificate	−0.81*** (0.28)
Forest _Unemployed	−0.94* (0.38)
Technology and fuel (vs. no mention of the purpose)	0.10*** (0.14)
range of Technology and fuel	2.84*** (0.31)
Technology and fuel_Middle school certificate	−0.46* (0.27)
Alternative Specific Constant (ASC)	0.60*** (0.20)
ASC_Student or Employed	0.41*** (0.15)
ASC_Intercontinental flyer	0.57*** (0.19)
ASC_Member of an environmental association	0.40*** (0.17)
ASC_Believe existence of climate change	0.60*** (0.18)
N. Obs.	7368
LL constant only	−775
LL	−5698
AIC	11,474
BIC	11,743
Chi-square	4555
P Chi-square	0.00

Note: *, **, *** indicate statistical significance at the 90%, 95%, and 99% levels, respectively. The full description of the measurement units and of the coding of each variable is described in Table 8 in the Appendix. The variables that are not statistically significant have been removed from the table.

to the description of the project also if it deals with technological and alternative fuel solutions.

The constant is statistically significant and positive, meaning that independently of the quantity of CO_2 and of the specific purpose of the project, there is a willingness to contribute for reducing or offsetting the emissions produced. This positive attitude is larger for students, in line with the results of Schwirplies et al., (2017), Blasch and Farsi (2012, 2014) and Lu and Shon (2012), who found higher willingness to pay for younger people. It is larger also for employed people, as reported by Fatihah and Rahim (2017), Schwirplies et al. (2017), Araghi et al. (2016), Cheung et al. (2015), Choi (2015), Blasch and Farsi (2014, 2012), Lu and Shon (2012), Akter et al. (2009) and Brouwer et al. 2008, who found that higher income levels were positively correlated with higher willingness to pay. A larger willingness to donate a contribution is also found for people travelling long distances (intercontinental flights vs. national or continental flights), for members of environmental associations or individuals who have actively participated in environmental protests, and for people who believe that climate change exists, in line with almost all the studies that have controlled for these factors.

4.1. Willingness to pay per ton of CO_2

Following the methodology proposed by Hensher et al. (2006, 2005), we estimated the parameters of the best fitting model (RPL_3, Table 5) at the individual level and we calculated the willingness to pay for 1 ton of CO_2 for each person interviewed. On the basis of the values obtained we calculated the average willingness to pay of the sample. The average value differs according to the quantity of CO_2, the purpose of the project and if the purpose of the project is mentioned or not. Up to 1.2 ton of CO_2, the average is €24 per ton if no mention is made about the project purpose, €27 per ton if it is aimed at improving the aircraft technology or at increasing the use of alternative fuels and €38 per ton if the project is aimed at afforestation, reforestation and forests protection. For additional quantities of CO_2, the average is equal to €12 per ton if the project purpose is not mentioned and it increases to €16 and €26 in the other two scenarios (Table 6). This result is consistent with the evidence reported by Choi et al. (2018), Sonnenschein and Smedby (2018), Choi (2015) and Choi and Ritchie (2014), who find that the willingness to pay becomes smaller for long–haul flights, hence for larger quantities of CO_2.

Our estimates are within the range of values found by Blasch and Farsi (2014, 2012) and MacKerron et al. (2009) and are slightly

Table 6
Average of individual willingness to pay per ton by quantity of CO_2 reduced or offset and by project purpose.

Quantity of CO_2	Purpose not mentioned	Technology and alternative fuel	Forest protection and restoration
up to 1.2 ton	€24	€27	€38
above 1.2 ton	€12	€16	€26

lower than those obtained by Brouwer et al. (2008) and Sonnenschein and Smedby (2018), most probably because we focus on voluntary contributions and not on mandatory ones. Indeed, as found by Segerstedt and Grote (2016) and Wiser (2007), the willingness to pay is systematically lower for voluntary offsets than for coercive instruments since the latter prevent free-riding and are therefore associated with higher acceptance. However, our estimates are lower than those obtained by Schwirplies et al. (2017) and higher than the values reported by Lu and Shon (2012), Choi and Ritchie (2014) and Choi et al. (2018). The differences might be due to the methodology used to collect the data: we performed a choice experiment instead of a contingent valuation one as Lu and Shon (2012) did. According to Hanley et al. (2001), in fact, values estimated for a whole bundle of characteristics using the contingent valuation approach are lower than the sum of the value of each characteristic estimated via choice experiments. The differences could also be due to the metric used to express the willingness to pay: euro per percentage of carbon offset in our case study, euro per ton in the study by Schwirplies et al. (2017). Indeed, Foster and Mourato (2003) demonstrate that choice experiments exhibit large sensitivity to scope, which cannot be controlled for if the willingness to pay is expressed as euro per ton and the quantity of tons is not varied during the experiment. The sample selection could have also made the difference: our case study includes only air travellers, while also non-air travellers are included in the research by Schwirplies et al., (2017), Choi et al. (2018), and Choi and Ritchie (2014). In fact, while air travellers had actually experienced a budget constraint when purchasing an air ticket, non-air travellers have not and cannot anchor their stated willingness to pay to a real choice situation. Additional factors that could explain the differences are the different periods in which the surveys were carried out and the nationality of the respondents. Environmental consciousness has recently increased, although at different rates in different countries (Golob and Kronegger, 2019), moreover, the willingness to pay for environmental public goods is significantly influenced by the disposable income (Baumgärtner et al., 2017) which differs by country.

Our results are higher than the current average offset prices in the voluntary carbon markets, ranging between €3-€5 per ton (Hamrick and Gallant, 2018) and of the donation proposals offered by the largest airlines, ranging from €3 to €23 per ton (Zelljadt, 2016). They are however consistent with the ICAO's forecasts of the carbon offset prices, ranging between a low assumption of €5–€9 per ton to a high assumption of €18–€29 per ton in 2020 and 2030, respectively.[6] Moreover, they are in line with the estimates we obtained in a previous research focused on the willingness to pay per ton of CO_2 produced by road transport (Rotaris and Danielis, 2019). Finally, comparing our estimates with the social cost per ton of CO_2, which is equal to €32 according to the Environmental Protection Agency (EPA, 2016), we find that the willingness to pay of Italian air travellers is in line with the value of the negative externalities produced. The estimates of the social costs of one ton of CO_2 is however highly uncertain, as documented by Nocera et al. (2018).

4.2. Willingness to pay per flight

We also calculated the median willingness to pay for a net-zero carbon emission flight at the individual level, distinguishing by type of flight (domestic, continental and international flights) and by project purpose. Averaging the values calculated for each individual, we obtained the values reported in Table 7. Our results are in line with the findings reported by van Birgelen et al. (2011) and within the range of values reported by Hinnen et al. (2015) and Cheung et al. (2015). The differences between our results and the findings reported by other authors might be due to the methodology used to collect the data (face-to-face vs. online survey) and the use of contingent valuation experiments instead of choice experiments (e.g. Fatihah and Rahim, 2017; Jou and Chen, 2015). The absence of the "no choice" option (e.g. Araghi et al., 2016; Choi, 2015) could have also made the difference, since it reduces the realism of the choice tasks and influences the estimates obtained, as demonstrated by Brazell et al. (2006) and Paredes-García and Castaño-Tostado (2019). Finally, the sample selection (e.g. in Choi, 2015; Fatihah and Rahim, 2017 also non-air travellers were interviewed) and the nationality of the sample could have had a role too. Our estimates are higher than the voluntary contribution proposed by the airlines used by our sample when the interviews were performed, which ranged from a minimum of €3 per flight (Swiss International Airlines; British Airways; Iberia; Vueling) to a maximum of €23 per flight (US Airways; British Airways; Iberia; Vueling).

Table 7
Willingness to pay per flight by distance travelled (round trip) and project purpose.

	Purpose not mentioned	Technology and alternative fuel	Forest protection and restoration
Domestic (0.22 ton)	€14	€18	€28
Continental (0.6 ton)	€24	€28	€38
Intercontinental (3.3 ton)	€52	€55	€66

[6] https://www.icao.int/Meetings/HLM-MBM/Documents/EAG15_CAEP%20Technical%20Analyses.pdf.

5. Conclusions

According to our results, the willingness to pay of Italian air travellers to reduce or offset the carbon emissions produced ranges from €12 to €38 per ton and from €14 to €66 per flight. The value depends on the quantity of CO_2 reduced or offset, the type of project financed via the donation, the distance travelled and the socio-demographic characteristics of the travellers. The willingness to pay is significantly lower if the aim of the project is not mentioned. Forest protection, afforestation or reforestation are preferred to projects aimed at aircraft technological improvement and at increasing the use of alternative fuels. We also found that the willingness to pay is lower for frequent flyers, for people travelling for business, for men, for unemployed and for people having a lower education degree. The values we have found are above the current prices of the certified emissions credits traded in the voluntary markets, which in 2018 ranged from €3 to €5, and it will suffice even if in the near future the prices increase up to €18, as predicted by ICAO. As for the social cost of the emissions produced, Italians' willingness to pay per ton would cover a large part of the value of the damage they cause due to their transport choice (estimated equal to €32 per ton by EPA, 2016).

The implications of our results for airlines are numerous. Firstly, air travellers should be offered the possibility to pay to reduce or offset the carbon emissions they produce. At the time of the survey, instead, 30 per cent of the airlines used by our sample, including the national carrier Alitalia, did not offer this possibility to their customers. The significant latent willingness to pay we have found, instead, suggests that air travellers are environmentally conscious and are willing to give their contribution to the environmental cause. Moreover, it would improve the brand/corporate image and would promote the carbon offsetting initiatives already voluntarily financed by some airlines. It will also allow airlines to go beyond the mandatory emission constraints set by ICAO, helping either the aviation industry or other industrial sectors reducing the emissions that would otherwise occur.

A second important implication of our research is that the design of the donation proposals is crucial in order to support air travellers' carbon offset behaviour. In fact, according to our results, the values proposed should be differentiated at least according to the distance travelled (domestic, continental, and intercontinental flights) or, even better, to the quantity of emissions produced during the flight, with values varying from €12 to €38 per ton according to the project type. Additional factors that should be taken into account to properly design the donation proposals are the travel frequency and the socio-demographic characteristics of the passenger, in particular gender, educational degree and occupational status. Our estimates suggest that the values proposed should be lower for frequent flyers, men, people with a low level of education, the unemployed and business travellers. When we performed the interviews, instead, the airlines used by the respondents that allowed air travellers to make a donation proposed the same amount to all passengers or, at best, three contribution levels: a low (on average €3), an intermediate (on average €6) and a high value (on average €9). Only two of the sixteen airlines used by our sample differentiated the values proposed according to the distance travelled or by the service provided (economy, business, first class), although four other airlines allowed freely chosen amounts as donations. In a sector characterized by highly differentiated price discrimination strategies, customizing the donation proposals should be a feasible task.

A third important implication of our analysis is that air travellers should be advised while—or preferably before—they are booking their flight about the quantity of CO_2 they will contribute to produce and the social cost of their choice, since our results demonstrate that environmental consciousness increases air travellers' willingness to pay. Currently, there are only a few carbon counters available on the web[7] and they are not easily available on the airlines' websites. A noteworthy exception is British Airways that has recently added to its website a carbon offset calculator which estimates the emissions net of the quantity already covered by the EU ETS and, starting from 2021, by CORSIA, a best practise that in our view should be followed by other airlines.

Moreover, the scope and type of project to be financed via the donations should be described clearly and in detail in special sections of the airlines' websites. Air travellers should be given the possibility of choosing among different types of projects. Properly communicating the characteristics of the projects and the quantity of emissions that the donation will reduce or offset is very important to the adoption of carbon offsetting behaviour by air travellers. Indeed, our results demonstrate that the willingness to pay significantly increases as the quantity of emissions reduced or offset increases and that priority should be given to projects aimed at afforestation, reforestation and forests protection since they are preferred to projects aimed at aircraft technological improvements or use of alternative fuels.

Finally, airlines should monitor and analyse new consumption behaviours such as the repeated purchase of carbon-offsets by air travellers. Understanding the factors driving the choices of the donors offsetting on a regular basis would help prioritising the initiatives to be financed and would enable to better design the donation proposals.

Policy makers have a crucial role in the transition of the aviation sector toward a more sustainable setting since effectiveness of climate change policies plays an important role at encouraging aviation carbon offsetting (Ritchie et al., 2020). Moreover, if there is a positive correlation between the stated willingness to pay of air travellers and the expectations for the willingness to pay of others, as Wiser (2007, p.431) has found for the voluntary green power market, reaching a critical mass of participants would be an additional necessary condition for the development of a voluntary offset aviation market. In order to develop such a stable base of contributors on which further contributions can grow policy makers should prevent the adoption of greenwashing practices (Olk, 2020), which could undermine the donors' trust. In fact, as demonstrated by Zhang et al. (2019a, 2019b), trustworthiness has a significant positive impact on purchase intention. Policy makers should also enhance the projects' effectiveness. To this aim they should identify the projects' eligibility criteria and appoint the certifying bodies in charge of the projects' evaluation. They should define the accounting and reporting rules to be followed by airlines when managing and investing the donations received. Moreover, they should monitor that

[7] Among the few are those from ICAO (www.icao.int/environmental-protection/CarbonOffset/Pages/default.aspx) and Terrapass (www.terrapass.com/carbon-footprint-calculator).

airlines comply with the rules defined and that the emission units financed with the donations are not double counted or double used. Information campaigns aimed at communicating the environmental impact of the aviation sector could also increase the environmental consciousness of air travelers further prompting their willingness to pay to reduce or offset the emissions produced. However, policy makers should support not only carbon offsetting projects, which might be a viable solution in the short-term but are alleged to be insufficient or inadequate in the long-term, but also research and development initiatives aimed at improving aircraft energy efficiency and use of alternative fuel or energy sources.

Our results could be useful also to those governments that are willing to set an air ticket tax, as recently done by Sweden, since the acceptability of such a fiscal policy depends on how effectively the tax is designed, that is the tax value, and on people's willingness to pay for such mandatory instruments. Since in the literature there are strong indications that people's willingness to pay is systematically lower for voluntary offset schemes than for coercive instruments (Segerstedt and Grote, 2016; Wiser, 2007), our results could also be used as reference lower bounds to design the tax values.

This study is based on stated preference data and should be in the near future complemented by the analysis of the current voluntary contribution of Italian air travellers on the basis of revealed preference data. This would allow us to detect the causes that are limiting the voluntary purchase of carbon offset units, which might be due to the inconvenience of paying the donation or to the lack of properly designed proposals offered by airlines. The analysis of revealed preference data will also allow us to test if our findings regarding the factors influencing the willingness to pay are confirmed and to better control for the hypothetical bias that might affect our results.

CRediT authorship contribution statement

Lucia Rotaris: Conceptualization, Formal analysis, Investigation, Writing - original draft. **Marco Giansoldati:** Investigation, Data curation, Writing - review & editing. **Mariangela Scorrano:** Investigation, Data curation, Writing - review & editing.

Appendix A

Table 8
Description of measurement unit and coding of the explanatory variables.

Explanatory variables	Measurement unit or coding
Price	Euro
Quantity of emissions reduced or offset	
• Quantity of CO_2	ton
• Quantity of CO_2 up to 1.2 ton	ton up to 1.2 ton
• Quantity of CO_2 over 1.2 ton	ton above 1.2 ton
Project type	
• Forest (vs. no mention of the purpose)	dummy: 1 if project aimed at afforestation, reforestation and forest protection, 0 if the project purpose is not described
• Technology and fuel (vs. no mention of the purpose)	dummy: 1 if project aimed at improving aircraft technologies and use of sustainable alternative fuels, 0 if the project purpose is not described
Male	dummy: 1 if the respondent is a man, 0 if she is a woman
Middle school certificate	dummy: 1 if the respondent has a middle school certificate, 0 if s/he has a high school certificate, a bachelor or a master degree, or a PhD
Occupational status	
• Employed	dummy: 1 if the respondent is an employed or a self-employed, 0 if s/he is retired
• Student	dummy: 1 if the respondent is a student, 0 if s/he is retired
• Unemployed	dummy: 1 if the respondent is a un employed, 0 if s/he is retired
Member of an environmental association	dummy: 1 if the respondent reports that s/he joined an environmental association or participated to an environmental protest, 0 otherwise
Believe existence of climate change	dummy: 1 if the respondent reports that s/he believes that climate change is going on, 0 otherwise
High frequent flyer	dummy: 1 if the respondent travelled by plane more than 9 times during the last three years, 0 otherwise
Business traveler	dummy: 1 if the respondent travelled for business last time s/he took a flight, 0 if the respondent was travelling for leisure
Intercontinental flyer	dummy: 1 if the last flight took by the respondent was an intercontinental one, 0 otherwise

Table 9
Estimates of the initial Logit models (standard errors in brackets).

Description of the explanatory variables and of the estimated parameters	MNL	RPL_1	RPL_2
Price (€)	−0.02*** (0.01)	−0.20*** (0.01)	−0.21*** (0.01)
range of Price		0.50*** (0.02)	0.56*** (0.02)
Price _Male			−0.03*** (0.01)
Price _Middle school certificate			−0.07*** (0.01)
Price _Unemployed			−0.10*** (0.02)
Price _Business traveler			0.04*** (0.01)
Price _High frequent flyer			0.13*** (0.01)
Quantity of CO_2 (ton)	0.28*** (0.02)	1.36*** (0.07)	2.30*** (0.15)
range of Quantity of CO2		1.36*** (0.07)	2.30*** (0.15)
Quantity of CO_2 _Male			−0.72*** (0.13)
Quantity of CO_2 _Middle school certificate			−0.54*** (0.22)
Quantity of CO_2 _Unemployed			−1.44*** (0.41)
Quantity of CO_2 _Business traveler			−0.52*** (0.14)
Forest (vs. no mention of the purpose)	0.50*** (0.04)	1.32*** (0.08)	1.64*** (0.12)
range of Forest		3.39*** (0.23)	3.67*** (0.25)
Forest _Male			−0.32* (0.15)
Forest _Middle school certificate			−0.85*** (0.27)
Technology and fuel (vs. no mention of the purpose)	0.34*** (0.04)	0.96*** (0.09)	0.96*** (0.14)
range of Technology and fuel		3.22*** (0.28)	3.02*** (0.28)
Technology and fuel_Middle school certificate			−0.48* (0.27)
Technology and fuel_High frequent flyer			−0.49* (0.25)
Constant	−0.38*** (0.10)	0.57*** (0.19)	0.79*** (0.20)
Constant_Male	−0.25*** (0.06)	−0.37*** (0.11)	−0.21* (0.12)
Constant_Student or Employed	0.22* (0.07)	0.64*** (0.13)	0.40*** (0.14)
Constant_Intercontinental flyer	0.12 (0.08)	1.30*** (0.16)	1.40*** (0.18)
Constant_Member of an environmental association	0.34*** (0.08)	0.39*** (0.16)	0.38** (0.16)
Constant_Believe existence of climate change	0.66*** (0.09)	0.57*** (0.17)	0.53*** (0.17)
N. Obs.	7368	7368	7368
LL constant only	−7975	−7975	−7975
LL	−7543	−5853	−5795
AIC	15,108	11,730	11,628
BIC	15,184	11,827	11,863
Chi-square	866	4250	4392
P Chi-square	0.00	0.00	0.00

Note: *, **, *** indicate statistical significance at the 90%, 95%, and 99% levels, respectively. The variables that are not statistically significant have been removed from the table.

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