The economic value of improved air quality in urban Africa: a contingent valuation survey in Douala, Cameroon

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ONLINE APPENDIX

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A. Management scenario

"Recent studies have revealed that the rapid growth of new vehicles and the number of old ramshackle vehicles is causing air pollution problems in Douala. The air pollutants emitted by these vehicles have a negative impact on your health and the environment. According to these studies, these levels of air pollution in Douala are expected to get worse in the future because of the growth of vehicles and population growth.

Suppose that policymakers are considering a new set of projects to reduce air pollution in Douala. Such project consists of: (Enumerator: Please show them pictures and visual aids in your hands so that they can really understand what you mean). (i) Planting of green trees (They absorb the air pollutants emitted by vehicles and motorcycles).(ii)) Removing older polluting vehicles from the road (the government will pay market value).(iii)The installation of air quality monitoring which be in charge of fixing limits on air pollution and measuring air pollutants. (iv) Subsidizing the purchase of new fuel-efficient, low-pollution minibuses (the subsidy would not be expected to change taxi fares). (v) Reducing traffic congestion.

This project is not free of charge. Can I continue or do you have some questions?

If more than 50% of the citizens vote for the program, the number of people who get sick because of breathing problems would decrease by about 25%. For credibility and efficacy reasons, the money collected from this management plan will be managed by a committee which consists of people elected by you in the different subdivisions. But, as other environmental projects, this will cost you something. Suppose that you were asked to vote for this program on a possible referendum, and if more than 50% of the people vote for, your household and other households in our country would pay a fixed surcharge CFA francs _____ and this will become a law and you will obtain all the benefits listed above. Also remember your monthly income and the efficacy of this environmental program. Besides, remember the surcharge is a one-time payment and would be added to your electricity bill next month. Lastly, before you tell us how you would vote on a possible referendum, you should consider that the results of the study will be made available to policymakers, and could serve as a guide for future decisions. In other words, the results from the study will have an actual effect, and you should consider this when answering the questions below.

Do you have any questions? "

Stoplight exercise text

Now I want to use the analogy of a traffic light to get you to think about the one-time surcharge you would be willing to pay for this air quality improvement. As you know, traffic lights have three colors: red, green and yellow. The red color at the top of the traffic light indicates we should stop. The green color indicates that we should go. If the light is yellow, we should slow down and think about whether we want to go through the intersection or stop.

Please think about your decision to vote for or against this referendum. There are bad, high surcharges (like the red light), when you are completely sure that you would not vote for the referendum (Enumerator: point to red light). There are good, low surcharges (like the green light) when you are completely sure that you would vote for the referendum (Enumerator: point to green light). And then there are some surcharges (like the yellow light) (Enumerator: point to yellow light) at which you are not sure whether you would vote for the referendum or not. Now I would like to read you a list of one-time surcharges. First, I will start with a very high surcharge-a red surcharge-and I will read you lower and lower surcharges. I would like you to tell me when the surcharge is in the yellow zone for you. That is, you might vote for the referendum at that level of surcharge but you might not. You are not certain. Then I will tell you a very low surcharge-a green one-and then read higher and higher surcharges. Again, tell me to stop when a surcharge is in the yellow zone for you-you are not completely sure you would vote for the referendum at that level of surcharge. Via the stoplight that you see, I would like to know how certain you are that you would (or would not) vote for the air quality improvement program, which color best describe your choice?

Time to think text

I would like to ask you the questions below. But, before I do it, I will give you more time to muse on what I am going to share with you now. In other words, I will explain to you the management plan that can be implemented in Douala to improve the air quality, what you have to pay for this program to be implemented and I will come tomorrow to ask you some questions. Please feel free to discuss the issue with your spouse or family member, friends and neighbor. This is the following information I would like to share with you (please pay attention and stop me if you don't understand anything): *<enumerator reads "Management Scenario"above>*.

B.   Sensitivity Analysis of "Percent Yes": Protest votes

Table A1: *Percent of "yes" responses, excluding response categories (1) and (4) as protests*

			P-value
Bid	Control	Time to think	Control versus time to think
200	56	42	0.12
350	72	38	0.00***
500	46	29	0.07*
1000	9	8	0.43

Notes: * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$. Response categories for the respondents' main reason for vote were: "(1) I don't trust the people that will manage the fund"; "(4) I don't want such policy"; and "(5) The government must search for another policy"

Table A2: *Percent of "yes" responses, excluding response categories (1), (4), and (5) as protests*

			P-value
Bid	Control	Time to think	Control versus time to think
200	65	52	0.15
350	75	38	0.00***
500	54	37	0.09*
1000	11	10	0.46

Notes: * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$. Response categories for the respondents' main reason for vote were: "(1) I don't trust the people that will manage the fund"; "(4) I don't want such policy"; and "(5) The government must search for another policy".

Table A3: *Probit model of the effect of time to think on the probability of a protest response*

Variables	Protest = (1) and (4)	Protest = (1), (4) and (5)
	Marginal effects	Marginal effects
	(Std Errors)	(Std Errors)
Bid	0.0001	0.0001
	(0.0003)	(0.0003)
TTT	-0.43**	0.02
	(0.18)	(0.16)
Male	0.10	0.08
	(0.19)	(0.17)
Age	-0.003	-0.001
	(0.01)	(0.01)
Income	-0.003	-0.003
	(0.002)	(0.001)
Educationlow	-0.18	0.06
	(0.20)	(0.27)
Educationmid	-0.10	0.22
	(0.21)	(0.18)
HHnumber	0.08**	0.03
	(0.03)	(0.03)
ConcernAirpoll	0.18	-0.07
	(0.27)	(0.22)
Respiratory	0.27	0.14
	(0.23)	(0.22)
Intercept	-0.91*	-0.54
	(0.51)	(0.43)

Notes: * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$. Response categories for the respondents' main reason for vote were: "(1) I don't trust the people that will manage the fund"; "(4) I don't want such policy"; and "(5) The government must search for another policy".

C. Results from the "Stoplight" Payment Card Exercise

After completing the single-bounded dichotomous choice, respondents were shown a list of prices. The enumerator explained that "green" prices are those that the respondent is very sure she would pay, "red" prices are those that she is very sure she would not pay, and "yellow" prices are those she is uncertain about. As Wang (1997) and Hanley et *al.* (2009) argued, respondents might prefer to state a range of values instead of a single value simply because they are unsure about the value to place on the proposed good or policy. We did not vary the order of the SBDC and the "stoplight" exercise, so responses to the latter could be anchored on responses to the former.

As discussed in the text, respondents in the control and TTT subgroups were only asked to complete this exercise if they said "yes" to the SBDC exercise. Because of this non-random selection, the results below should **not** be used for inferring WTP or for policy. Comparisons across treatments can still be informative, however. Because all ballot box respondents completed this exercise whether they answered "yes" or "no" to the SBDC, we drop those who said "no" to make the three subsamples comparable.

The results suggest that the lower bound, mid-point, upper bound, and range of mean WTP estimates are all significantly lower in both the TTT and ballot box treatment than in the control treatment (table A4). Compared to the control group, the midpoint is 26% lower for ballot box respondents and 33% lower for the TTT group. A non-parametric Kolmogorov-Smirnov test revealed that the distributions of interval midpoints, lower bounds, upper bounds, and ranges were all different at the 1% level.

Table A4: *Intervals of Willingness-to-Pay based on the "stoplight" payment card exercise, among respondents who said "no" to the dichotomous choice question*

	Control	Ballot box	Time to think	p-value (control vs. ballot	p-value (control vs. time to think)
Lower Bound (CFA)	301 (14)	195 (16)	199 (16)	0.00***	0.00***
Midpoint (CFA)	588 (23)	438 (26)	395 (32)	0.00***	0.00***
Upper bound (CFA)	875 (35)	682 (41)	591 (49)	0.00***	0.00***
Range (CFA)	574 (28)	487 (35)	392 (36)	0.07***	0.00***

Notes: * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$. 1 US\$=534 CFA. Standard errors are in parentheses. Ballot box respondents who answered "no" the single-bounded dichotomous choice question were dropped to ensure comparability of the three subsamples.

Figure A1 shows the percentage of respondents who reported that the stated price in the stoplight exercise was one was they were "definitely sure" they would pay. The figure again drops respondents who said "no" to the dichotomous choice question. Overall, as the stoplight price increases, the percentage of respondents who are "definitely sure" they would vote yes declines but more so for the control than the ballot box respondents.
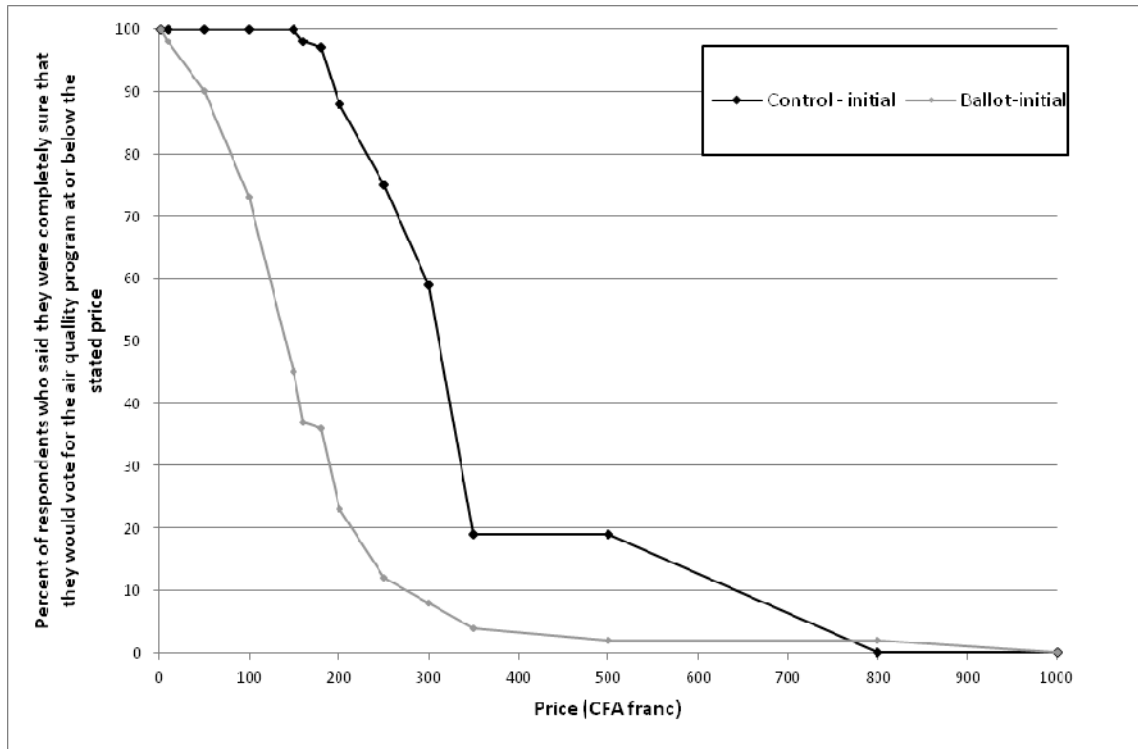
Figure A1: Percentage of respondents who were certain that they would pay for air quality program per experimental groups (based on raw data for stoplight).

Once we control for individual-level covariates in an interval regression model, the effect of the TTT and ballot box treatments remains (table A6). We estimate that giving TTT lowered mean WTP by CFA 157 (US$0.29), or 46% from the estimated mean. The ballot box treatment lowered mean WTP by 106 (US$0.19) or 64% from the estimated mean. Income is statistically significant and of the expected sign. Those with secondary school have lower WTP than those with university degrees, consistent with the results of the probit model on the dichotomous choice discussed in the main text.

Table A5: *Result of the stoplight pooling control, time to think and ballot box subgroups*

Variables	Coefficients
TTT	-156.74***
	(34.77)
BALLOT	-106.48***
	(33.85)
Male	0.49
	(32.34)
Age	-0.09
	(1.50)
Income	1.36***
	(0.26)
Educationlow	-5.73
	(57.65)
Educationmid	-72.86**
	(29.59)
HHnumber	8.60
	(5.74)
ConcernAirpoll	-37.99
	(46.94)
Respiratory	-31.41
	(36.24)
Intercept	292.59***
	(82.99)

Notes: Standard errors in parentheses. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$. 1 US\$=534 CFA. Ballot box respondents who answered "no" the single-bounded dichotomous choice question were dropped to ensure comparability of the three subsamples. TTT takes 1 and 0 for the control. Ballot box takes 1 and 0 for the control.

The mean parametric WTP from an interval model of the stoplight data (first period) is US\$ 0.94 and US\$ 0.68 per household for the control and ballot box groups respectively (Table A6). This difference is statistically significant at 1% level (p=0.00). The results also show a statistical difference between the control and time to think (p=0.00). Furthermore, the results from the revised stoplight exercise are similarly stable. For the ballot box and control respondents, the percentage of respondents who were "definitely sure" they would vote for the program at a given price (i.e. "green" prices) remains essentially the same during the first and second round of answers (see Figure A2), causing little to no change. Not surprisingly, willingness-to-pay estimates show the same pattern for the ballot box and control groups (the p-values for the statistical test of the differences in mean WTP between the first period and second period are 0,46; 0,43 for the ballot box and control respectively).

Table A6: *Mean WTP of the stoplight by experimental groups*

Experimental groups	Mean WTP (Std Errors)	CI[a]
Ballot box-original	363 (30)	[304, 422]
Ballot box-revised	366 (30)	[308, 425]
Control-original	504 (33)	[438, 568]
Control-revised	499 (34)	[432, 564]
Time to think	318 (26)	[267, 369]

Notes: (a) is the confidence interval of the mean WTP and is obtained by bootstrap on 1000 draws. Standard errors are in brackets and they are computed by the delta method. 1 US$=534 CFA.
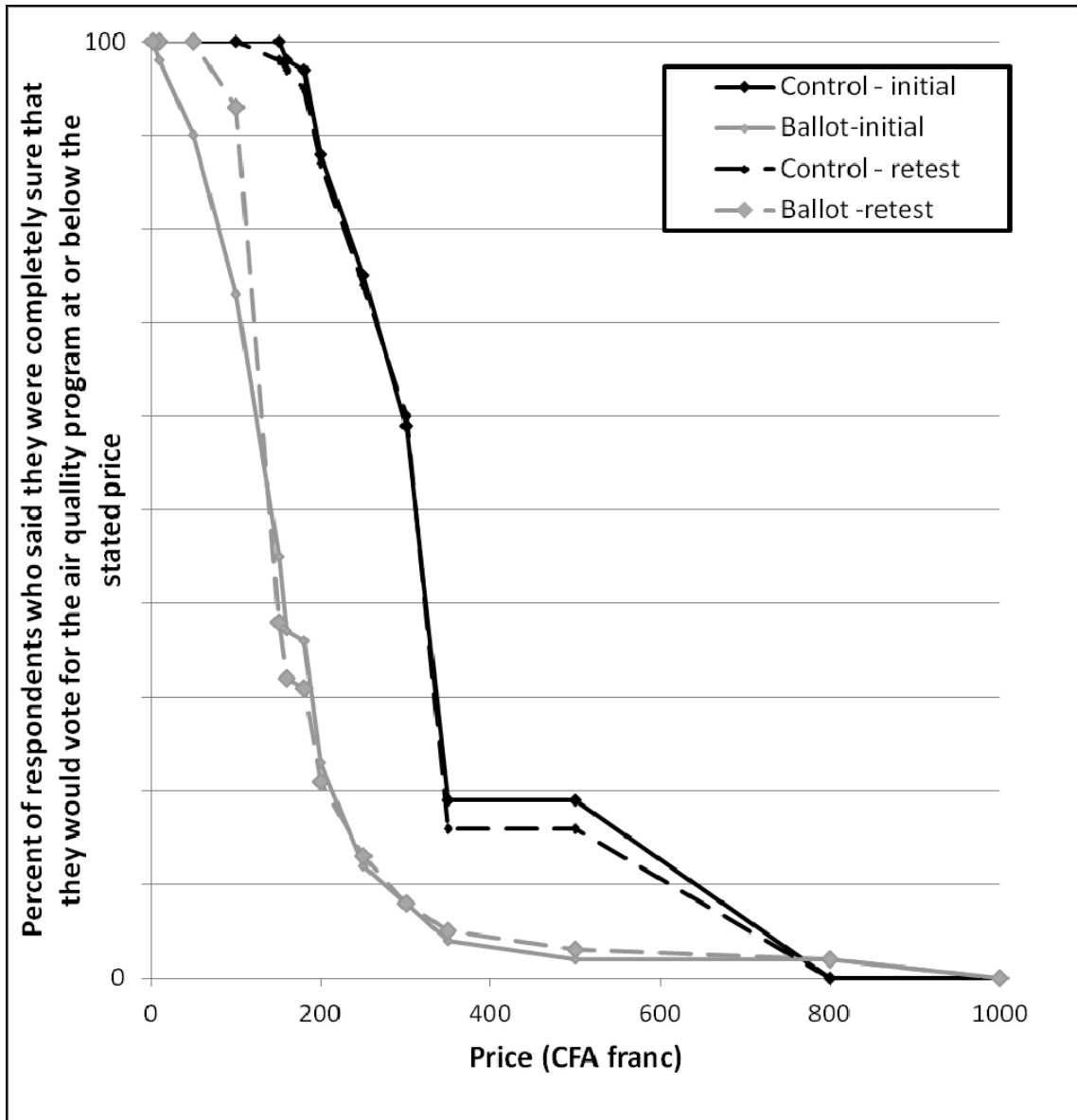
Figure A2: Percentage of respondents who were certain that they would pay for air quality program per experimental groups (based on raw data for stoplight and *revised* stoplight).

D. Sensitivity analysis: Probit model of dichotomous choice dropping protest responses.

Table A7: *Probit model of response to SBDC valuation question, pooling control and time to think subgroups, under two definitions of protest responses*

Variables	Coefficient[a] (Std Errors)	Coefficient[b] (Std Errors)
TTT	-0.62***	-0.59***
	(0.20)	(0.22)
Bid	-0.002***	-0.002***
	(0.0004)	(0.0004)
Male	-0.10	-0.05
	(0.21)	(0.22)
Age	-0.01	-0.01
	(0.01)	(0.01)
Income	0.01***	0.01***
	(0.002)	(0.002)
Educationlow	-0.56*	-0.49
	(0.32)	(0.34)
Educationmid	-0.92***	-0.81***
	(0.22)	(0.23)
HHnumber	0.06	0.05
	(0.04)	(0.05)
ConcernAirpoll	0.23	0.17
	(0.38)	(0.45)
Respiratory	0.30	0.29
	(0.28)	(0.32)
Intercept	0.07	0.28
	(0.63)	(0.67)

Notes: * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$. (a) Responses 1, 4 are considered to be protest responses. (b) Responses 1, 4 and 5 are considered to be protest responses. TTT takes 1 and 0 for the control. Response categories for the respondents' main reason for vote were: "(1) I don't trust the people that will manage the fund"; "(4) I don't want such policy"; and "(5) The government must search for another policy"

E. Sensitivity analysis: Non-parametric welfare estimates

Table A8: *Non-parametric results of the welfare estimates; protest definition 1*

Experimental groups	Mean WTP (Std Errors)		95% confidence intervals	
	Turnbull	Kriström	Turnbull	Kriström
Control	370 (36)	525 (39)	[366, 377]	[518, 532]
Time to think	225 (33)	360 (35)	[220, 231]	[354, 366]

Notes: Responses 1 and 4 are considered to be protest responses. 1 US$=534 CFA.

Table A9: Non-parametric results of the welfare estimates; protest definition 2

Experimental groups	Mean WTP (Std Errors)		95% confidence intervals	
	Turnbull	Kriström	Turnbull	Kriström
Control	399 (39)	560 (43)	[392, 406]	[552, 568]
Time to think	257 (33)	424 (42)	[251, 263]	[416, 432]

Notes: Responses 1, 4 and 5 are considered to be protest responses. 1 US$=534 CFA.
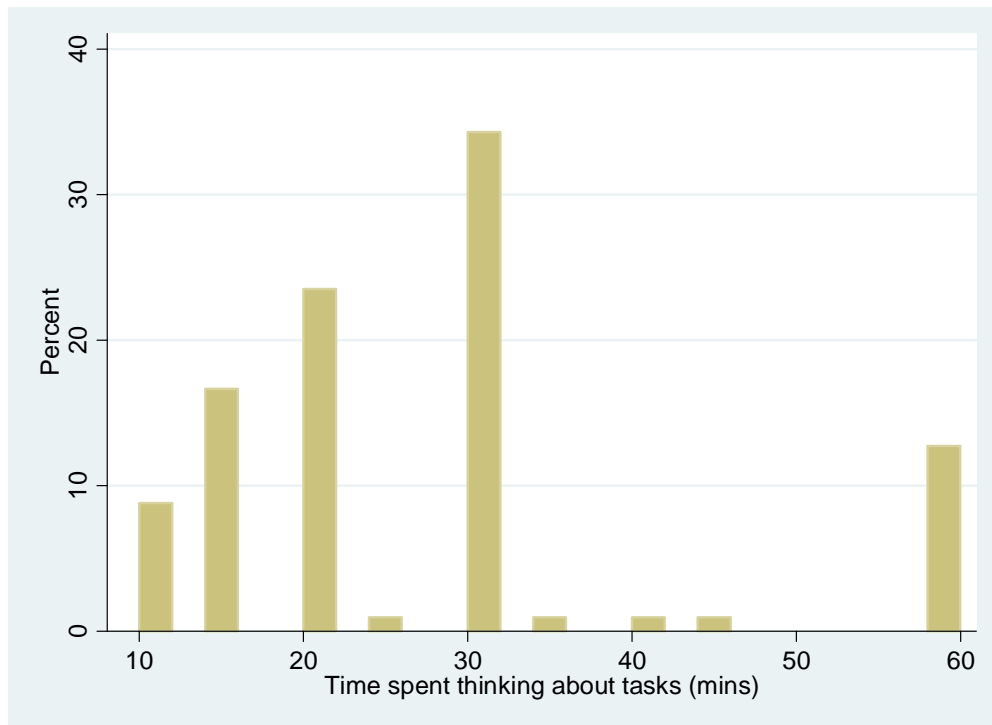
F. Time spent thinking about valuation task

Figure A3: *Time spent thinking about task*

G. Multivariate model of SBDC responses after allowing revisions overnight in the control and ballot box group

Table A10: *Probit model of the revised response to the dichotomous choice question*

Variables	Probit model with retest (control versus time to think, control versus ballot box) (Std Errors)
TTT	-0.67***
	(0.14)
Ballot	0.31**
	(0.13)
Bid	-0.002***
	(0.0002)
Male	-0.09
	(0.11)
Age	-0.01
	(0.01)
Income	0.01***
	(0.001)
Educationlow	-0.56***
	(0.19)
Educationmid	-0.64***
	(0.12)
HHnumber	0.01
	(0.02)
ConcernAirpoll	-0.28*
	(0.16)
Respiratory	-0.08
	(0.14)
Intercept	0.29
	(0.31)

Notes: Standard errors in parentheses. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$. TTT takes 1 for time to think and 0 for the retested control. BBB takes 1 for the ballot box and 0 for the retested control.

H. Sensitivity analysis: Mean WTP from SBDC with truncation

Table A11: *Mean WTP for SBDC by experimental groups with truncation: protest definition 1*

Experimental groups	Mean WTP (Std Errors)	CI[a]
Control	438 (31)	[378, 497]
Time to think	353 (29)	[297, 409]

Notes: Responses 1 and 4 are considered to be protest responses. The standard errors of the mean WTP of the parametric approach is calculated with the delta method. (a) is the 95% confidence interval of the mean WTP and is obtained by bootstrap on 1000 draws. 1 US$=534 CFA.

Table A12: *Mean WTP for SBDC by experimental groups with truncation: protest definition 2*

Experimental groups	Mean WTP (Std Errors)	CI[a]
Control	473 (32)	[411, 535]
Time to think	402 (43)	[337, 467]

Notes: Responses 1, 4 and 5 are considered to be protest responses. The standard errors of the mean WTP of the parametric approach is calculated with the delta method. (a) is the 95% confidence interval of the mean WTP and is obtained by bootstrap on 1000 draws. 1 US$=534 CFA.

Table A13: *Mean WTP for SBDC by experimental groups with linear form*

Experimental groups	Mean WTP (Std Errors)	CI[a]
Control-original	270 (64)	[132, 407]
Control-revised	307 (56)	[193, 421]
Time to think	-21 (168)	[-431, 390]
Ballot box-original	504 (97)	[272, 736]
Ballot box-revised	573 (108)	[360, 785]

Notes: Protest responses are not dropped. The standard errors of the mean WTP of the parametric approach is calculated with the delta method. (a) is the 95% confidence interval of the mean WTP and is obtained by bootstrap on 1000 draws. 1 US$=534 CFA.

Table A14: *Mean WTP for SBDC by experimental groups with linear form; protest definition 1*

Experimental groups	Mean WTP (Std Errors)	CI[a]
Control	424 (60)	[294, 553]
Time to think	113 (125)	[-195, 421]

Notes: Responses 1 and 4 are considered to be protest responses. CI means 95% confidence intervals. Standard errors are in parentheses. The standard errors of the mean WTP of the parametric approach is calculated with the delta method. (a) is the 95% confidence interval of the mean WTP and is obtained by bootstrap on 1000 draws. 1 US$=534 CFA

Table A15: *Mean WTP from SBDC by experimental groups with linear form; protest definition 2*

Experimental groups	Mean WTP (Std Errors)	CI[a]
Control	503 (59)	[376, 629]
Time to think	284 (92)	[64, 505]

Notes: Responses 1, 4 and 5 are considered to be protest responses. CI means 95% confidence intervals. The standard errors of the mean WTP of the parametric approach is calculated with the delta method. (a) is the 95% confidence interval of the mean WTP and is obtained by bootstrap on 1000 draws. 1 US$=534 CFA

I. Willingness-to-pay estimates based on revised dichotomous choice responses

Table A16: *Results from non-parametric estimation with retest (control versus ballot box treatments, including protest responses)*

Experimental groups	Mean WTP		95% confidence intervals	
	Turnbull	Kriström	Turnbull	Kriström
Control-original	260	387	[256, 264]	[382, 392]
Control-revised	273	403	[269, 277]	[398, 408]
Ballot box-original	452	652	[446, 458]	[645, 660]
Ballot box-revised	477	705	[471, 483]	[697, 713]

Notes: 1 US$=534 CFA.

Table A17: *Mean WTP of the retest for SBDC by experimental groups, without dropping protest responses, truncation*

Experimental groups	Mean WTP	CI[a]
Control-original	375	[324 , 426]
Control-revised	394	[332, 457]
Ballot box-original	496	[444, 547]
Ballot box-revised	512	[460, 564]

Notes: CI means 95% confidence intervals. (a) is the 95% confidence interval of the mean WTP and is obtained by bootstrap on 1000 draws. 1 US$=534 CFA.

References

Hanley, N., B. Kristrom, and J.F. Shogren (2009), 'Coherent arbitrariness: on value uncertainty for environmental goods', *Land Economics* **85**(1): 41-50.

Wang, H. (1997), 'Treatment of don't-know responses in contingent valuation surveys: a random valuation model', *Journal of Environmental Economics and Management* **32**(2): 219-232.