Reducing carbon footprint by replacing generators with solar PV systems: a contingent valuation study in Lagos, Nigeria

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ONLINE APPENDIX

A Appendix

A1. Stylized facts of Nigeria's energy situation

Figure A1 illustrates the percentage share of Nigeria's electricity produced from different sources and CO_2 emissions per capita. Before 1979, over 52% of Nigeria's power came from hydropower. However, since the discovery of oil, it has taken the lead and contributes to nearly 82% of total energy. It is noteworthy that electricity from other renewable sources remains at 0%. The sharp decline in the trend of CO_2 per capita in the 1990s could be due to a fall in aggregate production following the low global oil prices in those years.

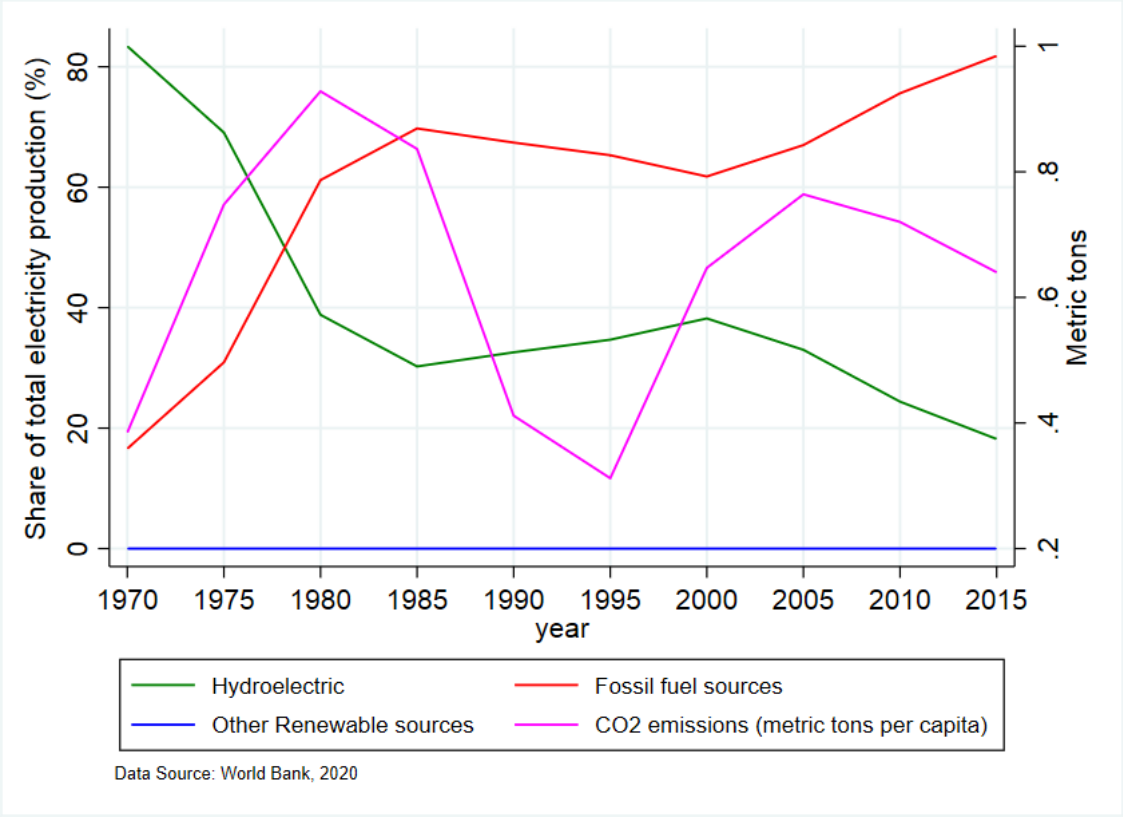

Figure A1. Share of different electricity sources and CO_2 emissions per capita.

Figure A2 illustrates maps of Nigeria and Lagos, including the study Local Government Areas (LGA) in Lagos State.

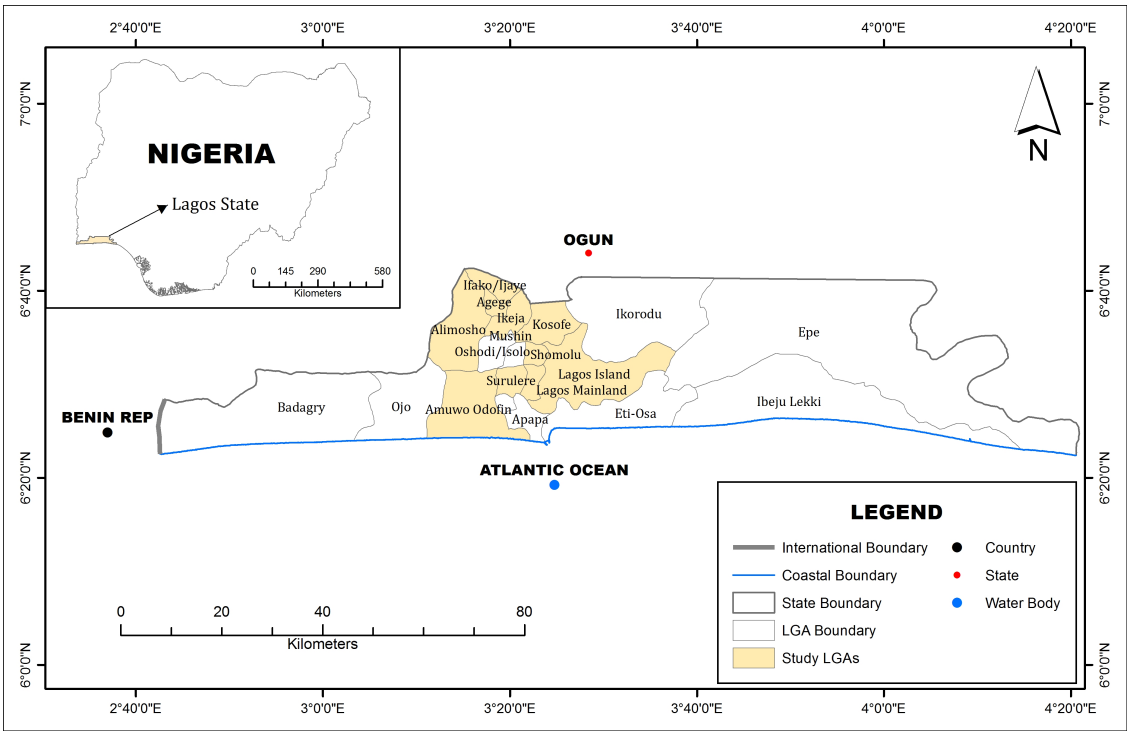

Figure A2. Map of Lagos state showing study LGAs.
Source: Author.

A2. Summary of bids

Figures A3 to A6 illustrate the bid levels used in the four scenarios and their acceptance rates. As would be expected, the acceptance rate mostly declines as the bid increases. We estimate the chi-square test of differences in the distribution of the bids across the four scenarios. The results show that the distribution is significantly different in scenarios I (p-value = 0.0005), II (p-value = 0.034), and III (p-value = 0.00004).

It is not significant in scenario IV (p-value = 0.64), although at level, the acceptance rate decreases marginally from 83% to 77% to 75% to 74%, and 72% as the bid increases. This could be because scenario IV eliminates generators; thus, households are a bit indifferent to the magnitude of the bids. In addition, it could be due to hypothetical bias, given that it cannot be wholly done away with in stated preference studies.

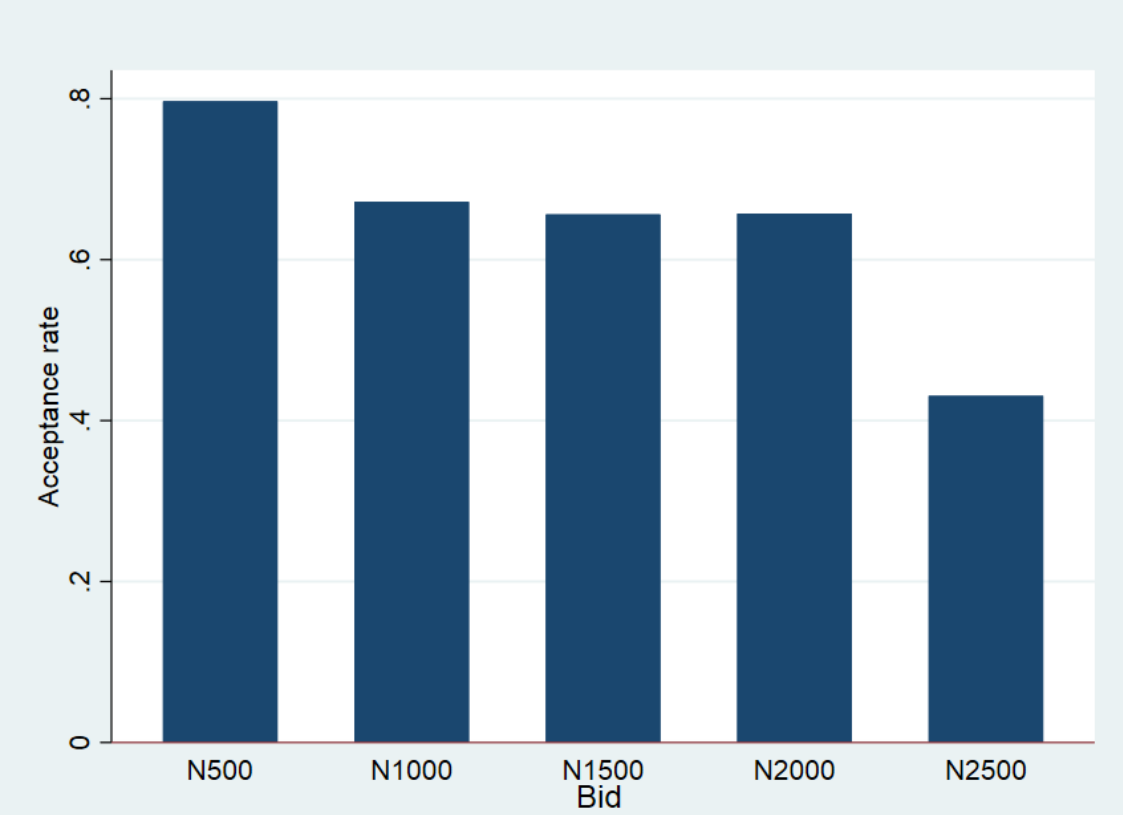

Figure A3. Scenario I: Acceptance rate.

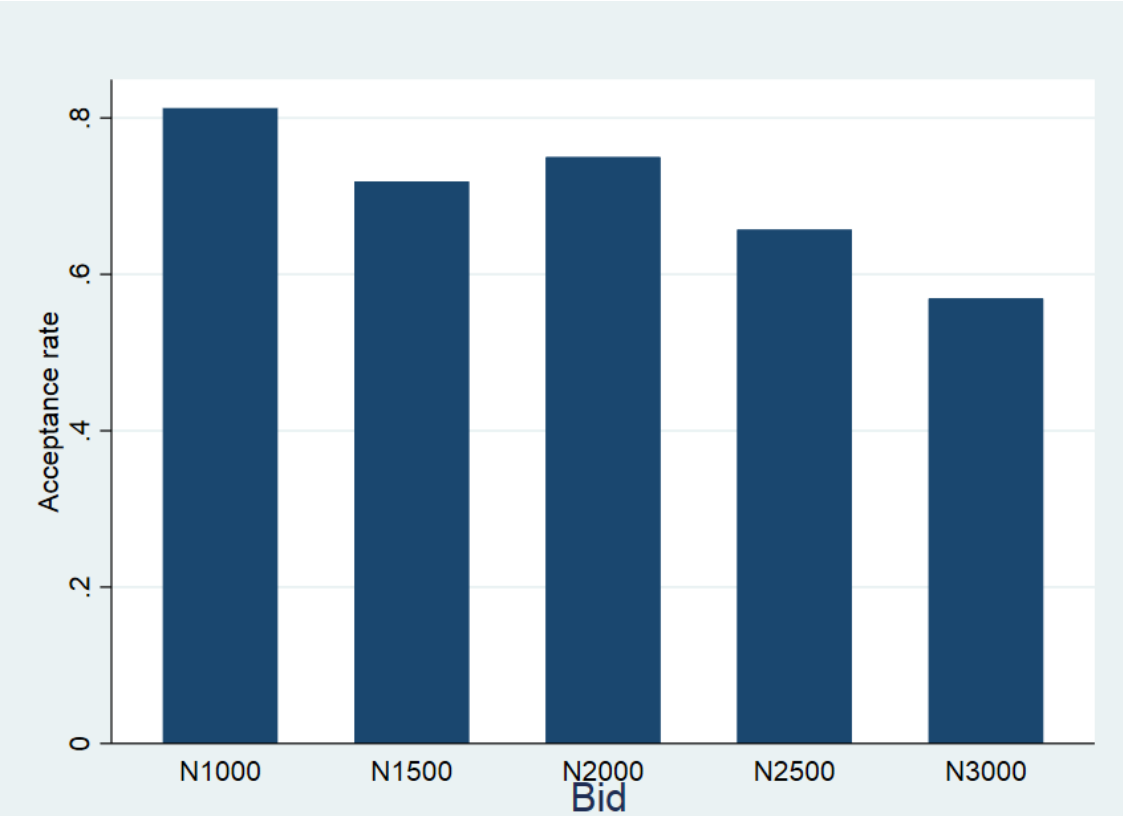

Figure A4. Scenario II: Acceptance rate.

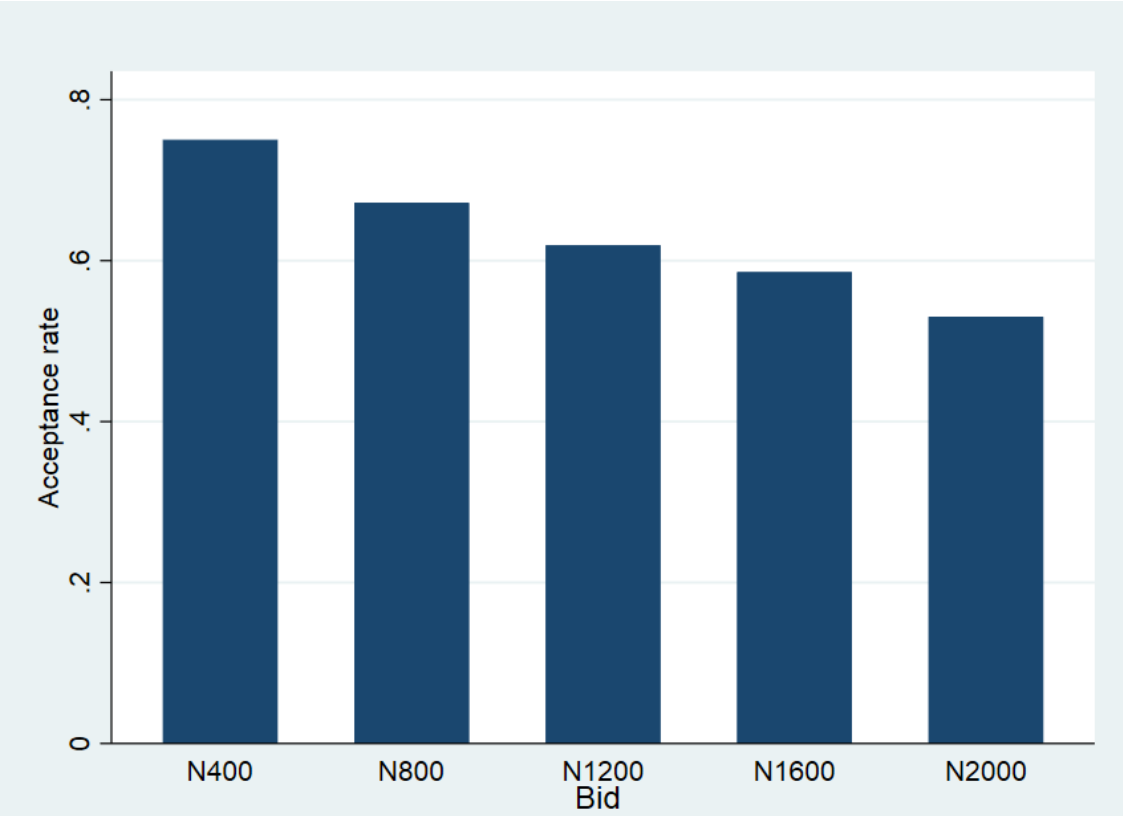

Figure A5. Scenario III: Acceptance rate.

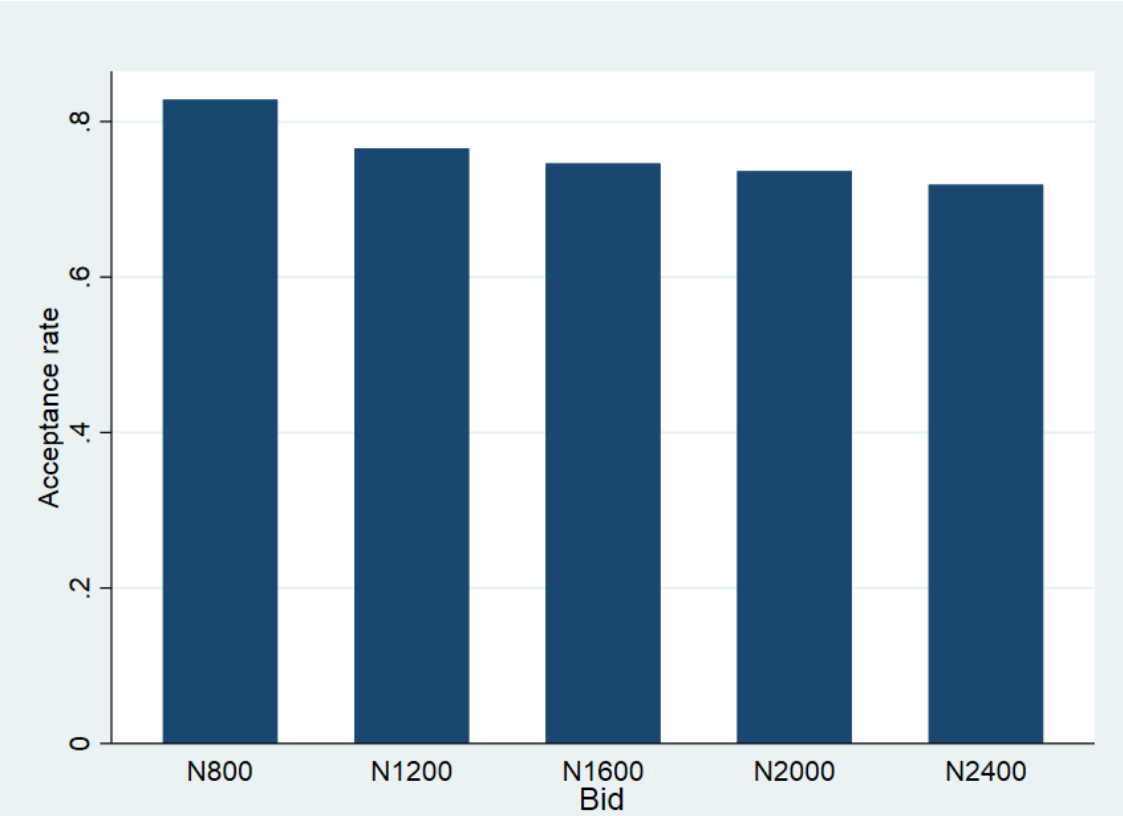

Figure A6. Scenario IV: Acceptance rate.

A3. WTP of owners of backup generators versus non-owners

We further estimate the WTP of generator users and nonusers. Households that use backup generators are expected to have a higher WTP than their counterparts because of the following factors: First, having a backup generator indicates a stronger preference for electric power. Second, it could be that they are wealthier than their counterparts. Third, the cost of self-generation. Thus, they could compare this with the bids offered to them.

Table A1 shows that in the first scenario, the mean WTP of generator owners is NGN3,529.36 ($9.75) compared to NGN3,191.42 ($8.82) of non-owners. In the second scenario, generator users are willing to pay NGN4,610.33 ($12.74), while nonusers are willing to pay NGN2,710.51 ($7.49). These are the WTP values obtained from the spike model. The two groups' WTP values are statistically different. Also, they are statistically different across methods.

Table A2 presents the results of scenarios three and four, which assume a 20% subsidy. In scenario three, self-generating households are willing to pay NGN3,420.29 ($9.45). In contrast, their counterparts are willing to pay NGN2,570.01 ($7.09). When a generator is wholly displaced, the former group is willing to pay NGN6,151.21 ($16.99), and the latter NGN3,544.78 ($9.79). Again, the difference between the means is significant within scenarios and, in most cases, across methods. This difference is expected because, unlike non-generator owners, households that use generators spend more on total electricity (grid electric power plus generator running costs). Thus, they are willing to pay more for solar PV to displace generators. Furthermore, our data shows that the average monthly income of generator users is NGN145,981.50 ($403.26) with a standard deviation of 111666.10. In comparison, non-users of backup generators' average monthly income is NGN123,961.10 ($342.43) with a standard deviation of 999853.62. Thus, the former group is wealthier relative to the latter.

Table A1. WTP of generator owners and non-owners in scenarios I and II

	Scenario I						Scenario II					
	Gen owners			Non-owners			Gen owners			Non-owners		
	Probit	Spike	Turnbull	Probit	Spike	Turnbull	Probit	Spike	Turnbull	Probit	Spike	Turnbull
WTP	NGN2652.65	NGN3529.36	NGN1435.80	NGN1868	NGN3191.42	NGN1334.38	NGN3992.90	NGN4610.33	NGN2312.32	NGN2341.10	NGN2710.51	NGN1696.19
S.E.	(401.86)	(471.55)	(105.14)	(290.59)	(812.37)	(152.15)	(726.62)	(538.48)	(86.74)	(337.23)	(397.28)	(161.07)
95% CI	1865.01-3440.28	2605.14-4453.59	1229.73-1641.87	2568.75-5417.05	3554.93-5665.73	1036.17-1632.59	1681.04-3002.95	3554.93-5665.73	2142.31-2482.33	924.51-4111.92	1931.86-3489.16	1380.50-2011.88
Obs.	236	236	236	91	91	91	236	236	236	91	91	91

Notes: WTP values are in Nigerian Naira. Standard errors are in parentheses.

Table A2. WTP of generator owners and non-owners in scenarios III and IV

	Scenario III						Scenario IV					
	Gen owners			Non-owners			Gen owners			Non-owners		
	Probit	Spike	Turnbull	Probit	Spike	Turnbull	Probit	Spike	Turnbull	Probit	Spike	Turnbull
WTP	NGN2518.22	NGN3420.29	NGN1249.05	NGN1700.01	NGN2570.01	NGN1179.71	NGN9281.48	NGN6151.21	NGN1877.08	NGN2254.15	NGN3544.78	NGN1451.26
S.E.	(813.13)	(576.39)	(69.39)	(311.80)	(604.16)	(125.11)	(11934.09)	1141.37	(85.00)	(378.86)	(814.57)	(92.25)
95% CI	924.51-4111.92	2290.58-4549.99	1113.05-1385.05	1088.88-2311.13	1385.88-3754.15	934.49-1424.93	-14108.91-32671.87	3914.16-8388.26	1710.48-2043.68	1511.59-2996.7	1948.26-5141.31	1270.45-1632.07
Obs.	236	236	236	91	91	91	236	236	236	91	91	91

Notes: WTP values are in Nigerian Naira. Standard errors are in parentheses.

Table A3. Cost of off-grid solar PV

Item name & description	Quantity	Unit price	Cost
PS-148 1.5KVA Inverter (Pure Sine Wave Inverter)	1	NGN75,000 /piece	NGN75,000
PS-036 250w solar panel (5BB solar panel)	4	NGN50,000 /installation	NGN20,000
ML2440 40A Solar Charge Controller (12/24V 40A MPPT)	1	NGN55,000 /piece	NGN55,000
GD12-200 Techfine 200AH Gel Deep Cycle Battery (Gel Deep cycle 12V/200AH)	2	NGN110,000 /piece	NGN220,000
BR2 Techfine 2 Battery Cabinet (Polished Metal Battery Rack)	1	NGN23,000 /piece	NGN23,000
IK-INST Installation Kit (Installation Kit)	1	NGN40,000 /installation	NGN40,000
SC-INST Service Charge (Service Charge)	1	NGN20,000 /installation	NGN20,000
TOTAL			**NGN633,000**

Source: Nexgen Energy & Allied Services Ltd, Nigeria.

Table A4. Model estimates - accounting for interviewer effects

	Probit (I)	LPM (I)	Probit (II)	LPM (II)	Probit (III)	LPM (III)	Probit (IV)	LPM (IV)
Variable	Coeff. (SE)	Coeff. (SE)	Coeff. (SE)	Coeff. (SE)	Coeff. (SE)	Coeff. (SE)	Coeff. (SE)	Coeff. (SE)
Bid	-0.0005 (0.0001)	-0.0002 (0.00004)	-0.0005 (0.0001)	-0.0001 (0.00003)	-0.0003 (0.0001)	-0.0001 (0.00004)	-0.0002 (0.0001)	-0.00007 (0.00004)
Age	-0.009 (0.008)	-0.003 (0.002)	-0.014 (0.008)	-0.003 (0.002)	-0.001 (0.008)	-0.0006 (0.003)	-0.004 (0.008)	-0.001 (0.002)
Male	0.198 (0.166)	0.067 (0.058)	0.508 (0.173)	0.156 (0.056)	0.339 (0.161)	0.120 (0.061)	0.259 (0.169)	0.078 (0.054)
Uni deg	0.430 (0.158)	0.145 (0.053)	0.195 (0.172)	0.062 (0.050)	-0.058 (0.158)	-0.018 (0.057)	0.076 (0.167)	0.028 (0.049)
Marriage	-0.195 (0.193)	-0.070 (0.066)	-0.303 (0.207)	-0.095 (0.060)	-0.164 (0.192)	-0.057 (0.069)	-0.263 (0.202)	-0.079 (0.059)
Children	0.344 (0.196)	0.120 (0.068)	0.504 (0.211)	0.156 (0.063)	-0.144 (0.191)	-0.052 (0.072)	0.243 (0.206)	0.083 (0.064)
Employment	0.038 (0.270)	0.009 (0.096)	0.186 (0.266)	0.052 (0.084)	0.061 (0.265)	0.019 (0.019)	0.509 (0.254)	0.169 (0.094)
ln(income)	0.144 (0.116)	0.051 (0.039)	0.356 (0.118)	0.102 (0.033)	0.179 (0.114)	0.065 (0.041)	0.105 (0.119)	0.036 (0.035)
Own generator	0.079 (0.166)	0.029 (0.056)	0.420 (0.173)	0.127 (0.054)	-0.115 (0.166)	-0.045 (0.083)	0.213 (0.170)	0.072 (0.054)
Own house	0.048 (0.239)	0.009 (0.080)	-0.003 (0.243)	-0.007 (0.069)	-0.121 (0.226)	-0.045 (0.083)	-0.051 (0.235)	-0.027 (0.073)
RE knowledge	0.260 (0.171)	0.094 (0.056)	0.426 (0.193)	0.127 (0.051)	0.084 (0.163)	0.027 (0.058)	0.106 (0.177)	0.029 (0.050)
DUMMY	0.227 (0.150)	0.082 (0.051)	0.253 (0.161)	0.080 (0.047)	0.259 (1.145)	0.097 (0.052)	0.170 (0.157)	0.051 (0.047)
Cons	-0.776 (1.280)	0.210 (0.442)	-3.078 (1.356)	-0.394 (0.406)	-1.377 (1.252)	-0.009 (0.464)	-0.720 (1.323)	0.250 (0.403)
N	327	327	327	327	327	327	327	327
R^2	0.10	0.13	0.17	0.19	0.06	0.08	0.05	0.06
LL	-191.21	-	-166.67	-	-202.45	-	-170.94	-
AIC	408.42	427.89	359.35	375.83	430.89	451.37	367.89	377.83
BIC	457.69	477.16	408.62	425.09	480.16	500.64	417.16	427.10

Notes: Standard errors (in parentheses are robust), LPM is linear probability model. DUMMY is a binary variable (0,1) that measures interviewer effect. I to IV correspond to the respective scenarios. N is number of observations, LL is log-pseudolikelihood, AIC is Akaike information criterion, and BIC is Schwarz's Bayesian information criterion.