An experimental study to explore WTP for aviation carbon offsets: the impact of a carbon tax on the voluntary action

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As Australia recently introduced a mandatory carbon price, this paper provides a rare perspective of how such institutional changes influence consumer preferences for voluntary climate action. When examined using three contingent valuation questions, the results show that the compliance mechanism induces a substantial reduction in the number of air travellers who are willing to pay extra for voluntary carbon offsets and in the payment amount, although the crowding-out effect is incomplete. A disproportionately larger welfare benefit is attached to the carbon offsets for a domestic flight than its international counterpart. Overall empirical findings advocate the continued role of voluntary programs.

Keywords: voluntary carbon offsets; carbon tax; contingent valuation; air travel; willingness to pay

1. Introduction

The aviation industry is one of the fastest growing industries in emitting greenhouse gases (The Global Aviation Industry 2010). As Australia provided a leading example with the introduction of a carbon price, Australian companies face both domestic and international pressure to mitigate their carbon footprints. Domestically, the Clean Energy Legislation, introduced on July 01, 2012, specifies domestic aviation as one of the targeted industries that are subject to a carbon price (or tax) of AU$23 per tonne of CO_2. Internationally, the EU Emissions Trading System was put into effect in 2005 and aviation emissions were included on the first day of 2012, aiming for a 50% reduction from the 2005 emission level by 2050 (European Commission Climate Action 2011). In Australia, major airlines have operated voluntary carbon offset programs since 2007. Qantas and Virgin Australia have “fly carbon neural” programs that are linked to various carbon offset projects around the world, involving forest protection, renewable energies, and efficient cook stoves (Qantas 2012). Offset payments by consumers are used to purchase carbon offsets from the projects that are accredited by the Australian National Carbon Offset Standard. With the introduction of the carbon price, these voluntary carbon offset schemes might work in parallel with the mandatory compliance regime.

There has been a range of criticism about carbon offsets in the literature. The critiques of carbon offsetting schemes relate to the low credibility, confusion and complexity of the schemes, as well as low levels of transparency (Gössling et al. 2007 ; Broderick 2008 ; Polonsky, Grau and Garma 2010). Other authors highlight that carbon offsetting has not resulted in direct reduction of emissions (Gössling et al. 2007), and that it is a cheap way to buy “environmental pardons” (Kollmuss and Bowell 2007); that is, for people to feel better about the greenhouse gases resulting from their flights.

Carbon offsets could act as disincentives to change the behaviours of travellers due to their low cost and ease (Metz et al. 2007). Nonetheless, voluntary carbon offsets have been the only channel for both airline companies and air travellers to address climate change in the absence of legal requirements and are expected to do so even after mandatory mechanisms to reduce carbon emissions are put in place.

Even though most air travellers are aware that their flights are contributing to climate change (Gössling et al. 2009) and say they are willing to pay a mandatory carbon tax (BBC 2007 ; Brouwer, Brander and Van Beukering 2008), a small portion (between 1% and 2%) of international travellers actually pay extra for voluntary offsets (Gössling et al. 2009 ; Chang, Shon and Lin 2010 ; McKercher et al. 2010), with about 10% stating their intention to do so (Hooper et al. 2008). Australian travellers showed a higher uptake rate of about 10% for domestic flights (Commonwealth of Australia 2009) or 16% for general offsetting experience (Mair 2011). Consistent with Mair (2011), these statistics suggest that there may exist a small group of committed travellers who are ready to pay their carbon offsets regardless of institutional changes.

A few empirical studies applied stated preference nonmarket valuation methods to measure willingness to pay (WTP) for aviation carbon offsets and reported its estimates per person ranging between AU$20 and AU$42 per tonne of CO_2 (Brouwer, Brander and Van Beukering 2008 ; MacKerron et al. 2009 ; Lu and Shon 2012). On the other side of the coin, there is the possibility that WTP values for carbon mitigation might be sensitive to changes in regulatory regimes. Recent findings showed a substantial decrease in the rate of support for a payment, when its hypothetical payment setting was changed from a mandatory regime (a carbon tax) to a voluntary regime (Akter et al. 2009 ; Stithou and Scarpa 2012). As one reason for this decrease, people are generally concerned of how others share the responsibility (Shaw and Thomas

2006). As to the impact of different payment vehicles on WTP levels, the literature shows mixed results using contingent valuation. On the one hand, respondents might have incentives to behave strategically so that they overstate their true preferences under a voluntary setting (Stithou and Scarpa 2012). On the other hand, respondents might tend to free-ride for the provision of the public goods under the voluntary regime so that their WTP estimates are lower than under the mandatory regime (Jakobsson and Dragun 2001 ; Wiser 2007). However, little is known in the literature about the impacts of new compliance regimes on offsetting behaviour and the resulting economic value of voluntary carbon mitigation under the regimes. Although governmental contributions to public goods can "crowd-out" voluntary contributions (Bowles 2008), this effect might be incomplete (Andreoni 1993). There is also a knowledge gap regarding the impacts of different methodological approaches on the WTP estimates, such as different geographical frameworks (i.e., domestic vs. overseas trips).

This paper aims to investigate how consumer preferences for aviation carbon offsets evolve with institutional changes in Australia, particularly involving the introduction of the mandatory carbon price. Passive use values for voluntary offsets will be comparatively examined with and without the collective payment. By doing so, this paper provides new insights into whether the mandatory payment causes a complete "crowding-out" effect. Further, the issue of whether or not WTP estimates are significantly different between domestic and international flights will be also examined.

The organisational structure of this paper is as follows. Recent nonmarket valuation studies involving aviation carbon offsets are briefly reviewed and research hypotheses are introduced in the following section. The theoretical models of this study are presented in Section 3, while survey designs and data collection procedures are described in Section 4. Sections 5 and 6 provide results and discussion, and concluding remarks, respectively.

2. Nonmarket valuation of aviation carbon mitigation

2.1. Nonmarket valuation

Climate change is a prime example of pure externalities on a global scale. Emissions of greenhouse gases had been mostly free until the human-caused climate change became widely accepted as public bads and became a part of an internalisation process after the 1992 UN Rio conference. Thus, reductions of greenhouse gases are public goods wherever the actual reductions occur on the planet. Consumers of the climate system do not compete against one another to enjoy improved climates or reduced impacts of climate change. Neither is there discrimination for their consumption of the global benefits. As the internalisation process is not completed, however, the welfare benefits or economic values of carbon mitigation are not fully revealed by available market signals, such as the prices of the emission trading schemes, carbon offset projects, and a carbon tax. Consequently, special valuation methods are required to measure the economic value placed on the changes of these goods by the public. Welfare benefits of public goods are commonly measured using contingent valuation methods (CVM) or discrete choice experiment (DCE).

The literature provides a few empirical studies that examined monetary values of carbon offsets in the aviation sector. Some researchers reported economic values of air travellers for their voluntary carbon offsets using double-bounded dichotomous choice CVM questions (Brouwer, Brander and Van Beukering 2008 ; Lu and Shon 2012). For example, Lu and Shon (2012) interviewed 1,339 Taiwanese international travellers at

Taoyuan International Airport in January 2011 and found a mean WTP per tonne of carbon emissions ranging between US$20 (about AU$20) and US$28 per person, depending on the destinations. Travellers to Northeast Asia expressed the highest WTP, about US$28, while those heading to Western and Southeast Asian countries expressed the lowest, about US$20. Brouwer et al. (2008) also collected survey data involving 400 passengers at Amsterdam Schiphol Airport in November 2006, and found a mean WTP of €25 (about AU$42) per tonne of CO_2 emissions, in a form of carbon travel tax. Among the respondents, European travellers showed the highest WTP (€41), followed by North Americans (€17) and Asians (€10). On the other hand, MacKerron et al. (2009) applied the DCM technique in an online survey involving 321 British adults aged between 18 and 34 in March 2007. For a hypothetical flight from New York to London that produces about a tonne of CO_2, the value of offsets was estimated to be £13.2 (about AU$33) per person.

2.2. Research hypotheses

Stated preferences can be influenced by various factors. In the area of aviation carbon offsets, institutional changes such as a new carbon price might work as an exogenous factor that influences offsetting behaviour of air travellers and their perceived economic values of voluntary carbon mitigation. Although institutional interactions between collective and voluntary regimes take place in the real world, the empirical evidence is rarely reported in the literature. Global carbon markets are still limited and the average price was US$6.1 per tonne of CO_2 in the voluntary markets and US$17.4 in the regulated markets in 2011 (Peters-Stanley and Hamilton 2012). As discussed above, the mandatory markets such as the Australian carbon price might not be able to reveal the full scale of consumer preferences for carbon mitigation; thus, there is a potential for a positive WTP for a group of consumers even after a mandatory carbon price is paid.

This expectation is to have a significantly lower but non-zero WTP for carbon offsets after introducing a carbon price (WTP_{price}) than the WTP without a carbon price (WTP_0):

H1A. $WTP_0 > WTP_{price}$

H1B. $WTP_{price} > 0$

Some endogenous factors can be also considered, such as different study frameworks. Framing variations of substitute goods and their level changes cause a significant impact on WTP estimates (Rolfe, Bennett and Louviere 2002). Framing effects in the context of aviation carbon offsets can be tested by comparing WTP estimates between domestic flights and international flights. Lu and Shon (2012) showed that Taiwanese travellers with different destinations might have different WTP values. However, it is not clear whether or not WTP values are significantly different between domestic and international (or intercontinental) flights. Considering that most compliance regimes are bound by jurisdictional limits, air travellers might hold different levels of WTP between the two geographical boundaries. This novel comparison does not have any reference in the literature, except for the case of domestic frequent flyers (but not international counterparts) who showed a higher WTP than the others (Brouwer, Brander and Van Beukering 2008). A recent study by Choi and Ritchie (2014) also indicated that being domestic frequent flyers might work as a major determinant for being carbon offsetters.

As a potential reason for the significant framing effect between domestic and international flights, a lack of alternative modes of transportation for international or intercontinental flights might make travellers feel less obliged to pay for voluntary carbon offsets. Alternatively, long-haul travellers might hold a strong sense of the right to travel, particularly for holidays, with relatively stronger moral responsibility attached to domestic flights (Higham and Cohen 2011). The perceived climate responsibility might work in balance with the right to travel and different principles or norms might be applied when individuals face two different offsetting frameworks (Becken 2007). Accordingly, our expectation is to observe a higher economic value attached to carbon offsets for domestic flights than that for international flights.

H2. $WTP_{dom} > WTP_{int}$

3. Theoretical model

CVM is one of the most widely used nonmarket valuation methods (Mitchell and Carson 1989 ; Bateman and Turner 1993 ; Venkatachalam 2004) and its applications adopt various types of questions, such as open-ended (Stithou and Scarpa 2012), payment ladder (Mahieu, Riera and Giergiczny 2012), dichotomous choice (Jin, Wang and Ran 2006), and payment cards (Ready, Navrud and Dubourg 2001). This paper adapted a payment ladder approach. In payment ladder applications, respondents are normally asked to select all the payment levels that they are willing to pay for the given policy change. Alternatively, respondents are provided with multiple payment levels and asked to indicate one particular level that they are willing to pay for the given policy situation. In order to employ random coefficients in the underlying indirect utility function (McFadden and Train 2000), a payment ladder question can be transformed into a discrete choice format. Given that respondents considered the full range of payment levels and selected the one that is close to their maximum WTP, other payment levels lower than the selected can be naturally interpreted as selected. As demonstrated by Choi (2013), each non-zero payment level in a particular CVM question can be interpreted as an additional attribute of the choice set that offers a binominal choice between a ‘select’ option with that particular payment and a ‘reject’ option without payment (McFadden 2001). If respondents select this level or higher, it is coded as ‘1’, otherwise as ‘0’. Consequently, a payment ladder question with six non-zero levels can be subsequently transformed into six binomial choice questions. This transformation helps researchers maximise the empirical information that are analytically available by employing random coefficient models.

The theoretical basis of the CVM and DCE methods is the random utility maximisation model. Respondents are expected to maximise their utilities during the choice process by selecting the alternative with the highest utility, while some parts of the overall utilities remain stochastic (McFadden 1987). The overall expected utility of individual q facing option i (U_{iq}) is described with the systematic component (V_{iq}) and the stochastic component (ε_{iq}). The systematic component is commonly known as the indirect utility and provides an empirically meaningful way to link between the choice behaviour of respondents and their maximised utilities. Following the characteristic theory of value (Lancaster 1966), the indirect utility can be described as the following function:

$$V_{iq} = \alpha_{iq}X_i + \beta_q(\alpha_{iq}Z_q) + \gamma_q M_i \quad (1)$$

where X_i is the alternative specific constant (ASC) that characterises alternative i with a non-zero payment ($X_i = 1$) for the proposed change (e.g., having voluntary carbon offsets in this study) against a zero payment alternative ($X_i = 0$) without the change in the binary choice setting; α is a normally-distributed random coefficient, and β and γ are non-random coefficients; $\alpha_{iq}Z_q$ is the interaction term between α_{iq} and a vector of respondent characteristics (Z_q); and M_i is each payment level that was offered to the respondents. In order to estimate these coefficients, individual choices in the given number of choice situations need to be examined and compared with a probability statement, following the logic of the maximum likelihood estimation. The probability for individual q to choose alternative i among A number of alternatives can be expressed as follows:

$$P_{iq} = P(i|i, j \in A) = P[(V_{iq} - V_{jq}) > (\varepsilon_{jq} - \varepsilon_{iq})] \text{ for all } j \neq i \in A \tag{2}$$

$$p_{iq} = \frac{\exp V_{iq}}{\sum_{j=1}^{J} \exp V_{jq}} \tag{3}$$

Different axiomatic assumptions on the random components and preference heterogeneity lead to different estimation models such as multinomial logit (MNL) models and random parameter logit (RPL) models. When choice models are estimated and coefficient estimates become available, WTP for a policy change can be calculated as a negative ratio between the parameter of the alternative specific constant (α) and the bid parameter (γ):

$$WTP = -\frac{\alpha + \beta\overline{Z}}{\gamma} \tag{4}$$

where $\overline{Z}$ is a vector of the mean values for respondent characteristics (Z_q).

4. Experimental study

In order to investigate whether a newly introduced carbon price and differing geographical boundaries of flights cause significant impacts on WTP for voluntary carbon mitigation, an online survey was carried out involving students and staff members of one Australian university in June 2012. Considering the increasing importance of young student travellers in the global tourism market (UNWTO/WYSE Travel Confederation 2011), the sample was constrained to Australian adults who were studying or working with a high educational qualification. Further, the survey was conducted as part of a large-scale project and offered unique observations before the carbon price was implemented. Thus, any generalisation of the results beyond this sample toward the wider society may be difficult or requires a cautious approach. CVM questions with multiple payment levels were included as a part of the survey that examined motivational factors for carbon offsetting behaviour and stated preferences. Following literature reviews and two focus group studies in the university, online questionnaires were improved using a pre-test involving 64 students. As to the background information for the contingent questions, respondents were provided with recent policy changes about the Clean Energy Future Legislation and asked to consider their recent air travelling and offsetting experience.

As Table 1 and Appendix A show, three contingent questions were described with the amount of carbon emissions from flights, characteristics of carbon offset projects that are available, other mitigation measures of airline companies, and payments for voluntary carbon offsets. Specifically, offset project descriptions were provided as location, type of projects, and legal effects of carbon credits. Other airline measures were introduced as biofuels, technologies, and operational efforts. Among these attributes, the amount of carbon emissions and the payment of the carbon price were varied among the three CVM questions, while other attributes were fixed as background information. This was designed to provide a simple and consistent valuation context to the survey respondents.

The payment levels were decided based on a literature review and the three levels of offsets offered by British Airways regardless of actual flight distances (GreenAir 2011): £3 (AU$5), £10 (AU$17) and £20 (AU33). As shown in Appendix A, payment levels were designed to provide more options compared to real offset payments for domestic flights. For example, as of June 2012, for a budget flight between Brisbane and Perth (an original ticket price of about AU$260 with baggage), individual travellers are asked to pay about AU$4 for voluntary offsets for their flights producing on average of about 412kg of carbon emissions. In this case, the payment unit is AU$9.20 per tonne of CO_2 equivalent. In terms of emission amounts, emission data for real exemplary flights were provided right before the contingent questions. For instance, air travels from Sydney to Perth and London cause about 330kg and 2,000kg CO_2 equivalent, respectively.

[Table 1 about HERE]

The three CVM questions were designed to deliver the identical background information except for the geographical boundaries and whether or not the carbon price[1] is paid over the original ticket prices. As shown in Appendix A, it was aimed to provide a consistent delivery of three valuation questions with the advanced disclosure of what respondents will do and how they understand the questions. This approach is known to avoid ordering effects (Bateman et al. 2004). The first question (CVM1) asked respondents to indicate their maximum WTP for a domestic flight (330kg CO_2), for which the carbon price was not charged, whereas the third question (CVM3) was for an international flight (2,000kg CO_2). The second question (CVM2) is for a domestic flight (330kg CO_2) that included the carbon price. In effect, the second and third questions were dependent on the first question in terms of differing valuation frameworks. This ordering was intentionally designed to examine the 'conditional' impact of the new carbon tax on people's WTP for carbon mitigation.[2] After all, this study is not interested in measuring the true economic value of this impact, but rather its relative size and significance.

The remaining part of the questionnaires was about individual characteristics that involve both psychometrics and socio-demographics. According to the value-belief-norm theory of Stern (2000), environmental attitudes and beliefs work as motivations for environmentally motivated behaviours (e.g., voluntary carbon offsets in this paper). This paper adopted two most widely used measurement scales in the literature: the New Ecological Paradigm (NEP) scale of Dunlap et al. (2000) for general attitudes and the Theory of Planned Behavior (TPB) of Ajzen (1991) for behaviour-specific attitudes and norms. It needs to be noted that although a poor or weak explanatory power of general attitudes for specific environmental action is generally shared in the literature (e.g., the principle of compatibility), their influence might work through indirect processes such as interpretation of the situation, heuristic comparison between alternatives, and perceived consequences of the alternatives (Ajzen 1989 ; Bamberg 2003).[3] Thus, examination of both general and behavior-specific attitudes might provide a better explanation of choice behaviors and stated preferences. These scales provided well established theoretical constructs with multiple indicator items that are expected to be jointly determined by individual factor scores. In order to avoid the endogeneity problem resulting from direct inclusion of attitudinal indicator items into choice models, the current study estimated a structural model before the resulting factor scores were subsequently incorporated into choice models: a sequential estimation of a structural choice model (Daly et al. 2012).

5. Results

The online survey was carried out on the campus of one Australian university in late June 2012, right before the Clean Energy Future Plan was put into effect. A total of 349 respondents completed the survey. As shown in Table 2, the sample included about equal numbers of students (n = 176) and staff (n = 173) respondents. Female respondents (about 69%) and young respondents who are less than 35 of age showed a dominant presence. As expected, students were mostly single (about 71%) with a low household income, while many staff respondents (about 65%) were married or partnered with their income levels belonging to a relatively high household income.

[Table 2 about HERE]

Among the sample respondents, 30% (106 respondents) had previously participated in voluntary offsetting programs at least once, which is substantially larger than the 16% experience rate of Mair (2011). This anomaly might be caused by different timings of the two studies because Mair (2011) collected the data in August 2008, or by a relatively high educational background of this sample. When respondents were asked to indicate their WTP in the three contingent questions, about 79% of the respondents showed a positive (non-zero) level of payment for voluntary carbon offsets without a carbon price, while this figure dropped to about 52% if there were a carbon price paid as a part of the ticket prices. Of the latter respondents, 53% (96 respondents) kept the same level of offset payments regardless of a carbon price. When asked about their support for the carbon price policy, 44% (153 respondents) reacted positively. This figure indicates a slightly higher level of support than a 33% level that was reported as a nationwide figure during this time (ABC 2013). Furthermore, a substantial portion of respondents identify themselves as frequent flyers either for domestic flights (46%) or international flights (39%). In terms of the general intention to pay voluntary carbon offsets, 39% (135 respondents) had a positive intention. This is substantially higher than the 10% figure of Hooper, et al. (2008).

Attitudinal characteristics were also analysed. Respondents as a whole had a positive predisposition toward carbon offsets. General environmental attitudes were measured using a shorter version of the NEP scale with ten statements (Dunlap et al. 2000): items 1, 3, 5, 6, 7, 8, 9, 12, 14, and 15. It was intended to have two items for each of the five 'theorised' facets of this scale.[4] These statements were assessed with five-point scores between 'strongly agree (1)' and 'strongly disagree (5)'. Odd numbered items were reverse coded so that higher scores indicate stronger pro-environmental attitudes. It is known that the NEP scale is a single factor and a total sum factor score is normally used (Choi and Fielding 2013). Its estimated factor score was 3.62 and its reliability coefficient was 0.71.

Further, in order to measure behaviour-specific attitudes of respondents several statements were prepared for two major factors following the guidelines of Ajzen (2002), which were assessed on a seven-point scale (e.g., extremely good-extremely bad). Estimated mean factor scores show that respondents on average have a slightly positive position in their attitudes toward offset payments (ATT; mean = 3.86), and people who are important or close to them are likely to work as a normative barrier to paying for carbon offsets (SN; mean = 2.46).[5] Their reliability coefficients were 0.90 and 0.87, respectively.

5.1. The impact of a carbon price

In order to test whether a carbon price and different geographical boundaries have a significant impact on WTP for voluntary carbon offsets, binary choice models (i.e., the transformed binary choices from the multiple payment levels) were constructed and improved by incorporating various characteristics of respondents as interaction terms. Most variables were coded as dummy variables, including support for a carbon price (CARP; neutral or disagree=0, agree =1), gender (GEN; male = 0, female =1), job (JOB; student=0, staff=1), and annual household income in AU$1,000 (INCOME). Attitudinal variables were also incorporated into choice models as estimated factor scores.

Three datasets were constructed from the three CVM questions and independently analysed using NLOGIT 4.0, for a domestic flight with or without a carbon price (CVM1-A and CVM2-A, respectively) and an international flight (CVM3-A). Following the argument of Mair (2011) regarding a group of committed travellers for aviation carbon offsets, this paper distinguished non-zero bidders and estimated new random parameter logit models separately: CVM1-N, CVM2-N, and CVM3-N, respectively. As a result, there were six models that were estimated either for the full sample or groups of non-zero bidders, as shown in Table 3. According to the estimation results, these models have a significant model fit at the 1% level, based on a Chi-square

(X^2) statistic. In terms of pseudo R^2 values, a value of 0.50 signifies an extreme model fit (Hensher and Johnson 1981). However, cautious interpretations might be required because the transformation process from a single CVM question to multiple binary choice sets might have caused an over-estimation of the fit.

In terms of utility sensitivity, respondents show significant heterogeneity around the means of the ASC parameters across these models. As to the source variables for the revealed heterogeneity, significant interaction terms for each model are only reported in Table 3. Behaviour-specific attitudes towards the voluntary offset payment show a positively significant impact on the economic value of voluntary mitigation across the six models. For the full sample, general pro-environmental attitudes display a positive impact on WTP only when a carbon tax is not included for a domestic flight (CVM1-A), while subjective norms have a positive impact on WTP if it is included as precondition (CVM2-A), ceteris paribus. As to the committed travellers under the price policy (CVM2-N), those who hold strong environmental attitudes or support the price policy are more likely to have a higher WTP value than the others, ceteris paribus. For the committed group members considering an international flight (CVM3-N), income levels show a positive impact on their WTP values for carbon-neutral flights.

[Table 3 about HERE]

Economic values for the three choice situations that were delivered by three contingent questions can then be calculated using the estimation results and equation (4). In order to do that, the first step was to consider significant interaction effects that were incorporated as parts of economic models. Mean values for the ASC parameters were recalculated using the following equation:

$$ASC = \alpha + \sum_{k=1}^{K} \beta_k \overline{Z}_k + \eta \qquad (5)$$

where α is the mean parameter of the ASC attribute as part of model outputs; $\overline{Z}_k$ and β_k are the kth interaction variable and its parameter, respectively; η is the parameter distribution that is defined by a standard deviation parameter σ for a normal distribution $N(0, \sigma^2)$. For example, for Model CVM1-A, the newly calculated mean for the ASC parameter estimate equals -15.4669+ 1.9704× NEP + 3.6619× ATT. As a result, the newly estimated ASC parameters for Models CVM1-A and CVM3-A are respectively 5.8135 and 15.0586. It is -0.6315 for Model CVM2-A, which is not significantly different from zero at the 0.05 level.

[Figure 1 about HERE]

Mean WTP estimates and their confidence intervals (Krinsky and Robb 1986) for the situational change between the CVM1 and CVM2 questions (i.e., the conditional impact of the carbon price) are shown in Figure 1. It should be noted that this paper aims to examine relative sizes and the statistical relationship between the WTP estimates of two different valuation conditions, not the absolute WTP values. The only difference between the two questions was whether or not the carbon price was paid for the identical domestic flight (i.e., the second question was conditioned on the first question). There are two sets of estimation results for the full sample and groups of non-zero bidders. Firstly, considering the results for the full sample (CVM1-A and CVM2-A in Figure 1), the domestic flight without paying the mandatory price has a mean WTP estimate of AU$9.80 per flight, while that for the same flight with the mandatory price is not significantly different from zero at the 0.05 level. The confidence interval for the latter (CVM2-A) provides a reference range of the mean WTP estimate, which can help test the first two hypotheses. Consequently, we can confidently accept H1A and confirm that the mandatory payment of a carbon price significantly influences people's WTP for aviation carbon offsets. In contrast, the WTP estimate becomes nil when the mandatory price needs to be paid, thus rejecting H1B.

Secondly, involving the estimation results for groups of non-zero bidders (CVM1-N and CVM2-N in Figure 1), both domestic flight situations with and without the carbon price have significantly positive WTP estimates at the 0.05 level. Mean WTP estimates are AU$13.94 and AU$11.04 per flight, respectively. As a result, HIA and HIB are accepted for these groups of travellers.

5.2. The impact of different geographical boundaries

Analyses were also conducted to test whether different geographical boundaries have a significant impact on WTP estimates, by examining estimation results from the two valuation questions without a carbon price. The two choice scenarios were the same except for their flying distances and carbon emissions. CVM1 relates to a domestic flight that produces about 330kg of CO_2, while CVM3 an international flight that produces about 2,000kg of CO_2.

Figure 1 shows that mean WTP estimates between the two flight situations are significantly different. However, it should be noted that their emission levels are also substantially different. In order to implement a systematic test of the third hypothesis (H2), two testing approaches were developed. The first approach was based on the One

Destination scheme of British Airways, which offers its passengers three fixed prices regardless of geographical boundaries (GreenAir 2011). The second testing approach applied a unit value of carbon emissions, which is the more traditional way of comparing estimates. For this purpose, a sensitivity test was used by taking varying levels of weight that the emissions attribute might have as a part of the mean WTP estimates. This paper included four weight levels: 100%, 75%, 50%, and 25%.

According to the first approach of the One Destination scheme, the mean WTP estimate for the international flight (CVM3-A in Figure 1) is AU$20.58 per flight, which is significantly larger than that for the domestic flight. If the committed groups are considered (CVM3-N), the mean WTP estimate is AU$31.15 per flight, which is also significantly larger than its domestic counterpart. As a result, H2 should be rejected.

On the other hand, the opposite was true when the second approach was taken as the testing method. In order to create the same flight condition that produces 1,000kg of CO_2, WTP estimates were recalculated according to the original emission amounts and the four weight levels. The new WTP estimates for the domestic flight and international flight are shown in Figure 2 (for the full sample) and Figure 3 (for the committed groups). There exists a clear trend from a 100% level (for example CVM1-A-100) to a 25% level (for example CVM1-A-25). As WTP values were proportionally transformed, they are subject to subsequently lower mean values and narrower confidence intervals. Nonetheless, mean WTP estimates for the domestic flight are consistently and significantly larger than those for the international flight, involving both the full sample and the committed groups. Therefore, this paper accepts H2 and confirms a higher WTP for domestic flights than international flights based on the same unit of carbon emissions.

[Figure 2 about HERE]

[Figure 3 about HERE]

6. Discussion and conclusions

As Australia recently introduced a mandatory carbon price, this study provides novel perspectives on how such institutional changes might influence the consumer demand for voluntary carbon mitigation, which were examined before the introduction. The primary objective of this research was to investigate interactions between collective and voluntary payment regimes. At the same time, the impact from different geographical frameworks on WTP was examined between domestic and international flights. The findings provide empirical evidence for the continued role of voluntary carbon offsets in the presence of the mandatory carbon price, thus support a complementary relationship between economic incentives and social preferences. As to the geographical impact of flights, travellers are willing to pay for neutralising their domestic flights approximately three times more than for neutralising international flights. Consequently, this finding supports the One Destination scheme of British Airways, which provide only several offset options to passengers regardless of the actual amount of carbon emissions.

The new compliance mechanism with a carbon price not only causes broad economy-wide impacts, but also induces a substantial reduction in the number of air travellers who pay extra for voluntary carbon offsets and in the payment amount. This paper showed that the proportion of non-zero bidders in contingent valuation was reduced from 79% to 52% when a domestic flight was imposed of the collective payment. This finding confirms the argument of an incomplete “crowding-out” effect for public goods (Andreoni 1993). This figure became 78% when the experiment was framed as an international flight without a collective payment. In terms of mean WTP estimates, the results showed a significant reduction when a carbon price is paid. The mean WTP for a domestic flight with the mandatory payment was not significantly different from zero. In contrast, the WTP gap between without and with the mandatory price became substantially reduced (i.e., AU$42.24.00 and AU$33.45 per tonne of carbon mitigation, respectively) when a group of committed travellers were only considered.

In the research context of this study, the collective payment was made independently and separately so that the voluntary offset payment was neither subject to free-riding (Jakobsson and Dragun 2001 ; Wiser 2007), nor to strategic behaviour (Stithou and Scarpa 2012). Accordingly, the valuation scenarios involved in this paper offers unique circumstances where the committed offsetters might act purely for their personal causes or moral satisfaction (Kahneman and Knetsch 1992). Their mean WTP that is significantly larger than zero provides a clear message for the aviation industry and policy makers about the nontrivial role of voluntary offset programs. However, this offsetting behaviour might be contradictory to the previous understanding of rational behaviour that reflects personal choices depending on how responsibilities are shared by others (Shaw and Thomas 2006), and to the “crowding-out” hypothesis (Bowles 2008).

The other issue in this paper was related to geographical boundaries of air travels. The collective payment of a carbon price, either in the form of tax or in the emission trading scheme, targets exclusively at domestic activities including air transportation, but the voluntary payment can be offered without the jurisdictional boundary. Empirical findings of this paper are consistent with the previous knowledge of the framing effects (Rolfe, Bennett and Louviere 2002) and the right-to-travel argument of Higham and Cohen (2011), which show a significantly larger WTP for a domestic flight based on the same unit of carbon emissions. Alternatively, other estimation biases such as scale effects might be also considered. International flights normally involve longer distances than domestic flights. Respondents who face an international flight might not be as sensitive to each unit of carbon emissions as they are to a domestic situation. As a result, their mean WTP for a tonne of CO_2 from the international flight becomes much smaller than that from the domestic flight.

The overall findings of this paper showed how contingent values are measured and estimated for passive use values for aviation carbon offsets, and also demonstrated that various population characteristics work differently for different experimental situations and their frameworks. Although the research findings offer additional insights into the evolving preferences for carbon offsets, limitations of the paper need to be carefully considered as well. The sample composition is not representative of the population. Although most implications of this study bear theoretical and practical relevance to policy, more exciting research explorations will be available for future studies by involving a more representative sample. For this purpose, a national sample can be designed to be stratified based on gender, age levels, and residential locations. Another shortcoming is about the limited information provided to the respondents. Ticket prices might provide valuable background information such as budget constraints and the comparative burden of paying extra for voluntary carbon offsets, thus improving the valuation context to be more realistic. Future studies may consider inclusion of price information for relevant flights. The third limitation is related to the characteristics of the committed travellers with non-zero bids. This paper did not fully engage in the discussion of preference heterogeneity and consumer profiles. As much as airline companies around the world continue their offsetting programs, this group of committed travellers need to be identified and prioritised for their communication and promotion activities for a world of carbon neutral flights.

Appendix A. Three valuation questions

SECTION C: Preferences for Voluntary Carbon Offsets

Over the next several questions, you are going to be asked to make choices based on some options available for your flights These options are described in terms of carbon emissions, carbon price, characteristics of offset projects, other alternative measures by airlines, and your voluntary payments. **Please look at the summary table below for information you will need to answer these questions.**

Table 1. Attributes for Voluntary Carbon Offsets of Your Flights

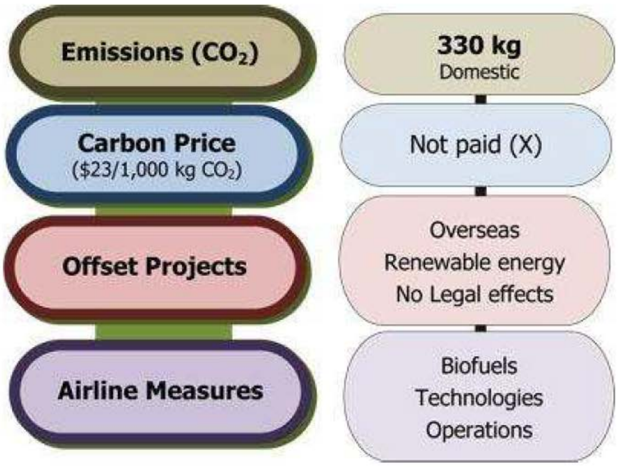
Attribute		Description
Carbon Emissions		Amount of carbon emissions from your flights depends on various factors, including travel distance, technology efficiency, and cargo weights.
Offset Projects	Location	Although most carbon offset projects are located in developing countries, domestic projects can be considered.
	Type	Major project types include renewable energy (solar panels or wind farms) and forest management (conservation or planting new trees).
	Legal effects	Offset payments can go to special projects that offer carbon credit units (ACCUs) cancelling off legal obligations, while most voluntary carbon offsets do not have legal effects.
Measures by Airlines	Biofuels	Low-carbon fuels (biofuels) can be used and blended with normal jet fuels.
	Technologies	Various technologies help reduce aviation emissions, such as aircraft designs, lightweight materials, and engine advances.
	Operations	Operational practices can be improved by reducing flight weight and improving flight procedures.
Voluntary Payments		Paying for carbon offsets is voluntary, additional to the original ticket price and a carbon price.

The quantity of carbon emissions mainly depends on the distance of the flight. For example, your flights from Sydney will produce different emission levels depending on the destinations as summarised in the following table:

Destination from Sydney	Distance (km)	CO_2 emissions (kg)
Brisbane	730	100
Perth	3,300	330
China (Shanghai)	7,800	1,000
London	17,000	2,000

[CVM Q1]

Suppose you make a domestic flight. Carefully consider the below characteristics of your flight, offset projects, and other measures of airlines:

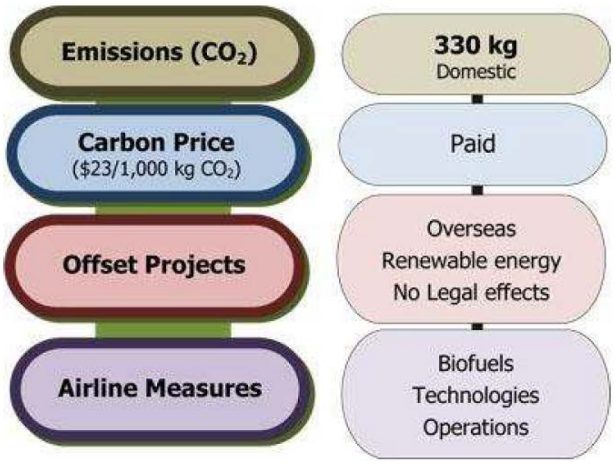


How much are you willing to pay for voluntary carbon offsets for this flight, with a carbon price not paid over the original ticket price?

$0	$1	$5	$10	$15	$30	$60

[CVM Q2]

Suppose you make a similar domestic flight as per the previous question. Carefully consider the below characteristics of your flight, offset projects, and other measures of airlines:

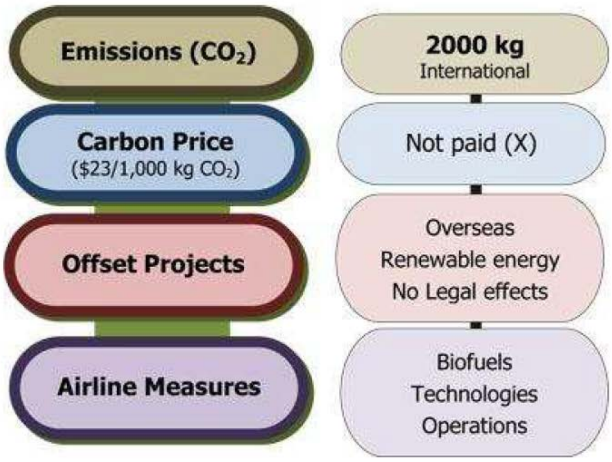


How much are you willing to pay for voluntary carbon offsets for this flight, with a carbon price paid over the original ticket price?

$0	$1	$5	$10	$15	$30	$60

[CVM Q3]

Suppose you make an international flight. Carefully consider the below characteristics of your flight, offset projects, and other measures of airlines:



How much are you willing to pay for voluntary carbon offsets for this flight?

$0	$1	$5	$10	$15	$30	$60	$200
○	○	○	○	○	○	○	○

[1] These questions clearly indicated a carbon price of AU$23 per tonne of carbon emissions. Provision of this information may be considered as value cues or anchoring effects. However, the carbon price policy was a real social and institutional change in Australia, which should be taken as a given background information of this study. This policy was subject to a long contentious debate before it was finally accepted in late 2011. Thus, results of this study should be considered to be conditional on this information. There may be a significant value cue or anchoring effect of the carbon price as part of the experimental design, which reflects a natural experiment.

[2] When this conditional impact was also measured in the opposite direction in a later study, the overall results were the same as reported in this paper.

[3] Non-market valuation studies normally involve hypothetical situations that are created to examine stated preferences. As a result, resulting economic values are essentially behavioural intentions that may face various barriers in reality that are not fully controlled in the research framework. Future studies may include actual choices as an explanatory variable to examine the attitude-action relationship.

[4] The five facets are the reality to limits of growth (items 1, 6, 11), anti-anthropocentrism (items 2, 7, 12), the fragility of nature's balance (items 3, 8, 13), rejection of exemptionalism (items 4, 9, 14), and the possibility of an ecocrisis (items 5, 10, 15).

[5] Items of subjective norms measure whether people close to or important to the respondents support the behaviour in concern. For instance, one item asked respondents to consider the statement "Most people who are important to me would think that I should pay for voluntary carbon offsets." A mean factor score lower than 4 means that it is less likely for respondents to agree with this statement.

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Table 1. Descriptive characteristics of contingent valuation questions.

Content		Description
Carbon Emissions (kg)		Amount of carbon emissions from your flights depends on various factors, including travel distance, technology efficiency, and cargo weights.
Offset Projects	Location	Although most carbon offset projects are located in developing countries, domestic projects can be considered.
	Type	Major project types include renewable energy (solar panels or wind farms) and forest management (conservation or planting new trees).
	Legal effects	Offset payments can go to special projects that offer carbon credit units (ACCUs) cancelling off legal obligations, while most voluntary carbon offsets do not have legal effects.
Measures by Airlines	Biofuels	Low-carbon fuels (biofuels) can be used and blended with normal jet fuels.
	Technologies	Various technologies help reduce aviation emissions, such as aircraft designs, lightweight materials, and engine advances.
	Operations	Operational practices can be improved by reducing flight weight and improving flight procedures.
Voluntary Payments (AU$)		Paying for carbon offsets is voluntary, additional to the original ticket price and a carbon price.

Table 2. Socio-demographic compositions (%) of the sample.

Variable		Full sample (n=349)	Students (n=176)	Staff (n=173)
Gender	Male	31.2	34.1	28.3
	Female	68.8	65.9	71.7
Marital	Single	42.1	71.0	35.3
Status	Married/separated	57.9	29.0	64.7
Age	15 - 24	29.8	51.7	7.5
	25 - 34	38.1	36.4	39.9
	35 - 44	14.9	5.1	24.9
	45 - 54	11.7	5.7	17.9
	55 or more	5.4	1.1	9.8
Income	$51,999 or less	35.5	60.8	9.8
	$52,000 - $103,999	32.1	19.3	45.1
	$104,000 or more	25.8	12.0	39.9
	Don’t know	6.6	8.0	5.2

Table 3. Estimation results using random parameter logit models.

Attribute	The full sample			Non-zero bidders		
	CVM1-A	CVM2-A	CVM3-A	CVM1-N	CVM2-N	CVM3-N
ASC	-15.4669**	-29.8361**	-69.0231**	0.8874	-2.5016*	-2.3219**
BID	-0.5931**	-0.9747**	-0.7360**	-0.3585**	-0.3924**	-0.1299**
ASC:AGE[b]					0.0623**	
ASC:INCOME[b]						0.0109**
ASC:CARP[b]					1.1579*	
ASC:NEP[b]	1.9704*					
ASC:ATT[b]	3.6619**	6.1872**	21.7631**	0.9455**	0.9332**	1.2826**
ASC:SN[b]		2.1551*				
NsASC[a]	7.0869**	14.1797**	35.5131**	2.5788**	2.7149**	2.4559**
Summary statistics						
LL	-614.63	-499.48	-718.80	-536.84	-364.95	-658.09
X^2	1673.64 [5]**	1903.93 [5] **	1949.12 [4]**	1205.39 [4] **	767.29 [6]**	1313.63 [5] **
Pseudo R^2	0.58	0.66	0.58	0.53	0.51	0.50
Respondents	349	349	349	274	180	271

[a] These are derived standard deviations of parameter distributions, assumed to be normally distributed.
[b] Interaction terms between the ASC random parameter and heterogeneity source variables. Only significant interaction terms are shown in this table; other insignificant terms were also examined and subsequently excluded.
* Significant at the 0.05 level, ** Significant at the 0.01 level.

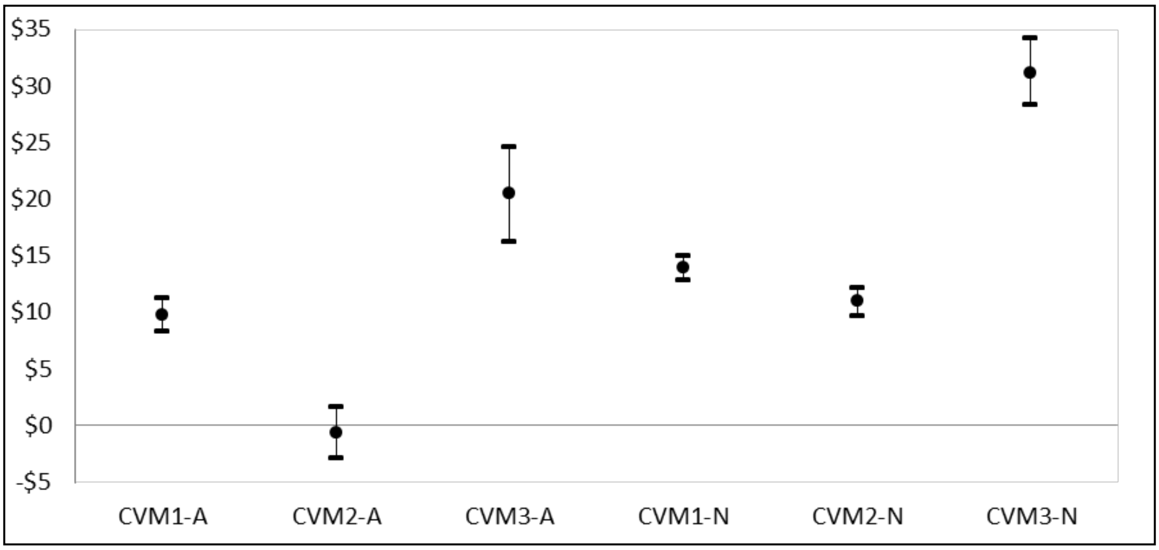

Figure 1. Mean WTP estimates and 95% confidence intervals.

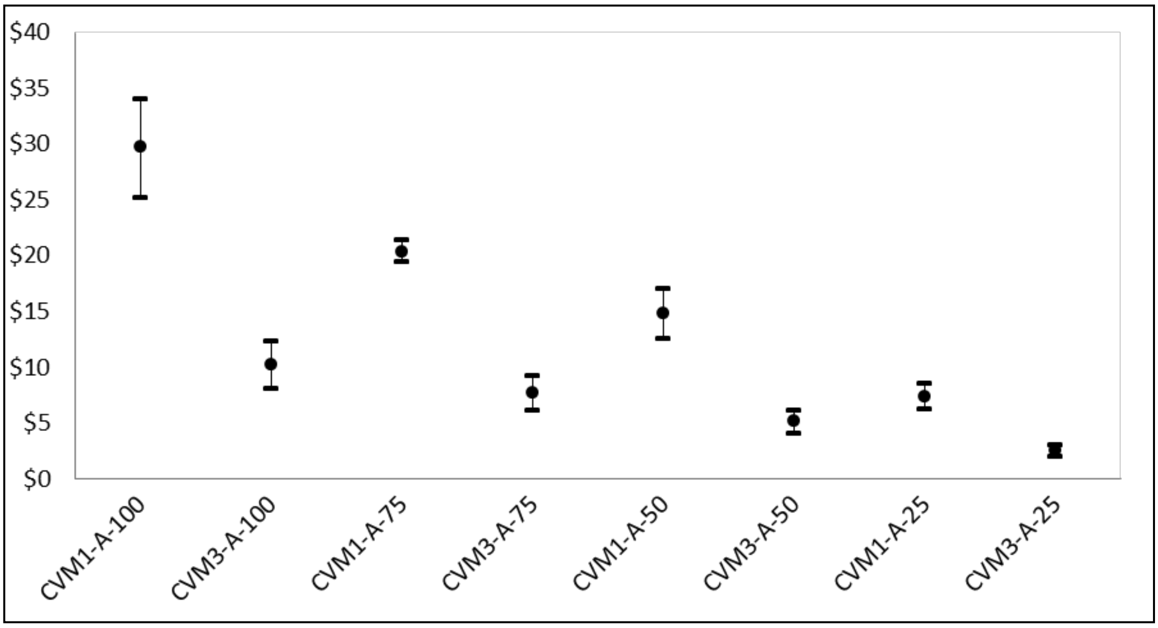

Figure 2. Mean WTP estimates and 95% confidence intervals for the full sample.

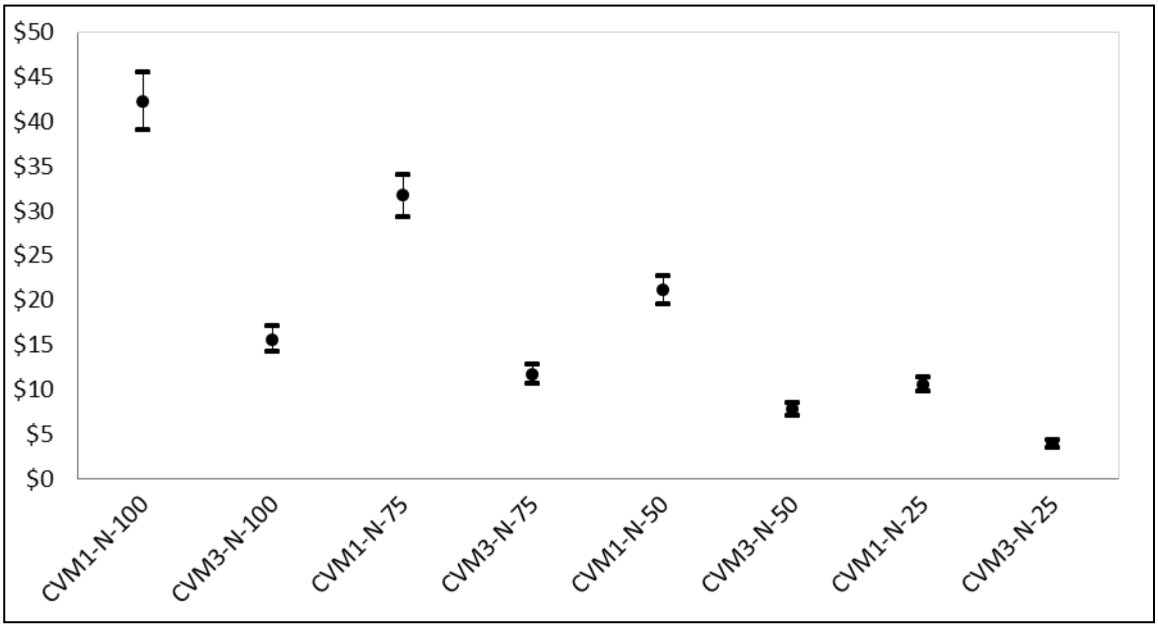

Figure 3. Mean WTP estimates and 95% confidence intervals for non-zero bidders.