

Supplementary information

People would rather pay more than fly less: implications for aviation decarbonisation

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Model specifications

The analytical modelling in this paper is based on the causal model shown in Figure S1. The main experimental variable was based on four principles of distributive justice, reflected in respective surcharge and budget designs, and a control group where no allocation or framing was presented. We measured two outcome variables, willingness to pay and willingness to change, and two moderator variables, personal fairness and group fairness. In addition, we analysed four covariates: flying frequency, flying purpose, income, and climate concern.

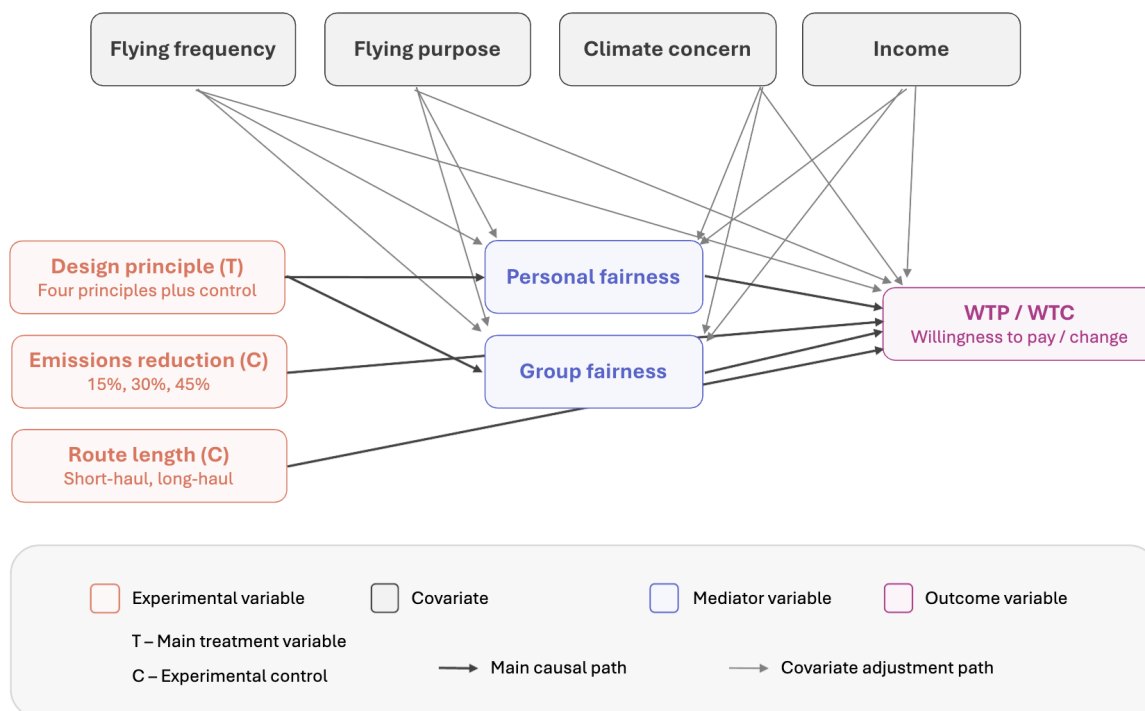


Figure S1: Causal model of this study, showing experimental, mediator, and outcome variables together with the measured covariates. The main treatment variable (T), design principle, represents four distributive justice principles (egalitarianism, limitarianism, prioritarianism, and proportionalism) plus a no-framing control, randomly assigned between subjects. Experimental control variables (C), emissions reduction level and route length, were also randomly assigned but are not the primary analytical focus. Route length was included only in the willingness-to-pay experiment and not in the willingness-to-change experiment. Grey arrows indicate covariate adjustment paths; models entering each covariate one at a time capture total effects on outcomes, including indirect effects operating through personal and group fairness perceptions; models including all covariates simultaneously isolate direct effects after controlling for fairness.

Below, we describe the model specifications used to produce each of the main figures. The three model types introduced in the main text — the basic experimental model (Equation 1), the subgroup interaction model (Equation 4), and the covariate prediction model — are used across Figures 1, 2, 4, and 5; Figure 3 shows the fairness scores descriptively and is not model-based.

Figure 1. The estimated marginal means and contrasts with the control group are computed from the basic mixed-effects model specified in Equation 1 of the main text, with the justice treatment T and the emissions reduction amount E as fixed effects, country-level random intercepts u , and, for willingness to pay, the relative added ticket cost C as an additional fixed effect.

Figure 2. The predicted outcome scores are computed from a covariate prediction model that includes personal fairness, group fairness, income decile, flying frequency (number of flights in the past 12 months), the climate concern sum score, and the emissions reduction amount as fixed effects, with country-level random intercepts. For willingness to pay, the relative added ticket cost is included as an additional fixed effect. Covariates are entered without interaction terms and predictions are obtained while the remaining covariates are held at their sample means.

Figure 4. The contrasts with the control group are computed from the subgroup interaction model specified in Equation 4 of the main text, run separately for flying frequency (on the left) and flying purpose (on the right). Each model includes the justice treatment, the subgroup variable, their interaction, the emissions reduction amount, and country-level random intercepts; willingness-to-pay models additionally include the relative added ticket cost.

Figure 5. The estimated marginal means and contrasts with the control group are computed from the subgroup interaction model specified in Equation 4 of the main text, with climate concern group (low / mid / high) entered as the subgroup variable interacting with the justice treatment. The model also includes the emissions reduction amount, country-level random intercepts, and for willingness to pay the relative added ticket cost.

Supplementary figures

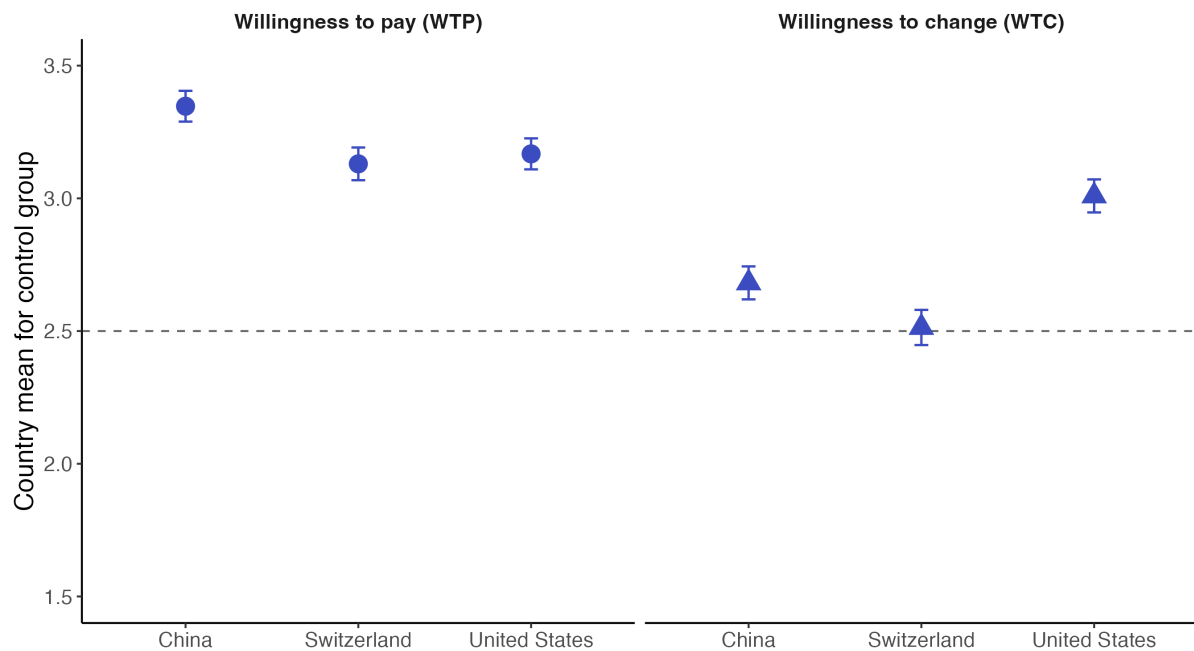


Figure S2: Estimated country means of the control group for A. willingness to pay and B. willingness to change based on country effects as random intercepts. There are no significant differences between the three countries in willingness to pay. Participants in the US were more willing to change their flying than their counterparts in Switzerland or China. The country means were estimated using the simple model set-ups with country-level random intercepts, two experimental variables – design principle and emissions reduction amount – and in the case of willingness to pay, relative added cost, specified in Equation 1.

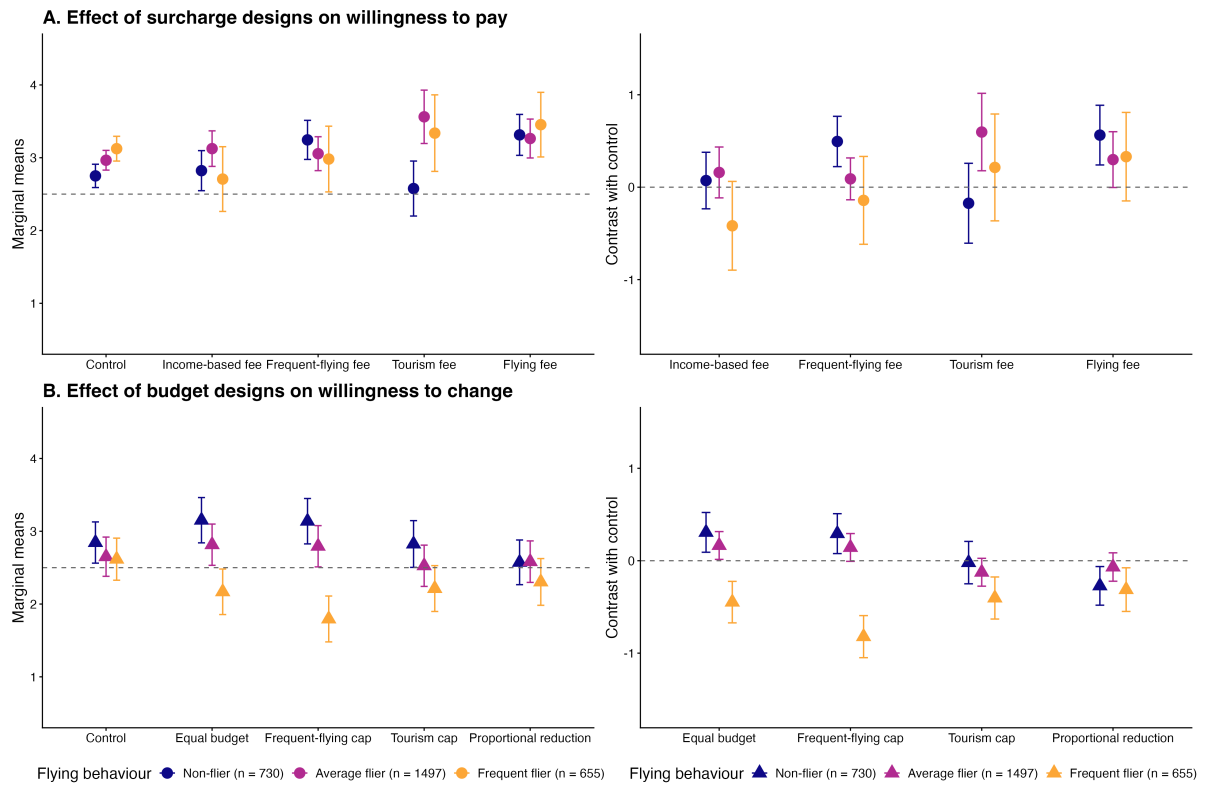


Figure S3: Estimated marginal means (left panels) and contrasts with the control condition (right panels) for WTP (circles) and WTC (triangles), stratified by flying frequency group (non-flier, average flier, frequent flier). Error bars show 95% confidence intervals.

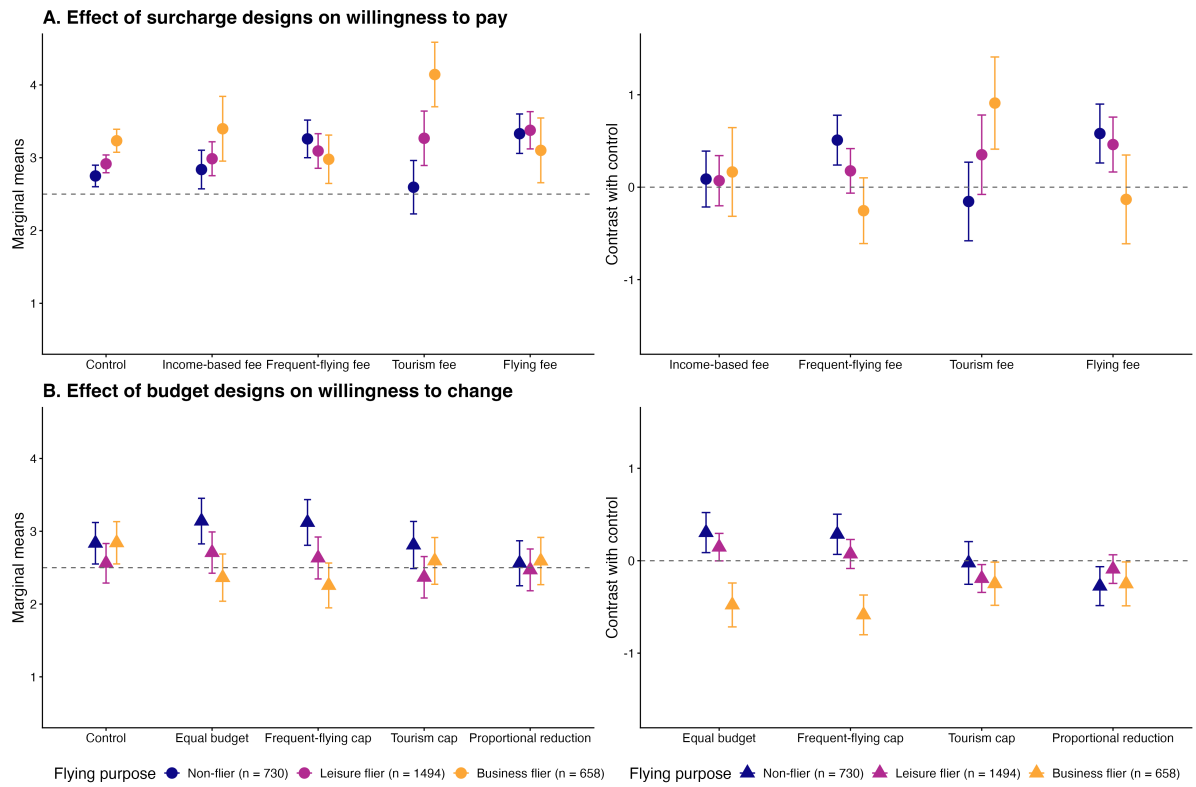


Figure S4: Estimated marginal means (left panels) and contrasts with the control condition (right panels) for WTP (circles) and WTC (triangles), stratified by primary flying purpose (non-flier, leisure flier, business flier). Error bars show 95% confidence intervals.

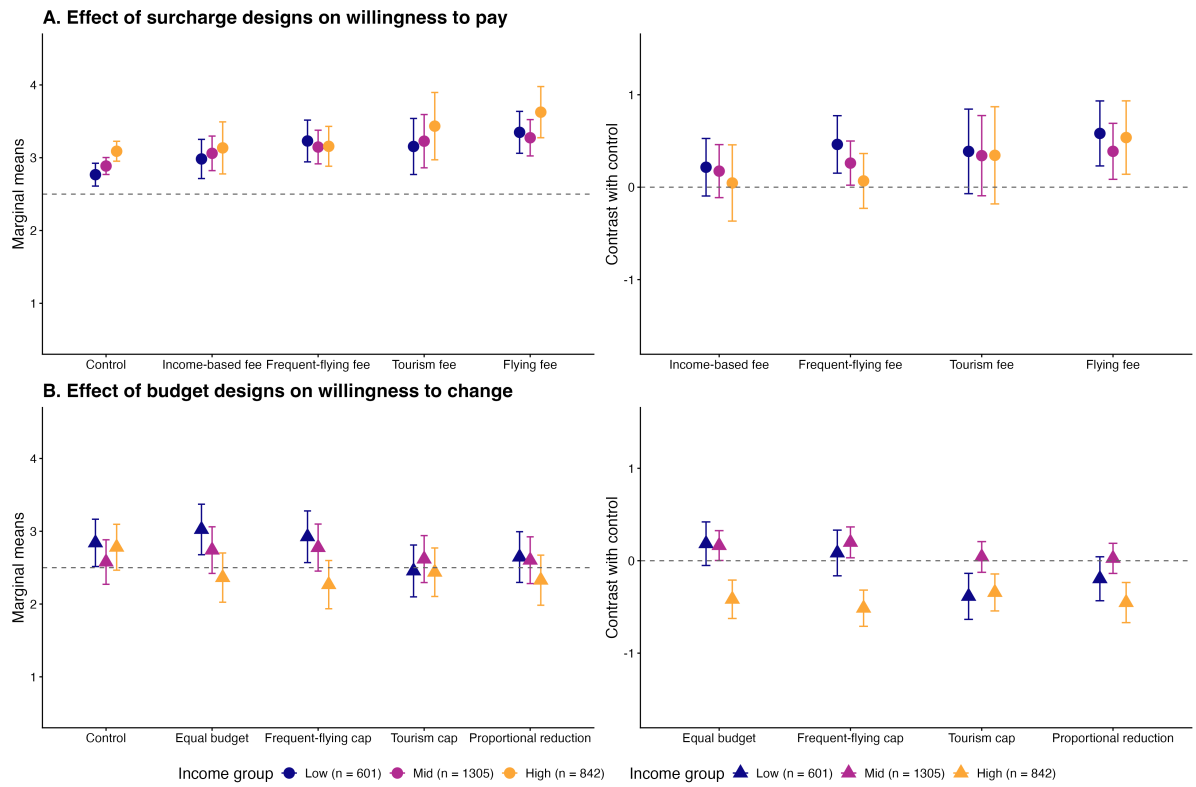


Figure S5: Estimated marginal means (left panels) and contrasts with the control condition (right panels) for WTP (circles) and WTC (triangles), stratified by income group (low, mid, high). Error bars show 95% confidence intervals.

Supplementary tables

Treatment	Switzerland		China		United States	
	WTC	WTP	WTC	WTP	WTC	WTP
Contrasts vs. control						
Egalitarianism	0.20 (0.10)	0.05 (0.10)	-0.20 (0.09)	0.05 (0.10)	0.18 (0.10)	-0.23 (0.10)
Limitarianism	0.15 (0.10)	0.24 (0.10)	-0.40 (0.09)	0.21 (0.14)	0.15 (0.09)	0.15 (0.09)
Prioritarianism	-0.28 (0.10)	-0.15 (0.13)	-0.21 (0.10)	0.29 (0.14)	-0.05 (0.10)	-0.39 (0.13)
Proportionalism	-0.04 (0.10)	0.10 (0.11)	-0.20 (0.10)	0.16 (0.11)	-0.26 (0.10)	0.05 (0.10)

Table S1: Country-level treatment–control contrasts from a fixed-effects model with treatment, country, and their interaction as predictors. Estimates are treatment–control contrasts from linear models with country as a fixed effect. Country is treated as a fixed effect here, rather than as a random intercept as in the main analyses, to allow explicit estimation of the treatment × country interaction. Standard errors in parentheses.

Experimental factor	WTC marginal mean (95% CI)	WTP marginal mean (95% CI)
Emissions reductions		
15%	2.69 (2.40, 2.99)	3.13 (2.98, 3.29)
30%	2.61 (2.32, 2.91)	3.10 (2.94, 3.25)
45%	2.59 (2.30, 2.88)	3.09 (2.93, 3.25)
Route length		
Long-haul		3.16 (3.02, 3.30)
Short-haul		3.09 (2.95, 3.22)

Table S2: Estimated marginal means for willingness to change (WTC) and willingness to pay (WTP) across experimental variables, emissions reductions level and route length. Values show marginal means with 95% confidence intervals in parentheses. Results are averaged over the levels of justice treatment. A value of 2.5 represents neutral sentiment, with values above it indicating greater willingness. Route length was only applied to willingness to pay and determined the base-level ticket price: \$150 for short-haul and \$400 for long-haul.

Treatment	WTC		WTP	
	Full sample	Filtered	Full sample	Filtered
Marginal means				
Control	2.69 (0.15)	2.71 (0.17)	2.95 (0.06)	2.94 (0.07)
Egalitarianism	2.75 (0.15)	2.75 (0.17)	2.98 (0.10)	2.98 (0.10)
Limitarianism	2.65 (0.15)	2.68 (0.17)	3.15 (0.09)	3.20 (0.10)
Prioritarianism	2.52 (0.15)	2.51 (0.17)	3.16 (0.17)	3.15 (0.18)
Proportionalism	2.52 (0.15)	2.53 (0.17)	3.32 (0.11)	3.30 (0.11)
Contrasts vs. control				
Egalitarianism	0.05 (0.06)	0.03 (0.06)	0.03 (0.11)	0.04 (0.12)
Limitarianism	-0.05 (0.06)	-0.03 (0.06)	0.20 (0.09)	0.26 (0.09)
Prioritarianism	-0.18 (0.06)	-0.20 (0.06)	0.21 (0.19)	0.20 (0.20)
Proportionalism	-0.17 (0.06)	-0.18 (0.06)	0.37 (0.13)	0.36 (0.13)

Table S3: Robustness check: excluding the highest income decile in Switzerland and the United States. Estimates are marginal means or treatment–control contrasts from linear mixed-effects models with a country random intercept. Standard errors in parentheses.

Treatment	WTC		WTP	
	Full sample	Filtered	Full sample	Filtered
Marginal means				
Control	2.69 (0.15)	2.67 (0.18)	2.95 (0.06)	3.01 (0.06)
Egalitarianism	2.75 (0.15)	2.66 (0.18)	2.98 (0.10)	3.06 (0.14)
Limitarianism	2.65 (0.15)	2.57 (0.18)	3.15 (0.09)	3.10 (0.12)
Prioritarianism	2.52 (0.15)	2.54 (0.18)	3.16 (0.17)	3.18 (0.23)
Proportionalism	2.52 (0.15)	2.46 (0.18)	3.32 (0.11)	3.32 (0.14)
Contrasts vs. control				
Egalitarianism	0.05 (0.06)	-0.01 (0.07)	0.03 (0.11)	0.05 (0.18)
Limitarianism	-0.05 (0.06)	-0.10 (0.07)	0.20 (0.09)	0.09 (0.13)
Prioritarianism	-0.18 (0.06)	-0.12 (0.07)	0.21 (0.19)	0.17 (0.27)
Proportionalism	-0.17 (0.06)	-0.21 (0.07)	0.37 (0.13)	0.31 (0.18)

Table S4: Robustness check: excluding the lowest four income deciles across all countries. Estimates are marginal means or treatment–control contrasts from linear mixed-effects models with a country random intercept. Standard errors in parentheses.

Treatment	WTC		WTP	
	Full sample	Filtered	Full sample	Filtered
Marginal means				
Control	2.69 (0.15)	2.71 (0.15)	2.95 (0.06)	2.95 (0.07)
Egalitarianism	2.75 (0.15)	2.74 (0.15)	2.98 (0.10)	2.97 (0.10)
Limitarianism	2.65 (0.15)	2.66 (0.15)	3.15 (0.09)	3.15 (0.10)
Prioritarianism	2.52 (0.15)	2.51 (0.15)	3.16 (0.17)	3.15 (0.17)
Proportionalism	2.52 (0.15)	2.54 (0.15)	3.32 (0.11)	3.31 (0.11)
Contrasts vs. control				
Egalitarianism	0.05 (0.06)	0.03 (0.06)	0.03 (0.11)	0.02 (0.12)
Limitarianism	-0.05 (0.06)	-0.05 (0.06)	0.20 (0.09)	0.19 (0.09)
Prioritarianism	-0.18 (0.06)	-0.19 (0.06)	0.21 (0.19)	0.19 (0.19)
Proportionalism	-0.17 (0.06)	-0.17 (0.06)	0.37 (0.13)	0.36 (0.13)

Table S5: Robustness check: excluding non-fliers in China. Estimates are marginal means or treatment–control contrasts from linear mixed-effects models with a country random intercept. Standard errors in parentheses.

Treatment	WTC		WTP	
	Full sample	Filtered	Full sample	Filtered
Marginal means				
Control	2.69 (0.15)	2.68 (0.15)	2.95 (0.06)	2.94 (0.06)
Egalitarianism	2.75 (0.15)	2.73 (0.16)	2.98 (0.10)	2.96 (0.10)
Limitarianism	2.65 (0.15)	2.61 (0.16)	3.15 (0.09)	3.14 (0.10)
Prioritarianism	2.52 (0.15)	2.51 (0.16)	3.16 (0.17)	3.14 (0.17)
Proportionalism	2.52 (0.15)	2.51 (0.16)	3.32 (0.11)	3.31 (0.11)
Contrasts vs. control				
Egalitarianism	0.05 (0.06)	0.06 (0.06)	0.03 (0.11)	0.02 (0.12)
Limitarianism	-0.05 (0.06)	-0.07 (0.06)	0.20 (0.09)	0.21 (0.09)
Prioritarianism	-0.18 (0.06)	-0.17 (0.06)	0.21 (0.19)	0.20 (0.19)
Proportionalism	-0.17 (0.06)	-0.17 (0.06)	0.37 (0.13)	0.38 (0.13)

Table S6: Robustness check: excluding speeders, defined as respondents in the fastest 5% of survey completion times. Estimates are marginal means or treatment–control contrasts from linear mixed-effects models with a country random intercept. Standard errors in parentheses.

Sample description

Variable	Switzerland		United States		China	
	Sample	Target	Sample	Target	Sample	Target
Sample size	<i>n</i> = 1100		<i>n</i> = 1254		<i>n</i> = 1100	
Age						
18–24	9.1%	9%	12.3%	12%	10.2%	12%
25–34	18.7%	18%	19.9%	18%	21.0%	20%
35–44	19.2%	19%	16.7%	18%	17.7%	18%
45–54	19.1%	18%	17.3%	16%	18.2%	16%
55–64	16.9%	18%	15.9%	17%	32.6%	34%
65+	17.0%	18%	17.9%	19%	0.3%	
Gender						
Female	51.4%	50%	49.7%	51%	46.4%	49%
Male	48.6%	50%	50.0%	49%	53.6%	51%
Non-binary			0.3%			
Language region						
German	70.5%	73%				
French	27.8%	27%				
Italian	1.1%	0%				
Romansch	0.6%	0%				
Flying distribution						
Median flights	2		1		4	
25th percentile	0		0		2	
75th percentile	4		3		6	
90th percentile	6		5		10	
Share non-fliers	36.9%		47.7%		18.1%	
Income distribution						
Decile 1	13.0%		10.6%		2.1%	
Decile 2	8.7%		10.0%		2.9%	
Decile 3	6.2%		12.2%		1.4%	
Decile 4	7.2%		9.8%		2.3%	
Decile 5	8.9%		10.0%		5.8%	
Decile 6	14.6%		15.2%		11.0%	
Decile 7	9.9%		10.8%		28.2%	
Decile 8	10.2%		8.2%		21.0%	
Decile 9	5.2%		7.2%		14.0%	
Decile 10	3.3%		4.7%		11.0%	

Table S7: Sample characteristics across the three survey samples. Language region is only applicable to Switzerland. Age, gender, and language region were used as quota variables during data collection. The quota for the oldest age group in China was pooled as 34% for the age group 55+, as it was not possible to collect a sufficient amount of online survey data among the 65+ age group in China. Income deciles do not sum to 100% in Switzerland because approximately 13% of respondents did not report their income ("Prefer not to say").

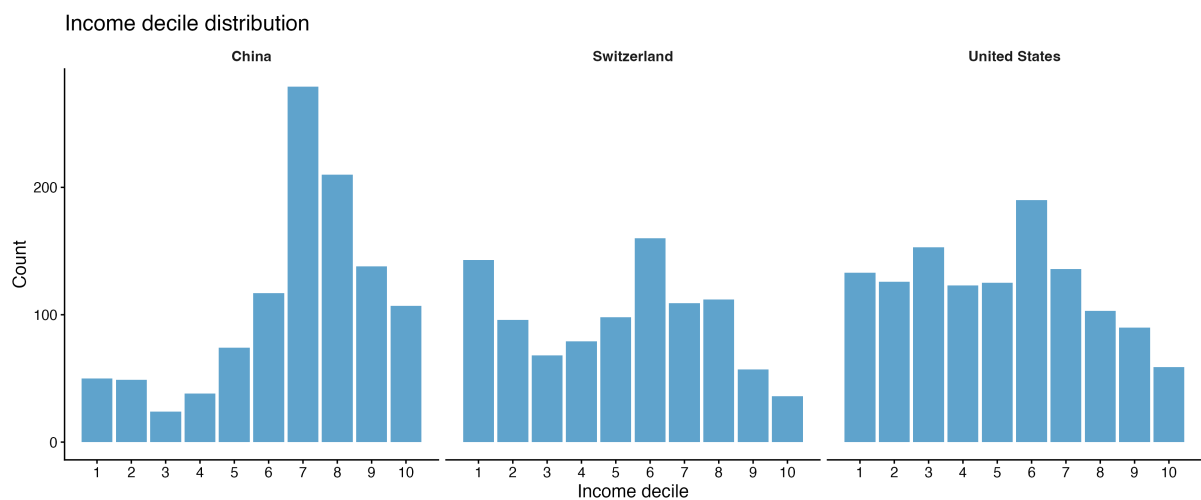


Figure S6: Distribution of self-reported income deciles across the three survey countries (US, Switzerland, China).

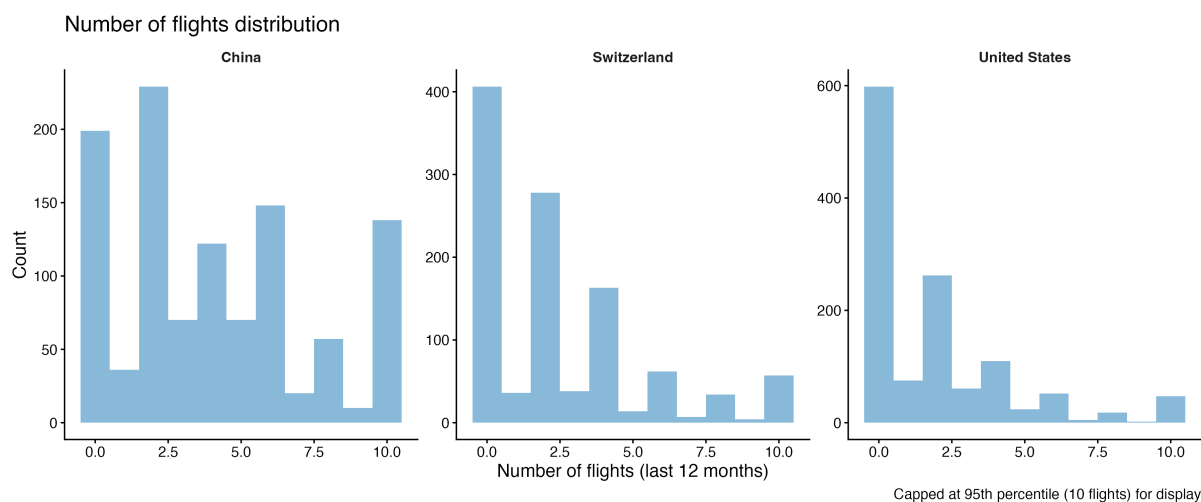


Figure S7: Distribution of the number of flights taken in the past 12 months across the three survey countries. Values are capped at the 95th percentile for display.

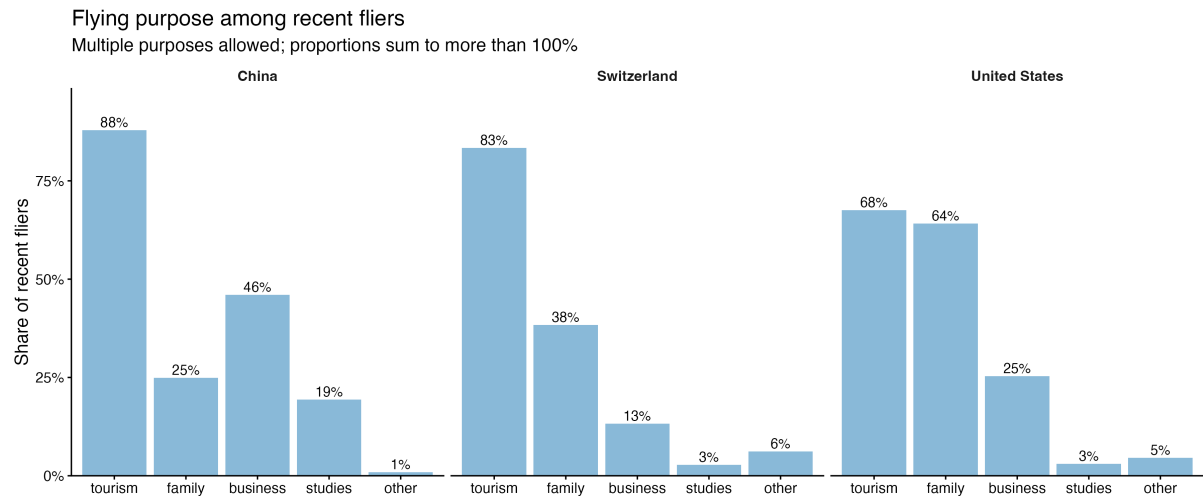


Figure S8: Flying purposes reported by recent fliers across the three survey countries. Respondents could select multiple purposes, so proportions sum to more than 100%.

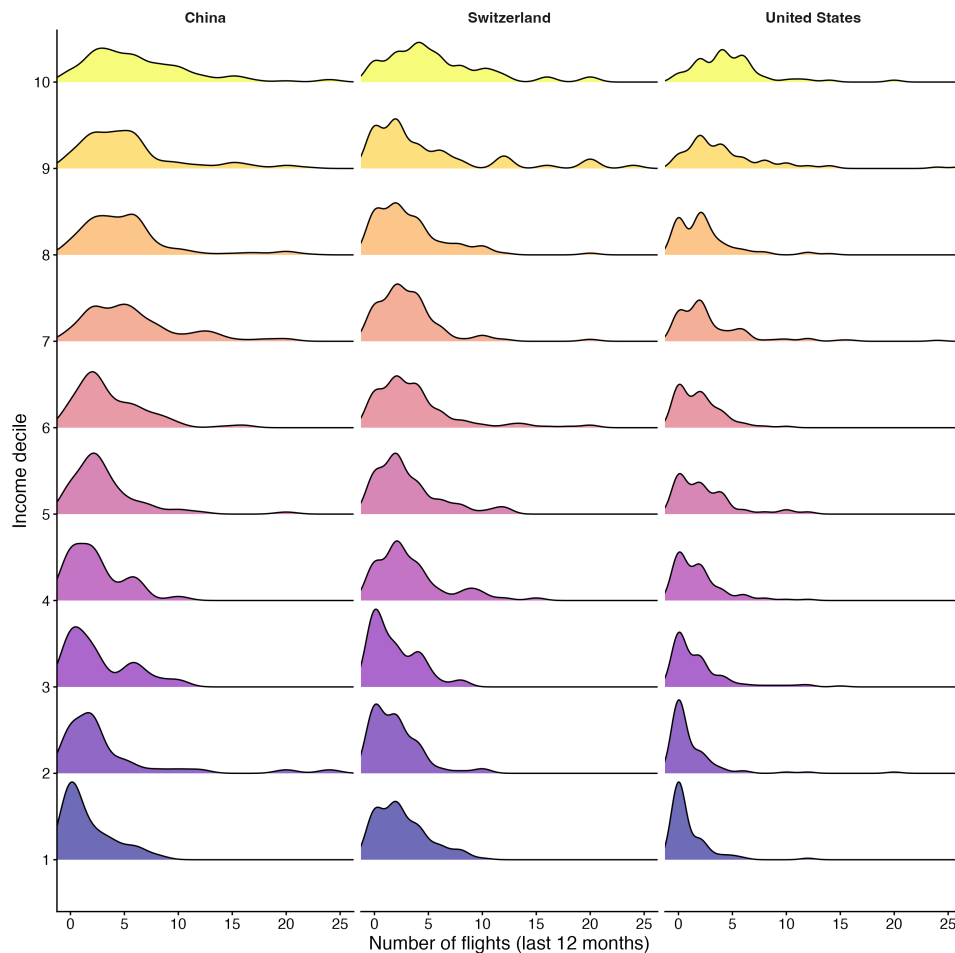


Figure S9: Kernel density plots for flying frequency (the number of flights taken in the last 12 months) across income deciles in China, Switzerland, and the US.

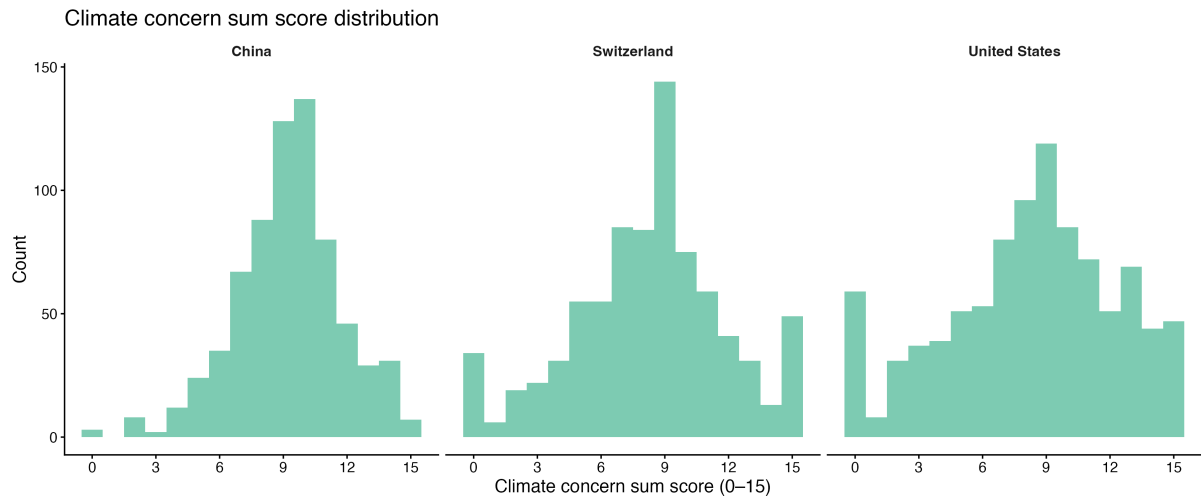


Figure S10: Distribution of the climate concern sum score (range 0–15, combining three items) across the three survey countries.

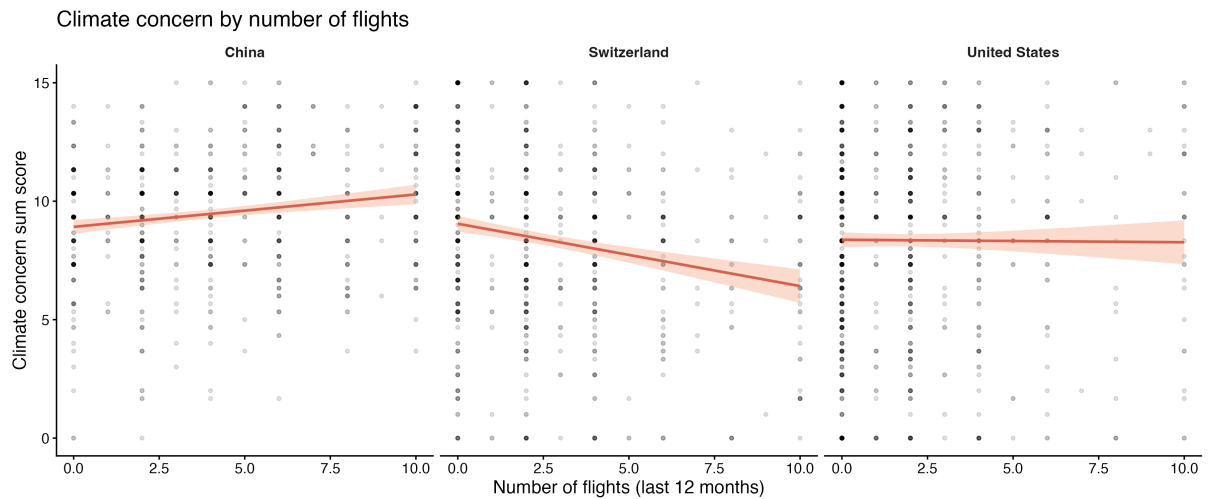


Figure S11: Relationship between number of flights in the past 12 months and climate concern sum score, shown separately by country. The line shows a linear fit with 95% confidence interval.

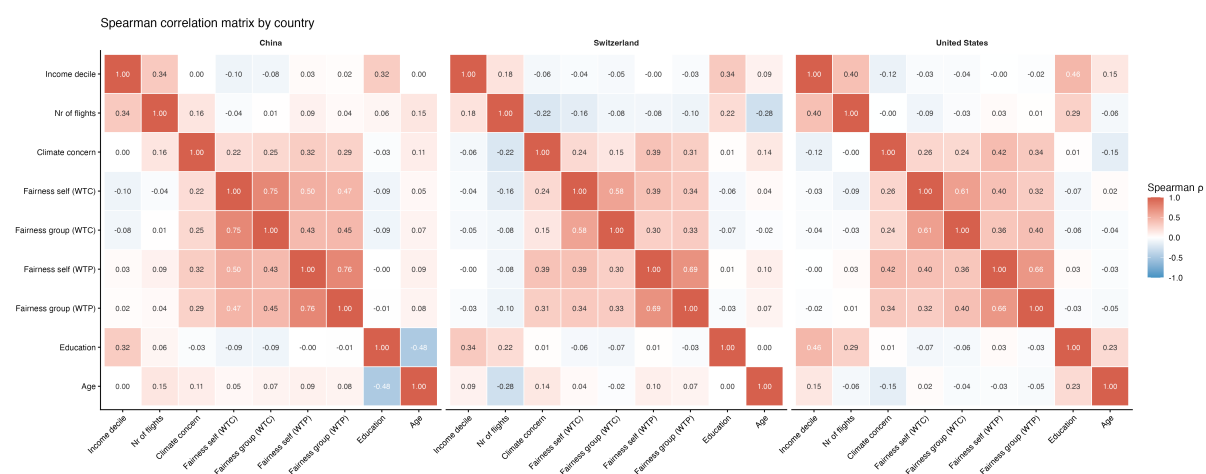


Figure S12: Spearman correlation coefficients among covariates (income decile, education level, climate concern score, flights per year), fairness perceptions (group and personal fairness for WTC and WTP), and the outcome variables (WTC and WTP), shown separately for each country.