Comment on "Risk Preferences are Not Time Preferences": Separating Risk and Time Preference

Online Appendices

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A Supplementary Tables and Figures

Table A1. Mean Allocation to Sooner Payment and Pairwise Wilcoxon Tests of Equality.

Gross Interest	CER	POS	NEG	IND	CER POS	CER NEG	CER IND	POS NEG	POS IND	NEG IND
				1 week	vs	5 weeks				
1	83.96	70.63	54.96	55.49	0.001	0.001	0.001	0.001	0.001	0.542
1.05	23.95	23.66	44.17	44.74	0.249	0.001	0.001	0.001	0.001	0.771
1.11	20.96	19.75	44.81	43.12	0.907	0.001	0.001	0.001	0.001	0.104
1.18	17.29	16.96	42.57	40.92	0.698	0.001	0.001	0.001	0.001	0.231
1.25	14.97	16.65	42.13	40.69	0.263	0.001	0.001	0.001	0.001	0.511
1.33	13.8	12.89	42.97	41	0.67	0.001	0.001	0.001	0.001	0.203
1.43	13.01	12.95	41.87	40.23	0.542	0.001	0.001	0.001	0.001	0.315
				16 weeks	vs	20 weeks				
1	78.47	72.84	54.14	52.84	0.038	0.001	0.001	0.001	0.001	0.647
1.05	20.22	20.75	45.66	44.91	0.453	0.001	0.001	0.001	0.001	0.926
1.11	16.56	16.51	45.58	43.03	0.465	0.001	0.001	0.001	0.001	0.232
1.18	12.64	12.83	43.69	42.23	0.402	0.001	0.001	0.001	0.001	0.694
1.25	9.27	12.79	44.06	40.87	0.036	0.001	0.001	0.001	0.001	0.12
1.33	8.27	11.48	42.17	40.4	0.003	0.001	0.001	0.001	0.001	0.223
1.43	8.099	11.32	41.3	39.34	0.008	0.001	0.001	0.001	0.001	0.227

Table A2. Tobit Regression Results.

	CER vs POS	NEG vs IND	CER/POS vs NEG/IND
treatment	-134.7**	-7.881	-280.1***
	(58.21)	(8.46)	(28.07)
interest rate	3,439***	183.7***	252.4***
	(681.1)	(48.75)	(52.83)
time	-92.33*	-0.439	1.108
	(55.91)	(5.405)	(4.152)
treatment x interest rate	819.7**	39.8	1,411***
	(319.2)	(45.91)	(143.7)
treatment x time	-62.61	2.185	-47.17**
	(71.3)	(7.739)	(20.8)
interest rate x time	451.1	6.2	-6.945
	(288.6)	(31.03)	(23.98)
treatment x interest rate x time	261.5	-20.07	219.6**
	(376.7)	(46.27)	(106.7)
constant	-648.1***	12.77	-1.107
	(136.1)	(9.445)	(10.47)
# clusters	111	111	111
Pseudo R-square	0.052	0.004	0.046
F-test: risk (p-value)	0.01	0.655	0.001
F-test: time (p-value)	0.162	0.923	0.189
F-test: interest rate (p-value)	0.001	0.001	0.001

Table A3. Tobit Regression between CER and POS for Two Time Menus.

	1 week vs 4 weeks	16 weeks vs 20 weeks
treatment	-133.0**	-200.3**
	(56.75)	(79.76)
interest rate	3,397***	3,946***
	(683.2)	(826.7)
treatment x interest rate	809.1***	1,097**
	(311.3)	(431.5)
constant	-639.6***	-751.8***
	(136.5)	(165.8)
# clusters	111	111
Pseudo R-square	0.004	0.059
F-test: risk (p-value)	0.006	0.039
F-test: interest rate (p-value)	0.001	0.001

Table A4. Individual Level Difference between CER and POS with Varying Choice Errors.

Gross	error = 0			error ≤ 5			error ≤ 10		
Interest	CER > POS	CER = POS	CER < POS	CER > POS	CER = POS	CER < POS	CER > POS	CER = POS	CER < POS
				1 week	vs	5 weeks			
1	24	85	2	24	85	2	24	85	2
1.05	8	89	14	8	91	12	8	94	9
1.11	12	86	13	12	88	11	12	90	9
1.18	10	89	12	9	92	10	9	93	9
1.25	8	90	13	7	93	11	6	95	10
1.33	12	89	10	11	91	9	9	95	7
1.43	9	90	12	8	91	12	8	95	8
				16 weeks	vs	20 weeks			
1	19	84	8	18	85	8	18	85	8
1.05	10	87	14	9	90	12	8	93	10
1.11	10	87	14	10	89	12	9	93	9
1.18	8	91	12	8	91	12	8	93	10
1.25	5	92	14	5	92	14	3	95	13
1.33	2	95	14	2	96	13	2	98	11
1.43	3	94	14	3	94	14	2	97	12

Table A5. Spearman Correlation across Conditions.

Interest	CER/POS	CER/NEG	CER/IND	POS/NEG	POS/IND	NEG/IND
			1 week vs 5 weeks			
1	0.61	0.14	0.07	0.25	0.28	0.57
1.05	0.8	0.16	0.13	0.11	0.12	0.3
1.11	0.79	0.14	0.21	0.11	0.21	0.56
1.18	0.84	0.21	0.3	0.23	0.3	0.6
1.25	0.86	0.17	0.24	0.08	0.26	0.59
1.33	0.82	0.14	0.27	0.09	0.25	0.54
1.43	0.79	0.04	0.22	0.02	0.2	0.53
			16 weeks vs 20 weeks			
1	0.61	-0.03	0.22	0.21	0.27	0.53
1.05	0.74	0.17	0.17	0.21	0.14	0.26
1.11	0.73	0.05	0.18	0.17	0.13	0.44
1.18	0.71	0.16	0.15	0.15	0.13	0.45
1.25	0.76	0.06	0.08	0.03	0.19	0.44
1.33	0.74	0.04	0.18	0.02	0.19	0.59
1.43	0.73	0.1	0.11	0.07	0.15	0.59
Average	0.75	0.11	0.18	0.13	0.2	0.5

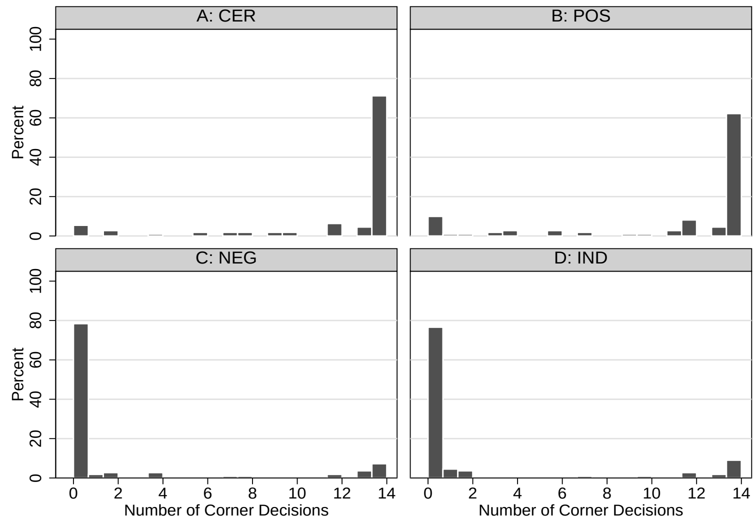

Figure A1. Individual Level Corner Decisions across Conditions.

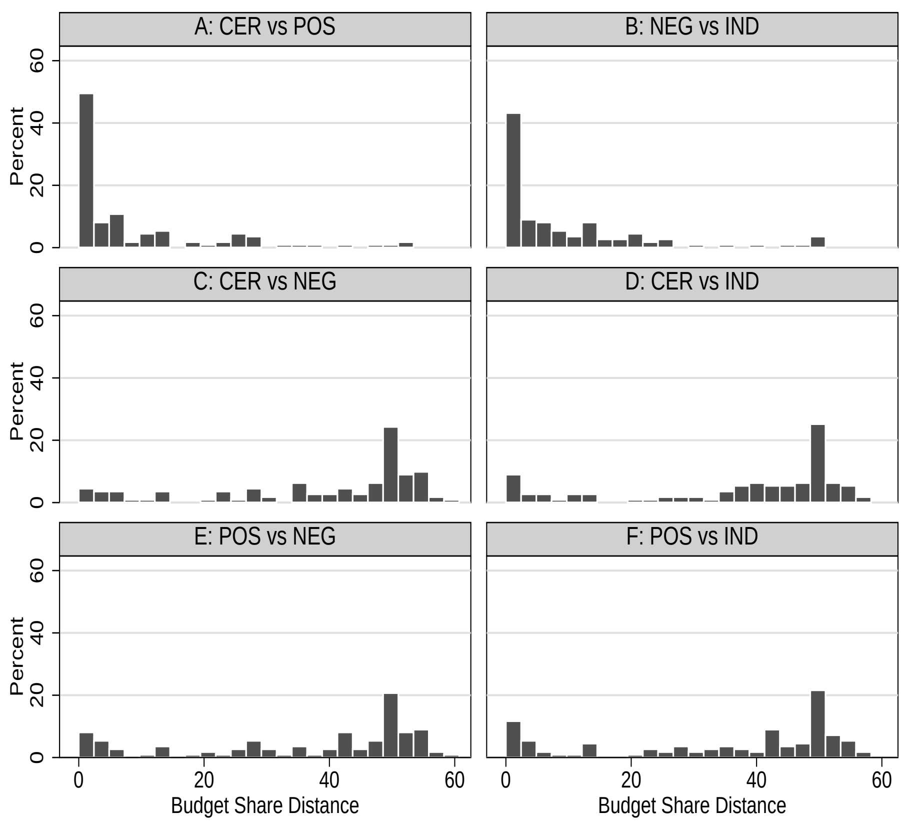

Figure A2. Individual Budget Share Distance across Conditions.

B Existence of a Cross-over in Epstein–Zin and Chew–Epstein–Halevy

In this appendix, we show how Epstein-Zin and Chew–Epstein–Halevy can exhibit a cross-over between CER/POS and NEG/IND as observed.

B.1 Cross-over in Epstein–Zin

We show here Epstein–Zin can generate a cross-over under the condition of $\alpha < \rho < 1$. First, we have the optimal solutions in conditions CER, POS, and NEG: $c^{\star}_{1,C/P} = \frac{100(\delta(1+r))^{\frac{1}{\rho-1}}}{\delta^{\frac{1}{\rho-1}}(1+r)^{\frac{\rho}{\rho-1}}+1}$, $c^{\star}_{1,N} = \frac{100\delta^{\frac{\alpha}{\rho(\alpha-1)}}(1+r)^{\frac{1}{\alpha-1}}}{\delta^{\frac{\alpha}{\rho(\alpha-1)}}(1+r)^{\frac{\alpha}{\alpha-1}}+1}$. The FOC characterizing $c^{\star}_{1,I}$ is given by

$$\left(c_1^{\rho} + \delta c_2^{\rho}\right)^{\frac{\alpha}{\rho}-1}\left[c_1^{\rho-1} - \delta\left(1+r\right)c_2^{\rho-1}\right] + \left[c_1^{\alpha-1} - \delta^{\alpha/\rho}\left(1+r\right)c_2^{\alpha-1}\right] = 0,$$

which does not have an explicit solution. Notice that the function in the first square bracket corresponds to the FOC characterizing $c^{\star}_{1,C/P}$ and the function in the second square bracket characterizes $c^{\star}_{1,N}$. Therefore, $c^{\star}_{1,I}$ would be between $c^{\star}_{1,C/P}$ and $c^{\star}_{1,N}$ under certain monotonicity conditions. Moreover, we have $\left(c_1^{\rho} + \delta c_2^{\rho}\right)^{\frac{\alpha}{\rho}-1} \ll 1$ given $\alpha < \rho$, which could make $c^{\star}_{1,I}$ close to $c^{\star}_{1,N}$.

When $r = 0$, we have $c^{\star}_{1,C/P} = \frac{100\delta^{\frac{1}{\rho-1}}}{\delta^{\frac{1}{\rho-1}}+1}$ and $c^{\star}_{1,N} = \frac{100\delta^{\frac{\alpha}{\rho(\alpha-1)}}}{\delta^{\frac{\alpha}{\rho(\alpha-1)}}+1}$ with $c^{\star}_{1,I}$ in between. As $\frac{1}{\rho-1} < \frac{\alpha}{\rho(\alpha-1)}$ given $\alpha < \rho < 1$, the four optimal solutions satisfy $c^{\star}_{1,C/P} > c^{\star}_{1,I} > c^{\star}_{1,N}$. Moreover, the change in $c^{\star}_1$ to the change in r is more sensitive in CER/POS than in NEG because $(1+r)^{\frac{1}{\rho-1}}$ vanishes faster than $(1+r)^{\frac{1}{\alpha-1}}$ does. To sum up, it could generate the observed cross-over. Finally, note that $\alpha < \rho$ implies a preference for NEG over POS as $(c_1^{\rho} + \delta c_2^{\rho})^{\alpha/\rho} < c_1^{\alpha} + \delta^{\alpha/\rho} c_2^{\alpha}$ by triangular inequality, and we may have a reverse cross-over if $\rho < \alpha < 1$.

B.2 Cross-over in Chew–Epstein–Halevy

We show here Chew–Epstein–Halevy can generate a cross-over under the conditions of $f\left(0.5\right) < 1 - f\left(0.5\right)$ and $f\left(0.5\right) < f\left(0.75\right) + f\left(0.25\right) - f\left(0.5\right)$.

First, notice that one can simply represent Chew–Epstein–Halevy in terms of utilities given that there is a unique utility index u. The evaluations of four different conditions in our experiment are as follows:

$$
\begin{aligned}
U_{CER} &= u(c_1) + \delta u(c_2) \\
U_{POS} &= f(0.5)\left(u(c_1) + \delta u(c_2)\right) \\
U_{NEG} &= \begin{cases} f(0.5)\, u(c_1) + (1 - f(0.5))\, \delta u(c_2) & if\ u(c_1) \geq \delta u(c_2) \\ (1 - f(0.5))\, u(c_1) + f(0.5)\, \delta u(c_2) & if\ u(c_1) < \delta u(c_2) \end{cases} \\
U_{IND} &= \begin{cases} f(0.5)\, u(c_1) + (f(0.75) + f(0.25) - f(0.5))\, \delta u(c_2) & if\ u(c_1) \geq \delta u(c_2) \\ (f(0.75) + f(0.25) - f(0.5))\, u(c_1) + f(0.5)\, \delta u(c_2) & if\ u(c_1) < \delta u(c_2) \end{cases}
\end{aligned}
$$

The optimal allocations in CER and POS coincide. We proceed to show that a cross-over may exist between POS and NEG under the condition of $f(0.5) < 1 - f(0.5)$.[1]

When r is small, the optimal allocations $c^\star_{1,P}$ and $c^\star_{1,N}$ are likely to fall in the region in which $u(c_1) \geq \delta u(c_2)$. As $f(0.5) < 1 - f(0.5)$, we have the following relation on the first-order conditions characterizing $c^\star_{1,P}$ and $c^\star_{1,N}$:

$$
\frac{u'\left(c^\star_{1,P}\right)}{u'\left(c^\star_{2,P}\right)} = \delta(1+r) < \delta(1+r)\frac{1 - f(0.5)}{f(0.5)} = \frac{u'\left(c^\star_{1,N}\right)}{u'\left(c^\star_{2,N}\right)},
$$

which implies $c^\star_{1,P} > c^\star_{1,N}$ at r small. As r increases, the optimal allocations will shift to the region in which $u(c_1) < \delta u(c_2)$ and the above relation reverses accordingly:

$$
\frac{u'\left(c^\star_{1,P}\right)}{u'\left(c^\star_{2,P}\right)} = \delta(1+r) > \delta(1+r)\frac{f(0.5)}{1 - f(0.5)} = \frac{u'\left(c^\star_{1,N}\right)}{u'\left(c^\star_{2,N}\right)},
$$

which results in $c^\star_{1,P} < c^\star_{1,N}$ at r large. Intuitively, the unfavored outcome gets overweighted in NEG compared to POS, which makes the unfavored outcome relatively more attractive. As the sooner payment is initially favored and eventually unfavored as the interest rate increases, a decision maker first allocates less in the sooner payment and then more in the sooner payment in NEG compared to POS, which generates the cross-over as observed. Similarly, a cross-over will occur between CER/POS and IND under the condition of $f(0.5) < f(0.75) + f(0.25) - f(0.5)$. Moreover, given $f(0.75) + f(0.25) - f(0.5) \approx 1 - f(0.5)$, $c^\star_{1,N}$ and $c^\star_{1,I}$ will be close to each other and we have the overall patterns as observed.

[1] The probability weighting function is commonly observed to be inverse S-shaped: initially concave and eventually convex with a cross-over point at around one third. Therefore, $f(0.5) < 1 - f(0.5)$ is a reasonable assumption behaviorally. See Wakker (2010, chapter 7) for details.

B.3 Further Discussion on Epstein–Zin and Chew–Epstein-Halevy

We note here that Epstein and Zin (1989) and Chew and Epstein (1990) adopt different approaches in the recursive environment. Specifically, Epstein and Zin (1989) maintain the consistency assumption and discard time neutrality, whereas Chew and Epstein (1990) maintain time neutrality and abandon recursivity. Our experiment involves only degenerate recursive cases as all uncertainties are resolved at period one, which makes these models comparable. In other settings, these two models can be further differentiated. For example, Epstein and Zin (1989) point out that their specification is incompatible with the experimental evidence against expected utility theory as it admits EU for static risks. [2] Moreover, Epstein–Zin predicts a positive correlation between preference for NEG over POS and preference for early resolution over later resolution of uncertainty, which is also testable by experimental instruments. Meanwhile, Chew–Epstein–Halevy employs non-EU in risk using the same utility index as that in time, which can be tested by extending Andreoni and Sprenger (2012a) to assume non-EU in risk preference estimation.[3]

Cheung (2013) and Epper and Fehr-Duda (2013) also provide theoretical frameworks to analyze the allocation behavior in Andreoni and Sprenger (2012b). Cheung (2013) considers a behavioral model $\mathrm{E}_{\mu} v\left(u\left(c_1\right)+\delta u\left(c_2\right)\right)$ and shows that it can account for the cross-over between CER and IND. The behavioral model shares similar implications with Epstein–Zin, given that u and v intuitively capture intertemporal substitution and risk attitude.[4] Epper and Fehr-Duda (2013) apply rank-dependent probability weighting to explain the major findings in Andreoni and Sprenger (2012b). The model considered in Epper and Fehr-Duda (2013) is the same as that in Halevy (2008), which is a special case of Chew and Epstein (1990).

We would like to point out that the observed similar choice pattern between certain and uncertain conditions under MPL in Cheung (2013) can be rationalized by both Epstein–Zin and Chew–Epstein–Halevy. Consider the choice between receiving x at t_1 with probability p and receiving y at t_2 with the same probability p, where p equals 1 (certainty condition) or 0.5 (uncertainty condition). Under Epstein–Zin, the CEs of $(x,0)$ and $(0,y)$ are x and $\delta^{1/\rho}y$ at $p=1$, and $\left(0.5x^{\alpha}\right)^{1/\alpha}$ and $\left(0.5\delta^{\alpha/\rho}y^{\alpha}\right)^{1/\alpha}$ at $p=0.5$. For Chew–Epstein–Halevy, the utilities of $(x,0)$ and $(0,y)$ are $u\left(x\right)$ and $\delta u\left(y\right)$ at $p=1$, and $f\left(0.5\right)u\left(x\right)$ and $f\left(0.5\right)\delta u\left(y\right)$

[2] Epstein and Zin (1989) provide a more general recursive form in which the risk aggregator complies with the betweenness axiom. One can also consider a recursive form using rank-dependent utility for risk, which reduces to Chew–Epstein–Halevy in a degenerate recursive environment.

[3] Epper, Fehr-Duda, and Bruhin (2011) elicit risk and time preferences in an experimental setting and estimate the rank-dependent probability weighting function and discount factor using the same utility index, which is in accordance with the model of Chew–Epstein–Halevy.

[4] The behavioral model in Cheung (2013) admits the specific form of $p\left(c_1^{\rho}+\delta c_2^{\rho}\right)^{\alpha}+\left(1-p\right)\left(c_1'^{\rho}+\delta c_2'^{\rho}\right)^{\alpha}$ when evaluating μ.

at $p = 0.5$. Thus, both theories predict identical choice behavior across the two conditions.

C Structural Estimation of Aggregate Preferences

In this appendix, we estimate the preference parameters in Epstein–Zin and Chew–Epstein–Halevy. We adopt the two-limit Tobit maximum likelihood estimation to account for corner solution censoring.[5] To start with, we posit a hyperbolic discounting utility function with the same background consumptions following the methodology developed in Andreoni and Sprenger (2012a). For example, we have the following equation for Epstein–Zin under condition CER:

$$\mathrm{CE}_{CER} = \left((c_1 + w)^{\rho} + \beta^s \delta \left(c_2 + w\right)^{\rho}\right)^{1/\rho}$$

where δ is the discount factor for 4 weeks, $s = 1$ for 1-week versus 5-week time menu and $s = 0$ for 16-week versus 20-week time menu to capture the discount factor difference between the two time menus. If β is significantly smaller than 1, the discount factor is smaller for first time menu than for the second time menu, which supports the hyperbolic discounting hypothesis. w can be interpreted as the classic Stone–Geary consumption minima, intertemporal reference point, or background consumption, which is also included in the estimations in Andreoni and Sprenger (2012a, b). Taking the term w under consideration, the optimization under condition CER can be regarded as $\left((c_1')^{\rho} + \beta^s \delta \left(c_2'\right)^{\rho}\right)^{1/\rho}$ with the constraint $(1+r)\, c_1' + c_2' = 100 + (2+r)\, w$. The optimal solution is as follows:

$$c_{1,C}'^{\star} = \frac{(100+(2+r)w)(\beta^s\delta(1+r))^{\frac{1}{\rho-1}}}{(\beta^s\delta)^{\frac{1}{\rho-1}}(1+r)^{\frac{\rho}{\rho-1}}+1}$$

By subtracting w from c_1', we obtain the optimal allocation to the sooner payment as follows:

$$c_{1,C}^{\star} = g\left(r, \alpha, \rho, \beta, \delta, w\right) = \frac{(100+(2+r)w)(\beta^s\delta(1+r))^{\frac{1}{\rho-1}}}{(\beta^s\delta)^{\frac{1}{\rho-1}}(1+r^j)^{\frac{\rho}{\rho-1}}+1} - w$$

For condition POS, we have the same optimal allocation. The optimal allocation for condition NEG is similarly specified as

$$c_{1,N}^{\star} = g\left(r, \alpha, \rho, \beta, \delta, w\right) = \frac{(100+(2+r)w)(\beta^s\delta)^{\frac{\alpha}{\rho(\alpha-1)}}(1+r)^{\frac{1}{\alpha-1}}}{(\beta^s\delta)^{\frac{\alpha}{\rho(\alpha-1)}}(1+r)^{\frac{\alpha}{\alpha-1}}+1} - w.$$

[5] The structural estimation for corner choices in CTB has been an issue of debate. Andreoni and Sprenger (2012a, b) mainly adopt the non-linear least squares technique and discuss in detail the censored data issue. They show that accounting for censoring issues has little influence on the estimates. In a recent study, Harrison et al. (2013) thoroughly discuss the potential problems with corner solutions and propose multinomial logit (MNL) as an alternative estimation technique. However, the MNL estimates indicate that the utility function over time is convex (Harrison et al., 2013; Cheung, 2013) and significantly different from being linear, which we think is unlikely. Therefore, we build the two-limit Tobit specification into the non-linear regression model to conduct the estimation.

$c^{\star}_{1,I}$ has no explicit solution, and the optimal c_1 in NEG satisfies the following FOC:

$$\begin{aligned}
&\left((c_1+w)^{\rho}+\beta^{s}\delta\left((100+(2+r)\,w)-(1+r^{j})\,(c_1+w)\right)^{\rho}\right)^{\alpha/\rho-1}\times\\
&\left[(c_1+w)^{\rho-1}-\beta^{s}\delta\,(1+r)\left((100+(2+r)\,w)-(1+r)\,(c_1+w)\right)^{\rho-1}\right]+\\
&\left[(c_1+w)^{\alpha-1}-(\beta^{s}\delta)^{\alpha/\rho}\,(1+r)\left((100+(2+r)\,w)-(1+r)\,(c_1+w)\right)^{\alpha-1}\right]=0.
\end{aligned}$$

We assume that $c_1 = g(r,\alpha,\rho,\beta,\delta,w)+\varepsilon$, where $\varepsilon \sim \text{Normal}(0,\sigma)$. It can be interpreted as errors arising when subjects choose the optimal allocation. In the actual experiment, the observed allocation y_1 is censored between 0 and 100. We specify the two-limit Tobit likelihood as follows:

$$P(y_1)=\begin{cases}1-\Phi\left(g(r,\alpha,\rho,\beta,\delta,w)/\sigma\right), & \text{if } y_1=0\\ \phi\left((y_1-g(r,\alpha,\rho,\beta,\delta,w))/\sigma\right), & \text{if } 0<y_1<100\\ 1-\Phi\left((100-g(r,\alpha,\rho,\beta,\delta,w))/\sigma\right), & \text{if } y_1=100\end{cases}$$

As we could not obtain an explicit solution for condition IND, we exclude it from the estimation.[6] The data generated by individual i with interest rate r^j and condition k are denoted by $\left\{y_i^{jk}, r^j, k\right\}$, where y_i^{jk} is the allocation to the sooner payment given the interest rate r^j under condition k. We then conduct group estimation for $\alpha,\rho,\beta,\delta,w$ and σ, and cluster robust standard error at the individual level using Stata 13.

For Chew–Epstein–Halevy, let $l = f(0.5)$ and $n = f(0.75)+f(0.25)$. We obtain the following candidate solutions:

$c^{\star}_{1,C/P} = \frac{(100+(2+r)w)(\delta(1+r))^{\frac{1}{\rho-1}}}{\delta^{\frac{1}{\rho-1}}(1+r)^{\frac{\rho}{\rho-1}}+1}$

$c'_{1,N} = \frac{(100+(2+r)w)[(1-l)(\delta(1+r))]^{\frac{1}{\rho-1}}}{((1-l)\delta)^{\frac{1}{\rho-1}}(1+r)^{\frac{\rho}{\rho-1}}+l^{\frac{1}{\rho-1}}}$ when $u(c_1) \geq \delta u(c_2)$ and $c''_{1,N} = \frac{(100+(2+r)w)[l(\delta(1+r))]^{\frac{1}{\rho-1}}}{(l\delta)^{\frac{1}{\rho-1}}(1+r)^{\frac{\rho}{\rho-1}}+(1-l)^{\frac{1}{\rho-1}}}$ when $u(c_1) < \delta u(c_2)$.

$c'_{1,I} = \frac{(100+(2+r)w)[(n-l)(\delta(1+r))]^{\frac{1}{\rho-1}}}{((n-l)\delta)^{\frac{1}{\rho-1}}(1+r)^{\frac{\rho}{\rho-1}}+l^{\frac{1}{\rho-1}}}$ when $u(c_1) \geq \delta u(c_2)$ and $c''_{1,I} = \frac{(100+(2+r)w)[l(\delta(1+r))]^{\frac{1}{\rho-1}}}{(l\delta)^{\frac{1}{\rho-1}}(1+r)^{\frac{\rho}{\rho-1}}+(n-l)^{\frac{1}{\rho-1}}}$ when $u(c_1) < \delta u(c_2)$.

Note that $c'_{1,N}$ may not satisfy $u(c_1) \geq \delta u(c_2)$, and $c''_{1,N}$ may not satisfy $u(c_1) < \delta u(c_2)$. If only one holds, that one will be the optimal solution. If both hold, the one delivering a higher utility will be the optimal solution. If both do not hold, the optimal solution will be in the kink, where $u(c_1) = \delta u(c_2)$. Therefore, we have the optimal solution for NEG as follows:

[6] For robustness check, we linearize the first-order condition in IND to obtain the approximate explicit solution and conduct Tobit estimation including all conditions. The results are not significantly different and support the separation. Specifically, given that the allocation behavior in NEG and IND are similar, we linearize the FOC in IND around $c^{\star}_{1,NEG}$ as a linear function $f\left(c^{\star}_{1,NEG}\right)+f'\left(c^{\star}_{1,NEG}\right)\times\left(c-c^{\star}_{1,NEG}\right)=0$ to solve the optimal $c^{\star}_{1,IND}=\left(f'\left(c^{\star}_{1,NEG}\right)\times c^{\star}_{1,NEG}-f\left(c^{\star}_{1,NEG}\right)\right)/f'\left(c^{\star}_{1,NEG}\right)$, which is a function of the known parameters. Then, we similarly build the Tobit specification and conduct a structural estimation including all four conditions.

$$c^{\star}_{1,N} = \begin{cases} c'_{1,N},\ if\ u\left(c'_{1,N}\right) \geq \delta u\left(c'_{2,N}\right),\ u\left(c''_{1,N}\right) > \delta u\left(c''_{2,N}\right) \\ c''_{1,N},\ if\ u\left(c'_{1,N}\right) < \delta u\left(c'_{2,N}\right),\ u\left(c''_{1,N}\right) \leq \delta u\left(c''_{2,N}\right) \\ c^{k}_{1},\ if\ u\left(c'_{1,N}\right) < \delta u\left(c'_{2,N}\right),\ u\left(c''_{1,N}\right) > \delta u\left(c''_{2,N}\right) \\ c'_{1,N},\ if\ u\left(c'_{1,N}\right) \geq \delta u\left(c'_{2,N}\right),\ u\left(c''_{1,N}\right) \leq \delta u\left(c''_{2,N}\right),\ U_N\left(c'_{1,N}, c'_{2,N}\right) > U_N\left(c''_{1,N}, c''_{2,N}\right) \\ c''_{1,N},\ otherwise \end{cases}$$

where c^k_1 represents the kink solution such that $u\left(c^k_1\right) = \delta u\left(\left(100 + \left(2+r\right)w\right) - \left(1+r\right)c^k_1\right)$, and different c_2 refer to $\left(100 + \left(2+r\right)w\right) - \left(1+r\right)c_1$ for their corresponding c_1.

For IND, we specify the optimal solution in the same way as follows:

$$c^{\star}_{1,I} = \begin{cases} c'_{1,I},\ if\ u\left(c'_{1,I}\right) \geq \delta u\left(c'_{2,I}\right),\ u\left(c''_{1,I}\right) > \delta u\left(c''_{2,I}\right) \\ c''_{1,I},\ if\ u\left(c'_{1,I}\right) < \delta u\left(c'_{2,I}\right),\ u\left(c''_{1,I}\right) \leq \delta u\left(c''_{2,I}\right) \\ c^{k}_{1},\ if\ u\left(c'_{1,I}\right) < \delta u\left(c'_{2,I}\right),\ u\left(c''_{1,I}\right) > \delta u\left(c''_{2,I}\right) \\ c'_{1,I},\ if\ u\left(c'_{1,I}\right) \geq \delta u\left(c'_{2,I}\right),\ u\left(c''_{1,I}\right) \leq \delta u\left(c''_{2,I}\right),\ U_{IND}\left(c'_{1,I}, c'_{2,I}\right) > U_{IND}\left(c''_{1,I}, c''_{2,I}\right) \\ c''_{1,I},\ otherwise \end{cases}$$

As we can obtain the optimal solutions for each condition, we conduct a two-limit Tobit MLE that includes all conditions together. We specify a power function $u(c) = c^{\rho}$ to make the estimation comparable with that of Epstein–Zin. With only $f(0.5)$ and $f(0.25)+f(0.75)$ in the optimal solutions, we estimate l and n directly instead of specifying a probability weighting function for $f(p)$. The parameters β, δ, w are specified similarly as those in the estimation of Epstein–Zin.

Table C1 presents the results of the estimated parameters. For Epstein–Zin, the estimated risk aversion coefficient is 0.441, which is significantly smaller than 1 ($p < 0.001$). The estimated intertemporal substitution coefficient is 0.988, which is significantly smaller than 1 ($p < 0.001$). Moreover, the intertemporal substitution parameter is significantly larger than the risk aversion coefficient ($p < 0.001$). Should the two parameters be equal, Epstein–Zin would reduce to DEU. Hence, our result rejects DEU, and $\rho > \alpha$ further suggests a preference for NEG over POS.

For Chew–Epstein–Halevy, the non-parametric estimate of the probability weight for $f(0.5)$ is 0.420, which is significantly smaller than 0.5 ($p < 0.001$).[7] The non-parametric estimate of the probability weight for $f(0.25)+f(0.75)$ is 0.999, which is significantly higher than $2f(0.5)$ ($p < 0.001$) and not significantly different from 1 ($p > 0.316$). This finding supports the theoretical prediction of the cross-over between CER/POS and NEG/IND, and the similarity between NEG and IND when $f(0.5) < 1 - f\left(0.5\right) \approx f(0.25)+f(0.75) - f\left(0.5\right)$. If $f(p) = p$, Chew–Epstein–Halevy reduces to DEU. Therefore, our result again rejects DEU. The curvature of the utility function is 0.987, which is significantly smaller than 1 (p <

[7] On the one hand, given that the utility of NEG is $f\left(0.5\right)u\left(c_1\right) + \left(1 - f\left(0.5\right)\right)\delta u\left(c_2\right)$ when $u\left(c_1\right) > \delta u\left(c_2\right)$, the assumption $c^{\star}_{1,NEG} > 50$ at $r = 0$ requires $f\left(0.5\right) > \left(1 - f\left(0.5\right)\right)\delta$, which implies $f\left(0.5\right) \approx 0.5$ as δ is close to 1. On the other hand, one needs $f\left(0.5\right) < 0.5$ to generate a relatively smooth optimal sooner consumption in NEG. The estimation result shows that the effect of consumption smoothing is stronger.

Table C1. Estimated Parameters at the Aggregate Level.

	Coef.	Std. Err.	z	p > z	95% CI	
			Epstein–Zin			
α	0.441	0.098	4.51	0.000	0.249	0.632
ρ	0.988	0.002	573.11	0.000	0.984	0.991
δ	0.973	0.005	183.00	0.000	0.963	0.984
β	0.996	0.004	264.96	0.000	0.988	1.003
ω	5.240	5.843	4.48	0.000	2.950	7.530
σ	2.442	4.685	13.03	0.000	2.074	2.809
			Chew–Epstein–Halevy			
$f(0.5)$	0.420	0.001	417.20	0.000	0.418	0.422
$f(0.25) + f(0.75)$	0.999	0.001	1895.15	0.000	0.998	1.001
ρ	0.987	0.002	563.35	0.000	0.984	0.990
δ	0.974	0.004	231.51	0.000	0.966	0.982
β	0.999	0.001	1065.65	0.000	0.997	1.001
ω	3.439	4.872	3.53	0.000	1.529	5.349
σ	1.916	3.291	14.55	0.000	1.658	2.174

0.001). Overall, the estimation results of both Epstein–Zin and Chew–Epstein–Halevy show the distinction between risk and time preferences.

In Epstein–Zin, the four-week discount factor δ is estimated to be 0.973, which is significantly different from 1 ($p < 0.001$). The calculated annualized discount factor is 0.745. The estimated discount factor difference between the two time menus β is 0.004, which is not significantly different from 0 ($p > 0.239$), consistent with the findings in Andreoni and Sprenger (2012a). The estimates of δ and β in Chew–Epstein–Halevy are similar to those in Epstein–Zin.

D Experimental Instructions

Welcome to our study on decision making. The instructions are simple and if you follow them carefully and make good decisions, you could earn a considerable amount of money which will be paid to you in cheques before you leave today. Different subjects may earn different amounts of money. What you earn today depends partly on your decisions, and partly on chance. All information provided will be kept confidential. Information in the study will be used for research purposes only. If you have any questions, please raise your hand to ask our experimenters at any time. Cell phones and other electronic devices are not allowed, and please do not communicate with others during the experiment.

Earn Money:
To begin, you will be given $12 as show up fee. You will receive this payment in two payments of $6 each. The two $6 minimum payments will come to you at two different times. These times will be determined in the way described below. Whatever you earn from the study today will be added to these minimum payments.

In this study, you will make 56 choices over how to allocate money between two points in time, one time is sooner and one is later. Both the sooner and later times will vary across decisions. This means you could be receiving payments as soon as one week from today, and as late as 20 weeks from today.

It is important to note that the payments in this study involve chance. There could be a chance that your sooner payment, your later payment or both will not be sent at all. For each decision, you will be fully informed of the chance involved for the sooner and later payments. Whether or not your payments will be sent will be determined at the END of the experiment today. If, by chance, one of your payments is not sent, you will receive only the $6 minimum payment.

Once all 56 decisions have been made, we will randomly select one of the 56 decisions as the decision-that-counts. This will be done in three stages. First, we will pick a number from 1 to 56 at random to determine which one is the decision-that-counts and the corresponding sooner and later payment dates. We will then determine whether the payments will be sent based on chances, which we will describe in details later. Last, we will use the resolved chances to determine your actual earnings.

Note, since all decisions are equally likely to be chosen, you should make each decision as if it will be the decision-that-counts. When calculating your earnings from the decision-that-counts, we will add to your earnings the two $6 minimum payments. Thus, you will always get paid at least $6 at the chosen earlier time, and at least $6 at the chosen later time.

IMPORTANT: We will sign you cheques with the specified date at the end of today's experiment. Under Singapore banking practices, a cheque can be cashed only on or within 6 months of the date of the cheque. It is very IMPORTANT that you do not try to cash before the date of the cheque, since you will not be able to get the money, and it will also incur a $40 loss for the experimenter.

How it Works:

In each decision you are asked to divide 100 tokens between two payments at two different dates: Payment A (which is sooner) and Payment B (which is later). Tokens will be exchanged for money. The tokens you allocate to Payment B (later) will always be worth at least as much as the tokens you allocate to Payment A (sooner). The process is best described by example.

In the table below, in row 3, each token you allocate to one week later is worth $0.18, while each token you allocate to five weeks later is worth $0.20. So, if you allocate all 100 tokens to one week later, you may earn 100x$0.18 = $18 (+ $6 minimum payment) on this date and nothing on five weeks later (+ $6 minimum payment). If you allocate all 100 tokens to five weeks later, you may earn 100x$0.20 = $20 (+ $6 minimum payment) on this date and nothing on five week later (+ $6 minimum payment). You may also choose to allocate some tokens to the earlier date and some to the later date. For instance, if you allocate 60 tokens to one week later and 40 tokens to five weeks later, then one week later you may earn 60x$0.18 = $10.04 (+ $6 minimum payment) and five weeks later you would earn 40x$0.20 = $8 (+ $6 minimum payment). The Payoff Table shows some of the token-dollar exchanges at all relevant token exchange rates, which applies to all decisions in this experiment.

Sample Decision Making Sheet

Chance of Receiving Payments:

Each decision sheet lists the chances that each payment will be sent. Each decision in that sheet share the same chances that the payments will be sent. There are four cases.

Case A

If this decision were chosen as the decision-that-counts, both PAYMENT A and PAYMENT B will be sent for sure.

Case B

There are some chance that PAYMENT A and PAYMENT B will not be sent. If this decision were chosen as the decision-that-counts, we would determine the actual payments by throwing TWO ten-sided dices. There is 50% chance that PAYMENT A will be sent by throwing the first dice; there is 50% chance that PAYMENT B will be sent by throwing the

			Feb			
M	T	W	T	F	S	S
6	7	8	9	10	11	12
13	14	15	16	17	18	19
20	21	22	23	24	25	26
27	28	29				
			MAR			
M	T	W	T	F	S	S
			1	2	3	4
5	6	7	8	9	10	11
12	13	14	15	16	17	18
.	.	.	.	.	.	.
			MAY			
M	T	W	T	F	S	S
28	29	30	31			
			JUN			
M	T	W	T	F	S	S
				1	2	3
4	5	6	7	8	9	10
11	12	13	14	15	16	17
18	19	20	21	22	23	24
25	26	27	28	29	30	

In Each Row ALLOCATE 100 TOKENS BETWEEN			
	PAYMENT A (ONE WEEK from today)	**AND**	**PAYMENT B (FIVE WEEKS from today)**
No	A Tokens Rate A $ per token Date A		B Tokens Rate B $ per token Date B
1	________ tokens at $0.20 each one week later	&	________ tokens at $0.20 each five weeks later
2	________ tokens at $0.19 each one week later	&	________ tokens at $0.20 each five weeks later
3	________ tokens at $0.18 each one week later	&	________ tokens at $0.20 each five weeks later
4	________ tokens at $0.17 each one week later	&	________ tokens at $0.20 each five weeks later
5	________ tokens at $0.16 each one week later	&	________ tokens at $0.20 each five weeks later
6	________ tokens at $0.15 each one week later	&	________ tokens at $0.20 each five weeks later
7	________ tokens at $0.14 each one week later	&	________ tokens at $0.20 each five weeks later

second dice. Specifically, if the first dice tossed is odd, PAYMENT A will be sent; otherwise PAYMENT A will not be sent. If the second dice tossed is odd, PAYMENT B will be sent; otherwise PAYMENT B will not be sent.

Case C

There are some chance that PAYMENT A and PAYMENT B will not be sent. If this decision were chosen as the decision-that-counts, we would determine the actual payments by throwing ONE ten-sided dice. There is a 50% chance that both PAYMENT A and PAYMENT B will be sent, determined by the dice. Specifically, if the dice tossed is odd, both PAYMENT A and PAYMENT B will be sent; and there will be no payments if the dice tossed is even.

Case D

There are some chance that either PAYMENT A or PAYMENT B will not be sent. If this decision were chosen as the decision-that-counts, we would determine the actual payments by throwing ONE ten-sided dice. There is a 50% chance that either PAYMENT A or PAYMENT B will actually be sent, determined by the dice. Specifically, if the dice tossed is odd, PAYMENT A will be sent while PAYMENT B will not be sent; and PAYMENT B will be sent if the dice tossed is even while PAYMENT A will not be sent.

Things to Remember:

1. You will always be allocating exactly 100 tokens.
2. Tokens you allocate to Payment A (sooner) and Payment B (later) will be exchanged for money at different rates. The tokens you allocate to Payment B will always be worth at least as much as those you allocate to Payment A.

3. Payment A and Payment B will have different types of chance. You will be fully informed of the chances.

4. On each decision sheet you will be asked 7 questions. For each decision you will allocate 100 tokens. Allocate exactly 100 tokens for each decision row, no more, no less.

5. At the end of the study a random number will be drawn to determine which is the decision-that-counts. Because each question is equally likely, you should treat each decision as if it were the one that determines your payments. The payments you chose will actually be sent or not will be determined by chance, which is put down on the decision-that-counts.

6. Your payment, by cheque, will be given to you today.

References that do not appear in the main manuscript are as follows:

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