Chinese future frequent flyers' willingness to pay for carbon emissions reduction

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Abstract

Carbon offset programs and carbon taxes have not been introduced to China's aviation sector, but may be implemented in the coming decade. This research surveys Chinese university students to understand the factors associated with their willingness to participate in and pay for voluntary carbon offsets and compulsory taxes for domestic and international travel. Our survey subjects represent the future frequent flyers and a generation likely to be impacted the most by global warming. We find that their willingness to pay (WTP) for carbon emissions reduction is positively related to income, levels of environmental concern and trust in the carbon offsetting/reduction projects. Females tend to have a higher WTP than males. The intention to contribute during the Covid-19 pandemic was lower. The mean WTP for the voluntary offsetting regime for domestic travel is approximately 36.33 yuan, whereas the mean WTP for domestic travel under the compulsory regime is about 28.65 yuan. For international travel, these two figures are 45.37 yuan and 71.70 yuan, respectively.

Keywords: Contingent valuation; Willingness to pay; Voluntary carbon offsets; Carbon tax; Chinese aviation

1. Introduction

The environmental impact of air travel is greater than that of other transport modes in terms of per passenger trip (Li et al., 2017). Worldwide, airlines generated 915 million tonnes of CO_2 in 2019, representing about 2% of man-made CO_2 emissions (ATAG, 2020). With an increase in disposable income and the lower fares offered by low-cost carriers, there has been an ongoing demand for air travel (Zhang et al., 2017). Air transport emissions were not addressed in the 2015 Paris Climate Agreement. However, the International Civil Aviation Organisation (ICAO) has decided to introduce a program to curb the emissions produced by flights, which is called the Carbon Offsetting and Reduction Scheme for International Aviation (CORSIA). This program aims to achieve carbon neutral growth from 2020 by requiring airlines to limit their emissions or buy credits from environmental projects to compensate for their growth in CO_2 emissions. CORSIA is to be implemented in phases: the participation is voluntary in the pilot phase (2021–23) and the first phase (2024–26); except for a few exemptions, compulsory participation applies to all ICAO members in the second phase from 2027 to 2035.

China has grown to be the second largest aviation market and air travel demand is still growing there at a fast pace (Yu et al., 2019; Ma et al., 2020). Emissions from domestic air travel are not included in CORSIA. To date, Chinese carriers have not joined the CORSIA pilot and first phases. It is not known if their stance will change with the new emissions goal announced by President Xi in 2020.[1] Morrell (2009) suggested some policy responses that can be used to cut emissions in the aviation sector: limiting the number of flights operated, setting higher standards for new aircraft and/or engines, replacing fossil fuel with biofuel, enabling voluntary carbon offsetting, introducing

[1] Chinese President Xi Jinping declared a bold carbon emissions target at a meeting of the United Nations General Assembly in September 2020 that China aimed to reach peak emissions before 2030 and achieve carbon neutrality by 2060. This ambitious pledge surprised many people as China is the largest emitter of carbon dioxide (CO_2) and, for a long time, China's stance was that as a developing economy it should not share the same responsibility for cutting emissions as developed economies.

emissions taxes, etc. Offsetting means that the CO_2 emissions generated by air transport can be compensated for by reducing a similar amount of emissions elsewhere. Both airlines and passengers can participate in such a compensation scheme. More than thirty airlines around the world have been operating carbon offset programs. However, Reid (2020) reported that only 1% of passengers voluntarily donate money to offset their flying. Therefore, it has been suggested that voluntary carbon offset programs can be complemented by mandatory programs such as carbon taxes (Choi, 2015).

Quite a few studies examined the willingness to pay (WTP) for voluntary offsets in air transport (e.g., Chang, Shon & Lin, 2010; McKercher et al., 2010; Choi, 2015). The number of studies on the WTP for mandatory aviation carbon taxes is fewer (Denstadli & Veisten, 2020). Studies examining both are rare. To the best of our knowledge, no study has examined Chinese citizens' WTP for air travel emissions reduction. This paper aims to fill this research gap. Considering China's long-held attitude towards climate change (Richerzhagen & Scholz, 2008; Christoff, 2010) and the fact that Chinese carriers are reluctant to join the CORSIA pilot and first phases, the general public may have little knowledge about the application of voluntary carbon offsets or carbon taxes to China's aviation sector. Therefore, this research chooses Chinese university students as the target audience and answer this research question: what are the factors concerning China's future frequent flyers' willingness to participate in a voluntary carbon offset program and to pay a carbon tax for their domestic and international travel? The primary reason for using young university students as research subjects is because they are more educated and may have a higher environmental awareness than general air passengers.[2] They also belong to a generation likely to be impacted most by global warming.

[2] Many works on China's aviation market report a significantly higher percentage of passengers with tertiary qualifications (e.g. Jiang & Zhang, 2016). With the increase in income and the growth of low-cost carriers in China, air travel has become more affordable for all citizens. However, today's university students will be a significant part of the frequent air transport users in the future.

Specifically, this paper will use a contingent valuation (CV) survey to investigate Chinese university students' willingness to participate in both voluntary and mandatory emissions reduction methods, at a time when Chinese airlines face domestic and international pressures to mitigate the carbon footprints. The respondents will be presented with both domestic and international travel scenarios, which will enrich the existing literature with Chinese future frequent travellers' perceptions of air travel carbon emissions reduction programs and their intentions for contributing to them. This is the first single study that considers both voluntary compulsory emissions reduction methods in domestic and international markets. The findings of this research provide valuable information to the policy makers and airline management that can assist the implementation of these carbon reduction measures in the future. In the next section, relevant literature will be reviewed, followed by a discussion of the CV approach and survey design. The results are reported in section 4 and the last section contains policy implications of the findings and concluding remarks.

2. Literature review

Dodds et al. (2008) note that information and education about the concept of voluntary offsets are lacking. In most cases, passengers who donate to a carbon offset program are not assured that their money is safely and properly used for emission reduction projects. Lu and Shon (2012) found that passengers' knowledge and perception of a carbon offset scheme are significant factors influencing their willingness to pay (WTP). Therefore, it is not surprising that researchers found that only 1–2% of international passengers actually donated money for voluntary offsets (Chang et al., 2010; McKercher et al., 2010), although this figure is higher in some markets such as Australia's (Choi, 2015). The free riding theory has been used to explain the large discrepancy between the high proportion of passengers who express concern about the environmental impact of air travel and the low participation rates in voluntary carbon offset schemes (Foster et al., 1997). This also implies that the WTP for a public good such as the environment under a voluntary regime is lower than under a mandatory carbon tax arrangement (Jakobsson & Dragun, 2001; Wiser, 2007). Choi and Ritchie

(2014) show that travellers are willing to pay more for offsets that are endorsed and certified by a creditable body. Choi et al. (2016) and Chen (2013) reviewed psychological factors and pointed out that personal emotions and subjective norms are linked to the purchase intention. The demographic profiles of consumers such as age, education, gender and income (McLennan et al., 2014) and the design of the offset schemes, particularly credibility and transparency (Babakhani et al., 2017), might also be relevant, depending on the contexts. For example, younger passengers were found to be more likely to offset their carbon footprints of flying in McLennan et al. (2014). Zhang et al. (2019) also claimed that younger respondents with higher levels of income and education are more supportive of the carbon offset programs. Galley and Clifton (2004) found that older females have a higher tendency of engaging in pro-environmental behaviour while this is not the case in Mair (2011). In most studies, female consumers have demonstrated a higher economic value for carbon reduction than male consumers (Berenguer et al., 2005; Choi and Ritchie, 2014), though Mair (2011) reported the opposite.

As the voluntary programs are associated with low credibility and transparency (Polonsky et al., 2010), and that they do not directly reduce air transport emissions (Gössling et al., 2007), carbon taxes might be a more powerful way to cut CO_2 emissions in the aviation sector (Baumol & Oates, 1988). A carbon emissions tax is actually a Pigouvian tax levied on products with negative externalities (Pigou, 1929). It can be in the form of an aviation fuel tax or an air passenger tax paid by a passenger when purchasing a ticket (Qiu et al., 2020). In fact, from an efficiency perspective, economists believe that the voluntary offset program itself cannot replace other more efficient emissions reduction programs such as tradable emissions permits and mandatory carbon taxes (Knorr & Eisenkopf, 2020). Given such inefficiency, Knorr and Eisenkopf (2020) note that the airline voluntary offset program mainly benefits the airline and its passengers: the airline can create an environmentally friendly image for itself, and the passengers can reduce their guilt without the need to curtail their flying activities.

Seetaram et al. (2018) investigated the outbound tourists' WTP for air passenger duty (APD), a carbon tax in the UK that has potential environmental benefits. It was found that passengers intend to pay more APD for business class and long-distance travel. Hofer et al. (2010) evaluated the effectiveness of air traffic emissions taxes in the US. They found that emissions savings in the US aviation sector due to emissions taxes may be offset by the increase in automobile traffic and related carbon emissions. However, Akerman (2011) found that a change of transport mode from air or road to high-speed rail can result in a reduction in CO_2 emissions by 220,000 tonnes in Sweden. This implies that a carbon tax can generate a desired shift if high-speed rail is readily available as an environmentally friendly alternative to air transport (Prussi & Lonza, 2018).

Rotaris et al. (2020) provide a good review of the studies on WTP for voluntary and mandatory contributions for reducing or offsetting carbon emissions. About half of these studies examine the WTP for a flight (e.g., Lu & Shon, 2012) while the other studies focus on the WTP per tonne of CO_2 (e.g., MacKerron et al., 2019). The geographic focus of most of the existing literature on voluntary offsets is Europe (e.g., Brouwer et al., 2008; Blasch & Farsi, 2014) with a few papers on the Asia-Pacific region, including Australia (e.g., Choi & Ritchie, 2014; Choi et al., 2018; Shaari et al., 2020). Rotaris et al. (2020) and Denstadli and Veisten (2020) pointed out that most studies focus on the WTP for the voluntary contribution for air travel emissions reduction while studies estimating the WTP for mandatory taxation schemes are small in number. The former is important to airlines while the latter is of interest to policy makers. This study aims to examine both aspects which have received little attention in China's air transport sector and scholarly studies.

The values of WTP for voluntary carbon offset programs vary considerably in the existing studies. Even in the same study passengers of different demographic cohorts differ significantly in the average WTP. Jou and Chen (2015) investigated the WTP of

economy class air passengers for their flight from Taiwan to Hong Kong (1.5 hours' flying time) and estimated a mean WTP of only TW$39.05 (8.7 yuan).[3] A mean WTP of RM86 (about 140 yuan) was reported among Malaysian airline passengers by Shaari et al. (2020). In Europe van Birgelen et al. (2011) found that the average WTP for a short-haul flight was about €24 (180.8 yuan) and the mean WTP for a long-haul flight was €55 (about 414 yuan). A small number of studies estimated the WTP for carbon taxes that apply to all air passengers. Seetaram et al. (2018) reported that the mean WTP for economy and business classes on the short routes were £16.543 (146 yuan) and £24.116 (212 yuan), respectively. These values were close to the carbon rates actually charged. However, on the medium- and long-haul routes the mean WTP fell in the range between £22.885 (202 yuan) to £36.795 (324 yuan), respectively, which were far less than the tax rates actually applied. A study by Denstadli and Veisten (2020) shows that Norwegian tourists are willing to pay a higher carbon tax than that currently charged and that the WTP is not significantly influenced by the taxation schemes. Interestingly, Choi (2015) reported a partial crowding-out effect for the mandatory carbon tax, meaning that the compliance mechanism could reduce the amount of WTP for the voluntary carbon offsets as well as the participation intention. Overall, it appears that there is a variation in the amounts of WTP for both voluntary and mandatory contributions across countries, flying distances and demographic profiles.

Although the CV approach has been widely accepted as a powerful tool to understand the value of a product or service without monetary prices, it is subject to criticisms for the respondent uncertainty problem (Martínez-Espiñeira & Lyssenko, 2012). Quite often, the respondents have no past experiences with the good or service they are asked to evaluate. It might be the first time for them to hear of the product or the policy

[3] To allow for comparison, the following average exchange rates were used (2016-2019) to convert the WTP amounts to Chinee yuan (CNY): 1 AUD=4.9616 CNY, 1 MYR=1.6288 CNY, I EUR=7.5356 CNY, 1 TWD=0.2228 CNY, 1 GBP=8.8056 CNY, 1 USD= 6.7324 CNY. As we do not have the exact information as to the point in time at which the studies were conducted, the values in Chinese yuan are only indicative.

proposed for evaluation. Typical CV biases include hypothetical bias (due to the difference between respondents' indication and their actual payment), strategic bias (due to respondents' desire to influence an outcome), information bias (due to the lack of information) and starting point bias (due to the influence of the starting bid values used) (Boyle et al.,1985; Herriges & Shogren, 1996; Bhatia, 2007; Abebe et al., 2020). Hypothetical bias is the major concern for most CV studies. It arises due to the nature of hypothetical scenario where respondents tend to ignore their income constraints and overstate the WTP, especially in the voluntary contribution scenario (Blumenschein et al., 1998). Common methods that have been adopted by researchers to mitigate the hypothetical bias include follow-up certainty scales, and cheap talk scripts. Follow-up certainty scales ask respondents if they would actually pay the amount they expressed in their WTP (Li & Mattsson, 1995). Little and Berrens (2004) show that this approach can effectively eliminate the gap between the actual and hypothetical amounts of WTP. The cheap talk is the ex-ante communication used to help respondents understand the tendency to overstate WTP in the hypothetical scenarios (Morrison & Brown, 2019). However, the effect of using cheap talk is inconclusive in terms of reducing hypothetical bias (Morrison & Brown, 2019). Most importantly, Tussupova et al. (2015) note that to avoid hypothetical bias, researchers need to present believable and familiar scenarios to the respondents for consideration.

Contextual differences due to personal factors such as demographics have been well studied as reviewed earlier. However, contextual factors such as domestic and international flights that can influence the offset preferences and WTP, have been rarely studied (Ritchie et al., 2021). Choi et al. (2018) is one of the few studies that examine voluntary offset programs on both domestic and international flights for the case of Australia. Interestingly, they found that Australians would pay much higher to offset their domestic travel emissions than for international flights. Our study considers a range of contextual factors including domestic and international flights and voluntary and mandatory contributions in the Chinese context, which constitutes a major contribution to the literature. In addition, with the presentation of various scenarios to

the respondents, we actually provide full and balanced information about the emissions reduction approaches, which can help reduce the information bias associated with the CV approach (Ajzen et al., 1996).

3. Methodology and data

CV and discrete choice models are two popular approaches in eliciting consumers' WTP for a product that is not currently traded in the market with a price. The discrete choice model asks consumers to make hypothetical choices by making trade-offs among the attributes of the choice set (Zhang, 2012), while the CV approach directly asks respondents to subjectively determine the maximum sum that respondents are willing to pay for a given product (Mitchell & Carson, 1989). Lee et al. (2020) argue that compared with the CV approach, the discrete choice model is more burdensome as respondents must make choices by considering various attributes. The CV approach is a mature approach that has been applied in many fields, proved to be a valid and reliable tool to determine WTP for a non-market product. For that reason, this study adopts the CV approach.

The participants were recruited from four universities in China. Two universities are located in Beijing and one in Hangzhou and in Xi'an. The study was conducted in the period from 5 to 30 September 2020. Students from these universities were recruited to answer a survey comprising three main parts. Previous studies such as van Birgelen et al. (2011), Choi and Ritchie (2014) and Choi (2015) also used university students or staff as their survey subjects. Such convenience sampling approach has received many criticisms. It should be noted that our target audience are university students who are future flyers and we do not intend to generalise the findings to a larger population that includes current air transport users. The first part of our survey investigates the basic information of respondents, including age, gender, education level and monthly household income. The second part of our survey examines the respondents' subjective cognition about environmental protection and carbon offset projects. The five-point

Likert scale, ranging from '1=the lowest level or least degree' to '5=the highest level or highest degree', was adopted for the respondents to rate the four categories of variables included in the second part: environmental concerns, perceptions of the carbon offset scheme, impact of Covid-19 and the credibility of the carbon offset efforts. By asking a series questions about respondents' familiarity and responsibility about air travel carbon emissions, and airlines and governments' responsibilities, we actually walk the respondent to become familiar with the air travel emissions issues. This will certainly reduce hypothetical bias. The third part of our survey covers CV questions designed to elicit respondents' WTP for carbon offset projects. This is divided into four scenarios, contingent on whether the journey is a domestic one or an international one, and whether the carbon offset fees are collected voluntarily by the airlines (voluntary regime) or are collected compulsorily by the government (compulsory regime). The flying time of the domestic flight is defined to be 2–3 hours while that of the international one is between 9 and 12 hours, covering flights to Australia, Europe and North America.

Prior to the large-scale survey distribution, we asked thirty students to participate in pilot tests to check the wording of the questions to avoid ambiguity. Minor changes were made to four questions. To decrease the sampling bias, we first identified the WeChat groups of different disciplines, including undergraduate, masters and PhD students. Then the questionnaire was sent to each WeChat group and the members of each group were invited to participate. Eventually 850 surveys were collected, of which 808 were deemed valid.[4] The Cronbach's coefficient α based on the questions in part 2 is 0.69, indicating that our survey design is reasonably consistent (Nunnally, 1978).

The traditional CV approach needs large samples to obtain accurate estimations. Hanemann et al. (1991) suggest an alternative – a double-bounded model to improve the efficiency of the CV estimation. In this case, the respondent is asked with

[4] 42 incomplete surveys were discarded.

dichotomous choice questions. Assuming that the starting bid value is B1, the individual is asked, 'Will you be willing to pay B1?'. If the respondent says 'yes' to the starting bid value, a second question will be asked with a higher bid value, denoted by B2. If the respondent replies 'no' to the starting bid value, this will also be followed by a second question with a lower bid value, denoted by B3. With this approach we obtain two answers for each individual. Accordingly, each individual's response possibility will fall within the range of the following choices.

Pr(yes, yes)=Pr(B2<=WTP)

Pr(yes, no)=Pr(B1<=WTP<B2)

Pr(no, yes)=Pr(B3<=WTP<B1)

Pr(no, no)=Pr(WTP<B3)

As mentioned before, the carbon offset scheme is divided into four scenarios in this study based on whether the trip is domestic or international, and whether the fee collection is voluntary or compulsory. To elicit the WTP values, we need to present a starting bid price to the respondent. The CV approach does not give a theoretical guidance for the selection of bid levels. Researchers can use information from prior empirical research, pre-testing and industry experts to set the bid values (Johnston et al., 2017). In MacKerron et al. (2009) the participants were given the choice options for offset payments across £4 (35 yuan), £8 (70 yuan), £12 (106 yuan), £16 (141 yuan), £20 (176 yuan). These values represented the range of prices traded in the actual market. Eventually the authors found that WTP for a voluntary offset program without certification between New York and London (about 8–10 hours' flying time) was £24 (about 211 yuan). But no airline in China has introduced a carbon offset program and it is difficult to find a reference value to start with. Slater et al. (2019) projects that in China the carbon price will reach 116 yuan by 2030. By using the ICAO carbon emissions calculator,[5] we can find that a 2-hour journey such as between Beijing and Shanghai will generate 99.3 kg CO_2 per passenger. So a passenger can pay about

[5] Available at https://www.icao.int/environmental-protection/Carbonoffset/Pages/default.aspx.

10 yuan to offset his/her air travel footprint. We understand that the actual carbon prices can vary widely in a large range from one country to another and from one period to another. With growing concerns about climate change and increasing pressure to reduce carbon emissions, the price of carbon is expected to rise. With these considerations in mind, we created three versions of the questionnaire that differ in the bid values as indicated in the last column of Table 1.

Since the amount of carbon emissions rises as the route distance and travel time increase, B1 of the international trip (assuming a flying time of between 9 and 12 hours) is set higher than that of the domestic trip (assuming a flying time of between 2 and 3 hours). Also, as a compulsory payment regime is expected to collect a carbon offset fee from a wider range of consumers, B1 of a compulsory payment regime is set lower than that of a voluntary one. The detailed information of B2 and B3 is also reported in Table 1.

Table 1: Scenarios and bid values.

Scenario	Reduction regime	Flight	B1 (yuan)	B2 (yuan)	B3 (yuan)	Version
1	Voluntary	Domestic	30	50	10	Version 1
			40	60	20	Version 2
			50	70	30	Version 3
2	Voluntary	International	50	80	20	Version 1
			80	110	50	Version 2
			110	140	80	Version 3
3	Compulsory	Domestic	20	30	10	Version 1
			30	40	20	Version 2
			40	50	30	Version 3
4	Compulsory	International	30	50	10	Version 1
			40	60	20	Version 2
			50	70	30	Version 3

To further investigate the respondents' WTP for carbon offsetting and its determinants, an interval regression is constructed. For the CV approach, WTP can be modelled with

equation (1):

$$WTP_i(z_i, u_i) = z_i\beta + u_i \quad (1)$$

where z_i is a vector of explanatory variables. β is a vector of parameters and u_i is an error term following a normal distribution with a mean of zero and variance of σ^2.

One potential bias associated with the use of the double-bounded dichotomous choice is called starting point bias, which means that the estimated WTP may be biased towards the initial bid values presented to the respondent (Boyle et al.,1985; Herriges & Shogren, 1996). This bias is addressed by following the method proposed by Herriges and Shogren (1996). That is, the true WTP of respondents is a weighted average of the biased WTP and the initial bid value B1 as shown below.

$$WTP_i(z_i, u_i) *= (1-\gamma)WTP_i(z_i, u_i) + \gamma B1 \quad (2)$$

where $WTP_i(z_i, u_i)*$ is the true WTP of respondents after controlling for the anchoring effect. γ is the anchoring weight and $0 \leq \gamma \leq 1$. The respondents' WTP is closer to the starting bid value as γ approaches 1. In contrast, the estimated WTP is closer to the true WTP as γ approaches 0. This anchoring effect model has been widely used in the CV studies to tackle the starting bid bias (Chien et al.,2005; Flachaire et al.,2007).

The data of the independent variables of gender, age, education and income are from part one of the survey. Other independent variables are generated from the second part of the survey. The details of all of the independent variables, including descriptive statistics, are reported in Tables 2 and 3. It is quite interesting that about 70% of the respondents are female, which is quite similar to many previous studies examining carbon offset schemes such as Choi and Ritchie (2014) and Shaari et al. (2020). The vast majority of our respondents are studying for an undergraduate degree and are aged under 25 years. It is impressive to see a mean of 4.17 for the level of responsibility that an individual should assume, indicating that Chinese university students are willing to do something to reduce carbon emissions and to protect the environment. In general, the respondents put more trust in the government than in the airlines. Thus, the offset

schemes with government participation earn more credibility.

To estimate the parameters in model (1), we use the dichotomous choice approach. According to Wu (2009), Lu and Shon (2012) and Lopez-Feldman (2012), the likelihood function is expressed as follows:

$$L = \sum_{i=1}^{N} ln\left[\Phi\left(\frac{U_i - \beta' x_i}{\sigma}\right) - \Phi\left(\frac{L_i - \beta' x_i}{\sigma}\right)\right] \quad (2)$$

where U and L denote the upper and lower bounds of the interval, respectively. WTP falls within these two values. $\Phi(\bullet)$ is the standard cumulative normal distribution. Since the traditional model fitness measures R^2 and pseudo R^2 are not available in interval regression, following Lu and Shon (2012), we calculated the correlation coefficients between the predicted bound value and the observed bound value as a rough-and-ready fitness measure. We found that for the lower bound value, the correlation coefficients of predicted value and observed value are statistically significant at the 90% confidence level. For the upper bound value, the correlation coefficients of predicted value and observed value are statistically significant at the 95% confidence level. Thus, we are confident to say that the model has a fine fitness.

Table 2: Respondents' demographics.

		No. of respondents	**Percentage**
		808	
Gender	Male	246	30.4%
	Female	562	69.6%
Age	<18	22	2.7%
	18-25	760	94.1%
	25-30	17	2.1%
	>30	9	1.1%
Education	Undergraduate	694	85.9%
	Postgraduate	164	20.3%
Monthly household income (yuan)	<5000	166	20.5%
	5000-10000	282	34.9%
	10000-15000	169	20.9%
	>15000	191	23.6%

Table 3: Descriptive statistics of other independent variables.

	Variable	Definition	Obs.	Mean	Std. Dev.	Min.	Max.
Environmental concern	Environment	1 means the respondent having the lowest level of awareness of the environmental harm caused by air travel while 5 is the highest level of awareness.	808	2.53	0.89	1	5
	Obligation_person	1 means the respondent taking the least responsibility for offsetting his/her air travel carbon emissions while 5 means taking the highest responsibility.	808	4.17	0.86	1	5
Perceptions of carbon offset scheme	Influence_airline	1 means that the carbon offset schemes operated by airlines have no or little impact on carbon emissions reduction while 5 means carbon offset schemes operated by airlines have the highest impact on carbon emissions reduction.	808	2.91	0.93	1	5
	Influence_government	1 means that carbon offset schemes operated by government have no or little impact on carbon emissions reduction while 5 means that carbon offset schemes operated by government have the highest impact on carbon emissions reduction.	808	3.10	0.97	1	5
Impact of Covid-19	Carbon_covid	1 means that Covid-19 does not reduce the degree of urgency for carbon emissions reduction while 5 means that Covid-19 greatly reduces the degree of urgency for carbon emissions reduction.	808	3.08	0.95	1	5
Credibility of the carbon offsetting/reduction	Trust_airline	1 means the lowest level of trust in the airlines in using the proceeds collected for proper carbon offset projects while 5 means the highest level of trust.	808	2.97	0.89	1	5
	Trust_government	1 means having the lowest level of trust in the government in using carbon tax proceeds for proper carbon emissions reduction projects while 5 is the highest level of trust.	808	3.30	0.88	1	5

4. Results

Tables 4 presents the results of those who replied 'yes' to both bid values while Table 5 reports those who replied 'no' to both questions. For those who replied 'yes' to both questions, the survey asked them their highest WTP amount. The descriptive statistics of their WTP are also shown in Table 4. It is clear that the respondents are willing to pay more for international travel. Comparing the voluntary and compulsory regimes, a higher proportion of students replied 'yes' to both questions for the compulsory regime, particularly for domestic travel. This may be because students place a higher trust in government-led carbon offset schemes. Table 5 suggests that close to 50% of the respondents said 'no' to both questions for a voluntary offsetting program applying to international travel. However, if the program is voluntary then the percentage of respondents saying 'no' to both questions is halved.

Table 4: Percentages of yes-yes bids and WTP (yuan).

Scheme	Variable	Obs. for each scheme	Total obs.	%	Mean	Std. Dev.	Min.	Max.
Domestic-Voluntary	WTP	101	808	12.5%	77.63	30.88	50	200
Domestic-Compulsory	WTP	209	808	25.9%	63.08	40.24	30	500
International-Voluntary	WTP	103	808	12.7%	136.27	71.35	80	500
International-Compulsory	WTP	105	808	13.0%	100.34	61.32	60	500

Table 5: Percentages of no-no bids.

Scheme	Variable	Obs. for each scheme	Total obs.	%
Domestic-Voluntary	WTP	304	808	37.6%
Domestic-Compulsory	WTP	263	808	32.5%
International-Voluntary	WTP	374	808	46.3%
International-Compulsory	WTP	186	808	23.0%

Table 6 presents the interval regression results for the domestic journey. Columns (1) and (2) show the results for the voluntary and the compulsory regimes, respectively.

For the voluntary regime, the significant determinants of carbon offsetting WTP include gender, education, family monthly income, environmental concern, the sense of

obligation for environment protection, the trust put in airlines and government, and the impact of Covid-19. The determinants for the compulsory regime are largely consistent with those of the voluntary regime. However, family monthly income is not statistically significant and the rating of government-operated schemes is significant at the 10% level. It is apparent that under both regimes, female students have a higher WTP than male students.[6] For the voluntary regime, female students are willing to pay 6.4 yuan more than male students. They are happy to pay 9.6 yuan more than males under the compulsory regime. Interestingly, PhD and master's students tend to place a lower value on voluntary offsetting schemes than undergraduate students that are set as the base category. Family monthly income is significantly and positively associated with students' WTP under the voluntary regime, but not under the compulsory regime. Respondents who have high level of environmental cognition and feel obligated to environment conservation tend to pay more for carbon offsetting projects under both regimes. Students who place a higher level of trust in airlines and the government in using the fee collected properly have a higher WTP for the voluntary regime. Under the compulsory regime, the level of trust in airlines does not seem relevant. The variable 'Trust_government' plays a more important role than the variable 'Trust_airline'. This implies that in China the government can take the lead in pursuing carbon neutrality. Under both regimes the respondents agree that Covid-19 reduces the urgency of realising the carbon emissions reduction goal and would pay less if the pandemic persists.

The mean WTP for the voluntary regime for domestic travel is approximately 36.33 yuan, whereas the mean WTP for domestic travel under the compulsory regime is about 28.65 yuan.

[6] People may argue that we have a much larger sample size for the female group, which may result in sampling bias. To address this concern, we randomly extract 40% of female observations as our new female sample. By doing so, the numbers of observations for the two groups (male and female) are comparable, i.e. 225 females and 246 males. We repeat the random sampling process for 20 times and run the WTP regressions with new samples. The results show that the sign and magnitudes of the 'gender' variable are quite consistent.

Table 6: WTP and its determinants for carbon reduction schemes for domestic travel.

Variable	Voluntary (1)	Compulsory (2)
Gender	6.3851**	9.5511**
	(2.711)	(3.896)
Age	0.2139	1.8617
	(4.508)	(6.387)
Edu	-9.7030***	-7.3435*
	(3.141)	(4.461)
Income	2.0404*	0.2945
	(1.152)	(1.662)
Environment	3.9910***	4.3098**
	(1.365)	(1.978)
Obligation_person	4.0752***	4.2238*
	(1.522)	(2.194)
Influence_airline	2.3074	4.0251*
	(1.650)	(2.357)
Influence_government	0.6324	3.8336*
	(1.547)	(2.231)
Trust_airline	5.2253***	1.5173
	(1.780)	(2.536)
Trust_government	4.4962**	13.0848***
	(1.749)	(2.585)
Carbon_covid	-2.7891**	-5.5980***
	(1.310)	(1.907)
γ	0.9326***	0.8188***
	(0.151)	(0.218)
Constant	-68.1251***	-90.2274***
	(13.690)	(19.853)
WTP	**36.33 yuan**	**28.65 yuan**
Log likelihood	-1054.27	-1010.74
Wald x^2	140.63	113.42
$p>x^2$	0.00	0.00
Observations	808	808

Standard errors in parentheses; *** p<0.01, ** p<0.05, * p<0.1

Table 7 shows the interval regression results for an international journey. For both regimes, students from higher income families, having good environmental protection cognition, and accepting of the government's sensible use of the fee money are inclined

to pay more to support carbon offset schemes. Gender and the belief in the government's significant role in protecting the environment are significant factors affecting WTP under the compulsory regime but not so under the voluntary regime. Education level is a significant factor influencing WTP in the voluntary regime but not in the compulsory regime. As has been shown in Table 6, Covid-19 is associated with a lower level of WTP under both regimes.

The mean WTP under the voluntary regime for the international journey is about 45.37 yuan, while the average WTP of 71.70 yuan for the compulsory regime. This is quite different from the case of the domestic travel, where the mean WTP for the voluntary regime is higher than for the compulsory regime. Also although the flying hours are 4-5 times longer for international travel, there is not a proportional increase in the contribution amount for the carbon emissions. This may suggest that respondents have a higher level of sense of responsibility in offsetting their carbon footprints in the domestic market, which is consistent with recent findings reported in Choi et al.(2018) and Ritchie et al.(2021) that Australian consumers would be more willing to pay for domestic offset schemes than for international programs. Table 6 suggests that females tend to have a stronger passion in supporting voluntary offset programs for domestic case, but it is not the case for international flights. This is understandable as the respondents have lived in China with little exposure to the international markets. They may not have developed a strong sense of global citizenship. This may imply that a voluntary offset program can be introduced to the domestic market first.

It should be acknowledged that regardless of the domestic or international journey, the amounts of money expressed by Chinese respondents in regard to WTP are much lower than those of the European travellers. This is consistent with previous findings. For example, Brouwer et al. (2008) reported that European travellers' WTP is four times higher than that of Asian travellers. A strong contributing factor for a higher WTP is a strong sense of moral responsibility and concerns for climate change (Choi & Ritchie,

2014). European passengers tend to have a significantly higher awareness of these issues than travellers from other regions such as Asia (Brouwer et al., 2008).

Table 7: WTP and its determinants for carbon reduction schemes for international travel.

Variable	Voluntary (1)	Compulsory (2)
Gender	6.0382	15.5211***
	(4.320)	(4.823)
Age	4.2012	0.6370
	(7.211)	(7.867)
Edu	-8.5664*	-4.8110
	(4.985)	(5.439)
Income	4.4854**	3.3633*
	(1.833)	(2.035)
Environment	5.0040**	5.8744**
	(2.185)	(2.431)
Obligation_person	3.3830	2.5435
	(2.412)	(2.692)
Influence_airline	2.7385	2.6350
	(2.645)	(2.894)
Influence_government	1.1394	4.6756*
	(2.480)	(2.729)
Trust_airline	8.5750***	3.7591
	(2.871)	(3.137)
Trust_government	6.0577**	16.5486***
	(2.832)	(3.156)
Carbon_covid	-4.8677**	-6.0348***
	(2.111)	(2.325)
γ	0.5992***	0.9293***
	(0.081)	(0.089)
Constant	-84.6669***	-120.7450***
	(20.834)	(23.404)
WTP	**45.37 yuan**	**71.70 yuan**
Log likelihood	-974.98	-1027.98
Wald x^2	136.41	224.06
$p>x^2$	0.00	0.00
Observations	808	808

Standard errors in parentheses; *** p<0.01, ** p<0.05, * p<0.1

5. Discussion and conclusion

Although the details of the steps to achieve China's climate neutrality goal by 2060 have not been revealed yet, it is expected that in the next few decades there will be fundamental changes to every aspect of ordinary Chinese people's everyday life and the economy's production pattern in order to realise the greener China dream. The changes will affect inter-city travel, particularly travel by air. It is, therefore, important to set appropriate carbon offset and carbon tax prices which will help improve air passengers' awareness of the impact of their travel on the environment (Gupta, 2016). This paper surveys Chinese university students to understand how they would like to contribute to voluntary carbon offsets and compulsory taxes, popular emissions reduction measures that are likely to be adopted in China's aviation market in the coming decade.

Consistent with previous research (MacKerron et al., 2009), females show a higher level of sensitivity about the environmental aspect and are willing to pay more to compensate for carbon emissions for both domestic and international travel (except for voluntary offsetting on international routes). Apparently, female participation is of particular importance in the course of pursuing the carbon neutrality goal. The United Nations (2020) acknowledges that in making international and national climate policies, female participation can generate greater responsiveness, increase cooperation and deliver more sustainable outcomes. So, every effort should be made by Chinese airlines to ensure that female passengers' voices are heard when designing carbon emission reduction schemes.

In general, household income is positively related to the amount of money in regard to WTP. Again this is consistent with previous research findings such as Brouwer et al. (2008) and Shaari et al. (2020), indicating that the quality of the environment and carbon offsetting are normal goods. This represents an opportunity to introduce nationwide policies to curb carbon emissions, given that ordinary Chinese people's income has been steadily improving in recent decades and is likely to continue in the coming decades.

Lu and Shon (2012) find that age has a negative relationship with the WTP for carbon offsetting while Shaari et al. (2020) reports a positive relationship for this variable. The respondents in our study are mainly young adults and this variable does not vary much and so it does not capture a significant impact on the WTP. However, the education variable in this study has a negative sign, probably because education on environmental protection and climate change has not been taken seriously until recent years. This is understandable because for a long time China put economic growth as its priority and the environment could be sacrificed in meeting this goal. For a long time, school teachers themselves did not have necessary environmental knowledge and resources to implement the environmental education curriculum and guidelines issued by the Ministry of Education of China in 2003 (Tian & Wang, 2016). However, things have improved gradually in the last decade. With the environmental value becoming part of their early education, the new generation would have more knowledge about the environmental changes and thus can develop a stronger sense of social responsibility.

In fact, almost all previous studies point out that the level of environmental awareness (e.g., understanding the negative impact of flying on the environment) can significantly increase the WTP for carbon offsets or carbon taxes. The respondents in this study are no exception. The lack of understanding and awareness serves as a significant barrier that can deter and delay climate change action at both individual and national levels (González-Hernández et al., 2019). Without understanding the threat of climate change, airlines and individuals would make little effort to implement carbon emission mitigation schemes and adaptation actions. There is no doubt that environmental education can also help develop the sense of global citizenship and improve students' perception of their responsibility for emissions reduction in their daily life. The latter is positively associated with the amount of money in regard to WTP, at least in the domestic market as shown this research.

China is both the world's manufacturing hub and its largest carbon emitter. Thus, the Chinese government is in a unique position to lead actions reducing CO_2 emissions and preventing global warming. González-Hernández (2019) note that, on the one hand, people believe that the government should take more responsibility regarding the climate change agenda while, on the other hand, the government frequently was perceived as a bad decision marker and could not be trusted. Therefore, it is important for the government to win the trust of its people in implementing the government-led carbon emissions reduction projects. Increasing transparency can raise the credibility of the government and the carbon emissions reduction projects, which would increase Chinese travellers' WTP as suggested by our research. With the Chinese president's climate change pledge announced in 2020, Chinese travellers will form an expectation that reducing carbon emissions will be at the top of the government's agenda. If that is the case then an increase in trust in the government will likely ensue, which will in turn result in a higher WTP for both airline offset schemes and government carbon taxes on aviation.

Since 2020 the air transport sector has been affected severely by the Covid-19 pandemic and aviation activities have decreased substantially. Consequently, the ICAO has adjusted the emissions baseline rule under CORSIA for international aviation to reduce the airlines' obligations. The negative impact of Covid-19 on the WTP shows that people may become less vigilant in combating global warming, given that the pandemic lockdown and confinement measures have caused a decrease in economic activity. However, the OECD (2020) pointed out that the drop in emissions is temporary and will be insignificant for climate change if strong climate policy action is not taken. The WMO (2020) reports that a preliminary study suggests that there was a reduction in annual global emissions of between 4.2% and 7.5% in 2020 which, at the global scale, is not enough to cause the atmospheric CO_2 to drop. Such information should be delivered clearly to the general public so that taking steps to reduce CO_2 does not become a less urgent issue even if the pandemic persists. Understanding this will help Chinese people increase their willingness to participate in and pay for the carbon

footprints of their air travel.

In summary, our research finds that Chinese future frequent flyers' WTP for carbon emissions reduction is significantly related to their income, gender, education, cognition about environmental protection and the carbon offset schemes. The relatively lower level of WTP amounts reported in this study compared with those of European travellers is not surprising, as family income in China is lower and large-scale actions to reduce emissions have not been implemented across industries. The fact that this survey was conducted during the Covid-19 pandemic also contributed to this outcome. Most importantly, China was a reluctant participant in fighting global warming in the past and always sought exemption for its responsibilities in dealing with this problem. However, this fundamentally changed in 2020 and the serious commitment by President Xi will likely result in the introduction of carbon reduction schemes such as offsets and taxes in the aviation sector in the coming years. This is the first study to examine Chinese travellers' WTP in both scenarios for domestic and international travel, which will have practical policy implications for both the government and the aviation industry. More studies on these issues in the Chinese context can be expected in the near future because of the significant role that China can play in preserving our planet.

One limitation of this research is that the availability of high-speed rail is not considered in our survey. These days high-speed rail has been seen as a 'greener' transport mode than air (Dobruszkes et al.,2014). Brouwer et al. (2008) note that the existence of alternative transport would affect consumers' WTP for their carbon footprints. Some consumers may feel that morally they should contribute more for their air travel carbon footprints if they do not choose a greener alternative such as high-speed rail, a strong competitor to air transport in China (Zhu et al., 2019; Zhang, et al., 2020). This issue needs to be considered in future studies.

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