Temptation: Immediacy and Certainty

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Motivation and question

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- Time preferences, risk preferences, and their relationship are foundational to economics

- I study how a preference for immediacy is affected by uncertainty

Motivating example

Keren and Roelofsma (1995)

- Decide between a smaller reward or a larger delayed reward

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- Choose one:
  - \$50 today *modal*
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- The preference for immediacy is eliminated by uncertainty
- Little or no immediacy effect if consequence probability is 0.5 or 0.9

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- These suggest highly-likely consequences necessary for present bias
- Yet to be tested using certain (or even somewhat likely) consequences

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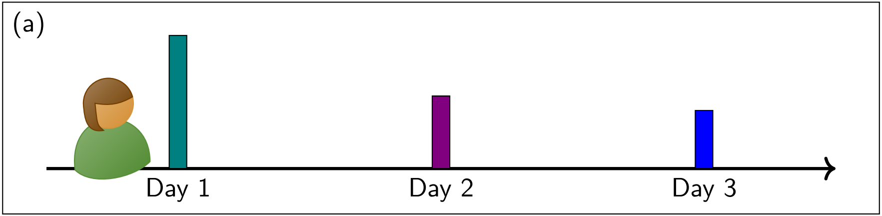
- Consumption utility flow $u(c_{t+\tau})$ at time $t + \tau$
- Constant discount factor: $0 \leq \delta \leq 1$

Background: dynamic consistency

(a) Value on Day 1: $U_1 = u(c_1) + \delta u(c_2) + \delta^2 u(c_3)$



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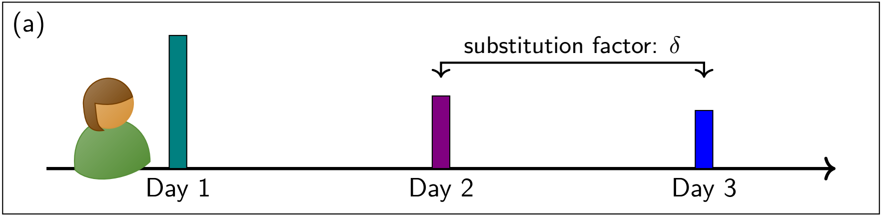

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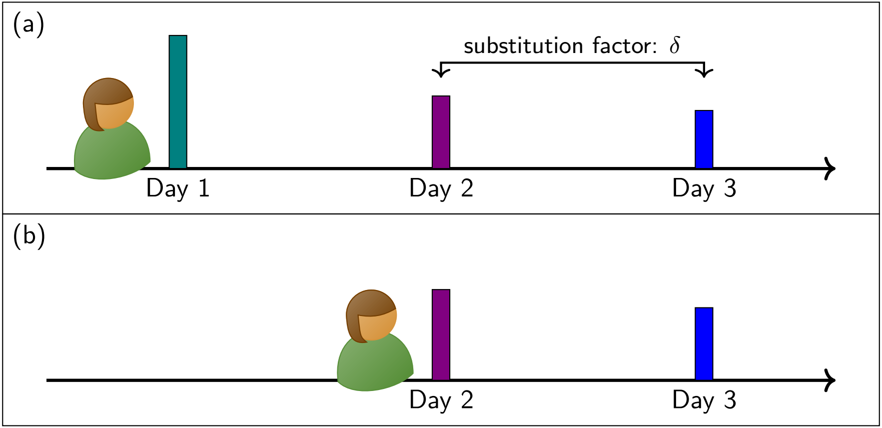

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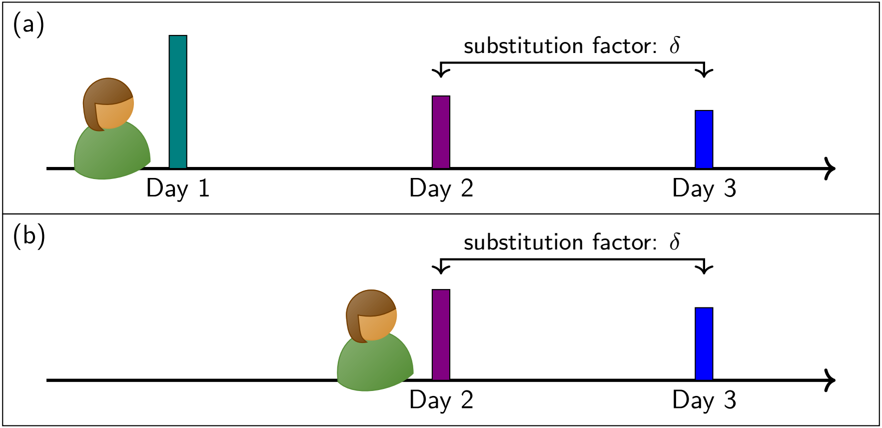

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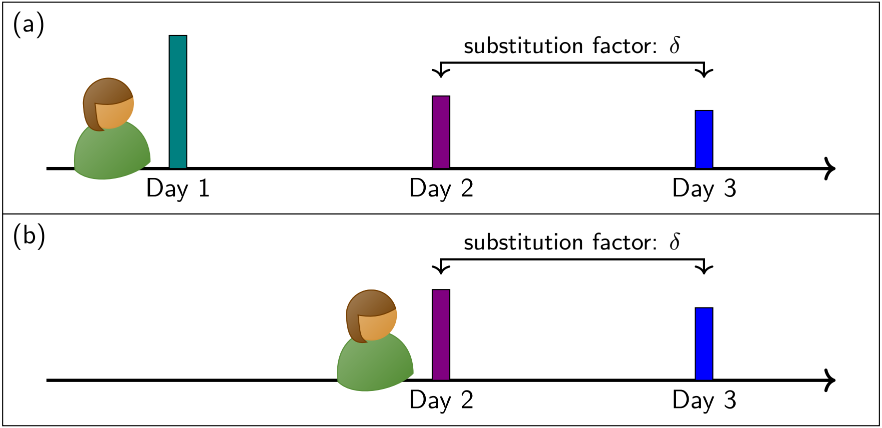
- Plan of action is consistent over time



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- Constant discount factor $0 \leq \delta \leq 1$
- Also discount all future periods by factor $0 \leq \beta \leq 1$
- Gives a preference for immediacy (present bias) if $\beta < 1$

Background: present bias

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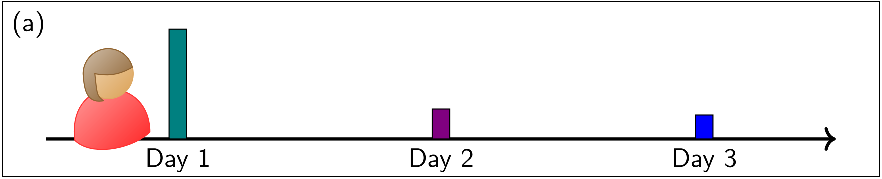

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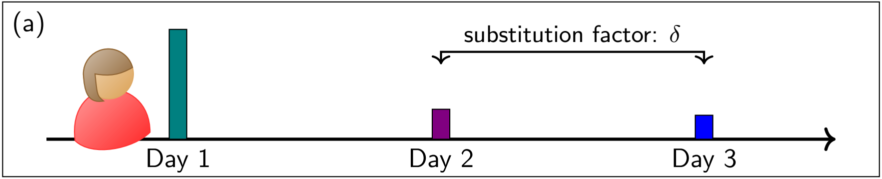

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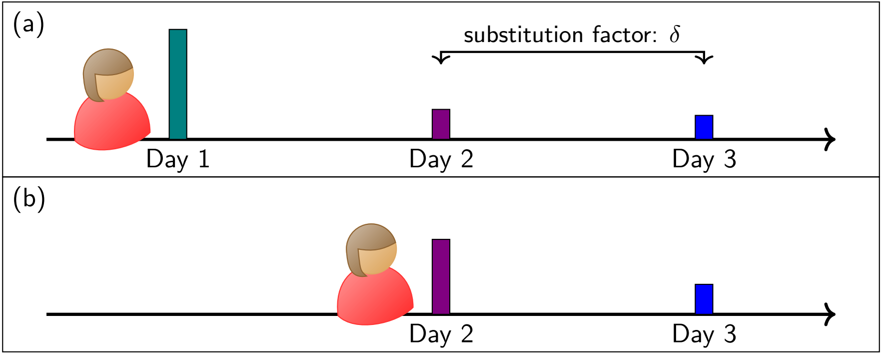

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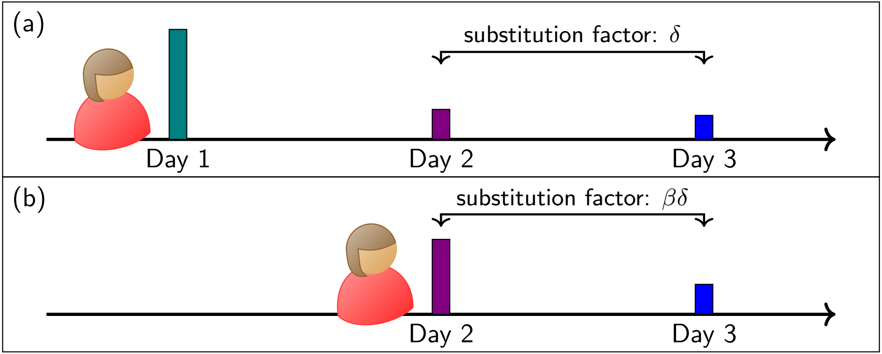

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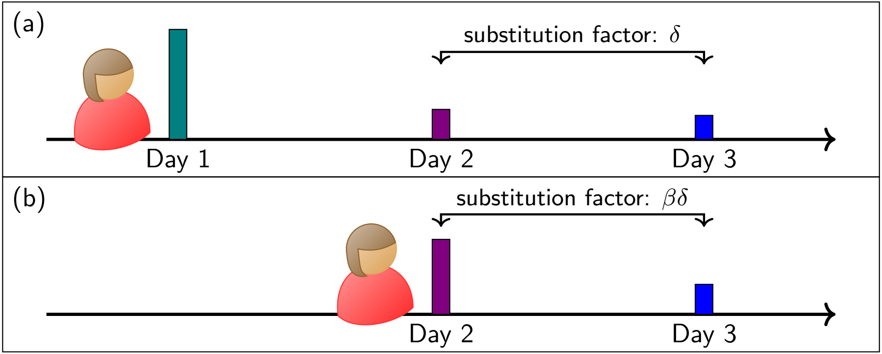
- Plan of action changes for immediate consumption



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- This literature uses substantial risk (e.g., $1/20$) to incentivize decisions

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- How does the incentive mechanism affect present bias factor β?

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- Summary of findings:
  - Individuals are far more present-biased if decisions are certainty implemented
  - Similar proportion of present-biased individuals; their bias is more severe
  - $\hat{\beta} = 0.93$ under risk, but $\hat{\beta} = 0.69$ under certainty

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- First session: \$1.50 Second: \$1.50 Third: \$6.50
- Subjects removed upon failure to complete a day's session

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Sun	Monday	Tuesday	Wednesday	Thursday	Friday	Sat
Oct 27	**Oct 28** work 10 tasks; make decisions	Oct 29	**Oct 30** work 10 tasks; make decisions; one decision selected; work implemented tasks	Oct 31	Nov 1	Nov 2
Nov 3	Nov 4	Nov 5	**Nov 6** work 10 tasks; work implemented tasks			Nov 9

Choose 0 to 360 tasks to delay at various price ratios

- First session: \$1.50 Second: \$1.50 Third: \$6.50
- Subjects removed upon failure to complete a day's session
- Ten decisions total: treatments vary probability of implementation

Real-effort task

PRACTICE MODE **The correct answers are already filled in to save you time.**

Complete 10 required rows of counting

Please count the number of zeros (“0”) on each line and enter it in the box.

Each row will be marked correct or incorrect. You must correct errors before submission.

Row No.	String	Count (“0”)
1	1000110011100011	8
2	1000010100000001	12
3	1110001110000011	8
4	0100110010101111	7
5	0000100010101110	10
6	1101001011001010	8
7	0000111001010001	10
8	1011100110010010	8
9	1110110100011111	5
10	0110001100111001	8

Check responses and save

Treatment: risky price, risky day (baseline)

- Allocate real effort between Day 2 and Day 9

Treatment: risky price, risky day (baseline)

- Allocate real effort between Day 2 and Day 9
  - $e_i^{\text{Day 2}} + R_i e_i^{\text{Day 9}} = 360$

Treatment: risky price, risky day (baseline)

- Allocate real effort between Day 2 and Day 9
  - $e_i^{\text{Day 2}} + R_i e_i^{\text{Day 9}} = 360$
  - Choose for each possible trade-off rate (price) $R_i \in \{1.5, 1.25, 1, 0.75, 0.5\}$

Treatment: risky price, risky day (baseline)

- Allocate real effort between Day 2 and Day 9
  - $e_i^{\text{Day 2}} + R_i e_i^{\text{Day 9}} = 360$
  - Choose for each possible trade-off rate (price) $R_i \in \{1.5, 1.25, 1, 0.75, 0.5\}$
- Decide on Day 0 and then again on Day 2

Day 0
Allocate at R_1 (prob $1/10$)
Allocate at R_2 (prob $1/10$)
Allocate at R_3 (prob $1/10$)
Allocate at R_4 (prob $1/10$)
Allocate at R_5 (prob $1/10$)

Treatment: risky price, risky day (baseline)

- Allocate real effort between Day 2 and Day 9
  - $e_i^{\text{Day 2}} + R_i e_i^{\text{Day 9}} = 360$
  - Choose for each possible trade-off rate (price) $R_i \in \{1.5, 1.25, 1, 0.75, 0.5\}$
- Decide on Day 0 and then again on Day 2

Day 0	Day 2
Allocate at R_1 (prob $1/10$)	Allocate at R_1 (prob $1/10$)
Allocate at R_2 (prob $1/10$)	Allocate at R_2 (prob $1/10$)
Allocate at R_3 (prob $1/10$)	Allocate at R_3 (prob $1/10$)
Allocate at R_4 (prob $1/10$)	Allocate at R_4 (prob $1/10$)
Allocate at R_5 (prob $1/10$)	Allocate at R_5 (prob $1/10$)

PRACTICE MODE	You will not have to work these tasks.

Split workload between Wed, Oct 30 and Wed, Nov 6

Choose how you want to split your workload of 360 rows of counting (in addition to the required 10 rows per workday).

In this scenario, ***working 1 more row next week reduces work by 1.25 row(s) this week.***

You're making five decisions on how to split the workload for Wed, Oct 30. You'll make five more similar decisions on that day.

A coin flip will determine whether a decision made today or a decision made on Wed, Oct 30 will be selected to actually matter.

One of today's five decisions may be randomly selected to actually split your workload.

The odds of this decision being the decision-that-matters are **10%**.

Wed, Oct 30	Click the slider below to choose.	**Wed, Nov 6**

Try moving the slider around to see how this trade-off rate splits your workload.

If this choice were selected to actually matter, your work schedule would be:

Sun, Oct 27	**Mon, Oct 28 (today)**	Tue, Oct 29	**Wed, Oct 30** 10 rows required	Thu, Oct 31	Fri, Nov 1	Sat, Nov 2
Sun, Nov 3	Mon, Nov 4	Tue, Nov 5	**Wed, Nov 6** 10 rows required	Thu, Nov 7	Fri, Nov 8	Sat, Nov 9

You will be able to adjust this decision before finalizing it.

Continue

PRACTICE MODE

How today's decisions are used

You made decisions about splitting work between this Wednesday and next Wednesday.

You will make similar decisions again Wednesday. One day will be selected for its decisions to actually matter.

Sun, Oct 27	**Mon, Oct 28 (today)** Decisions made	Tue, Oct 29	**Wed, Oct 30** Decisions made	Thu, Oct 31	Fri, Nov 1	Sat, Nov 2
Sun, Nov 3	Mon, Nov 4	Tue, Nov 5	**Wed, Nov 6**	Thu, Nov 7	Fri, Nov 8	Sat, Nov 9

You just made five decisions about how to split work between these days

Today's choices

Choice No.	Trade-off	Wed, Oct 30	Wed, Nov 6
1	1 to 0.5	360 rows	0 rows
2	1 to 0.75	235 rows	167 rows
3	1 to 1	139 rows	221 rows
4	1 to 1.25	52 rows	247 rows
5	1 to 1.5	0 rows	240 rows

You will make five similar decisions Wednesday

Wednesday's choices

Choice No.	Trade-off	Wed, Oct 30	Wed, Nov 6
1	1 to 0.5	x rows	x rows
2	1 to 0.75	x rows	x rows
3	1 to 1	x rows	x rows
4	1 to 1.25	x rows	x rows
5	1 to 1.5	x rows	x rows

After you make decisions Wednesday, a coin-toss will select which day's decisions are used

Today's choices

Choice No.	Trade-off	Wed, Oct 30	Wed, Nov 6
1	1 to 0.5	360 rows	0 rows
2	1 to 0.75	235 rows	167 rows
3	1 to 1	139 rows	221 rows
4	1 to 1.25	52 rows	247 rows
5	1 to 1.5	0 rows	240 rows

Wednesday's choices

Choice No.	Trade-off	Wed, Oct 30	Wed, Nov 6
1	1 to 0.5	x rows	x rows
2	1 to 0.75	x rows	x rows
3	1 to 1	x rows	x rows
4	1 to 1.25	x rows	x rows
5	1 to 1.5	x rows	x rows

Reveal

PRACTICE MODE **You will not have to work these tasks.**

Implement workload for Wed, Oct 30 and Wed, Nov 6

For this practice round, the coin-toss selected today's decisions to actually matter.

Accordingly, here are the decisions you made today to split the workload of 360 rows of counting.

One rate and your corresponding choice is randomly selected to actually matter.

These work amounts are in addition to the 10 rows of counting required on each day.

Choice No.	Trade-off	Wed, Oct 30	Wed, Nov 6
1	1 to 0.5	360 rows	0 rows
2	1 to 0.75	235 rows	167 rows
3	1 to 1	139 rows	221 rows
4	1 to 1.25	52 rows	247 rows
5	1 to 1.5	0 rows	240 rows

Reveal

PRACTICE MODE **On Wednesday, you'd be asked to complete 235 tasks, if this wasn't practice.**

On Wednesday, you would complete these counting tasks

Completed: 10 of 245 rows today (4%). **Remaining:** 235 tasks today.

Please count the number of zeros (“0”) on each line and enter it in the box.

Each row will be marked correct or incorrect. You must correct errors before submission.

Row No.	String	Count (“0”)
11	1000110011100011	8
12	1000010100000001	12
13	1110001110000011	8
14	0100110010101111	7
15	0000100010101110	10
16	1101001011001010	8
17	0000111001010001	10
18	1011100110010010	8
19	1110110100011111	5
20	0110001100111001	8

Check responses and save

Treatment: risky price, certain day

- Allocate real effort between Day 2 and Day 9
  - $e_i^{\text{Day 2}} + R_i e_i^{\text{Day 9}} = 360$
  - Choose for each possible trade-off rate (price) $R_i \in \{1.5, 1.25, 1, 0.75, 0.5\}$
- Decide on Day 0 and then again on Day 2

Day 0
Allocate at R_1 (prob 1/10)
Allocate at R_2 (prob 1/10)
Allocate at R_3 (prob 1/10)
Allocate at R_4 (prob 1/10)
Allocate at R_5 (prob 1/10)

Treatment: risky price, certain day

- Allocate real effort between Day 2 and Day 9
  - $e_i^{\text{Day 2}} + R_i e_i^{\text{Day 9}} = 360$
  - Choose for each possible trade-off rate (price) $R_i \in \{1.5, 1.25, 1, 0.75, 0.5\}$
- Decide on Day 0 and then again on Day 2

Day 0
Allocate at R_1 (prob 1/10)
Allocate at R_2 (prob 1/10)
Allocate at R_3 (prob 1/10)
Allocate at R_4 (prob 1/10)
Allocate at R_5 (prob 1/10)

- Just before Day 2 decisions, informed that a coin flip has selected only Day 2 decisions to matter

Treatment: risky price, certain day

- Allocate real effort between Day 2 and Day 9
  - $e_i^{\text{Day 2}} + R_i e_i^{\text{Day 9}} = 360$
  - Choose for each possible trade-off rate (price) $R_i \in \{1.5, 1.25, 1, 0.75, 0.5\}$
- Decide on Day 0 and then again on Day 2

Day 0	Day 2
Allocate at R_1 (prob 1/10)	Allocate at R_1 (prob 1/5)
Allocate at R_2 (prob 1/10)	Allocate at R_2 (prob 1/5)
Allocate at R_3 (prob 1/10)	Allocate at R_3 (prob 1/5)
Allocate at R_4 (prob 1/10)	Allocate at R_4 (prob 1/5)
Allocate at R_5 (prob 1/10)	Allocate at R_5 (prob 1/5)

- Just before Day 2 decisions, informed that a coin flip has selected only Day 2 decisions to matter

Treatment: risky price, certain day

- Allocate real effort between Day 2 and Day 9
  - $e_i^{\text{Day 2}} + R_i e_i^{\text{Day 9}} = 360$
  - Choose for each possible trade-off rate (price) $R_i \in \{1.5, 1.25, 1, 0.75, 0.5\}$
- Decide on Day 0 and then again on Day 2

Day 0	Day 2
Allocate at R_1 (prob 1/10)	Allocate at R_1 (prob 1/5)
Allocate at R_2 (prob 1/10)	Allocate at R_2 (prob 1/5)
Allocate at R_3 (prob 1/10)	Allocate at R_3 (prob 1/5)
Allocate at R_4 (prob 1/10)	Allocate at R_4 (prob 1/5)
Allocate at R_5 (prob 1/10)	Allocate at R_5 (prob 1/5)

- Just before Day 2 decisions, informed that a coin flip has selected only Day 2 decisions to matter
- One of these five decisions is implemented randomly

Treatment: certain price, risky day

- Allocate real effort between Day 2 and Day 9
  - $e_i^{\text{Day 2}} + R_i e_i^{\text{Day 9}} = 360$
  - Choose for each possible trade-off rate (price) $R_i \in \{1.5, 1.25, 1, 0.75, 0.5\}$
- Decide on Day 0 and then again on Day 2

Day 0
Allocate at R_1 (prob 0)
Allocate at R_2 (prob 1/2)
Allocate at R_3 (prob 0)
Allocate at R_4 (prob 0)
Allocate at R_5 (prob 0)

Treatment: certain price, risky day

- Allocate real effort between Day 2 and Day 9
  - $e_i^{\text{Day 2}} + R_i e_i^{\text{Day 9}} = 360$
  - Choose for each possible trade-off rate (price) $R_i \in \{1.5, 1.25, 1, 0.75, 0.5\}$
- Decide on Day 0 and then again on Day 2

Day 0	Day 2
Allocate at R_1 (prob 0)	Allocate at R_1 (prob 0)
Allocate at R_2 (prob 1/2)	Allocate at R_2 (prob 1/2)
Allocate at R_3 (prob 0)	Allocate at R_3 (prob 0)
Allocate at R_4 (prob 0)	Allocate at R_4 (prob 0)
Allocate at R_5 (prob 0)	Allocate at R_5 (prob 0)

Treatment: certain price, risky day

- Allocate real effort between Day 2 and Day 9
  - $e_i^{\text{Day 2}} + R_i e_i^{\text{Day 9}} = 360$
  - Choose for each possible trade-off rate (price) $R_i \in \{1.5, 1.25, 1, 0.75, 0.5\}$
- Decide on Day 0 and then again on Day 2

Day 0	Day 2
Allocate at R_1 (prob 0)	Allocate at R_1 (prob 0)
Allocate at R_2 (prob 1/2)	Allocate at R_2 (prob 1/2)
Allocate at R_3 (prob 0)	Allocate at R_3 (prob 0)
Allocate at R_4 (prob 0)	Allocate at R_4 (prob 0)
Allocate at R_5 (prob 0)	Allocate at R_5 (prob 0)

- One of these two decisions is implemented randomly

Treatment: certain price, certain day

- Allocate real effort between Day 2 and Day 9
  - $e_i^{\text{Day 2}} + R_i e_i^{\text{Day 9}} = 360$
  - Choose for each possible trade-off rate (price) $R_i \in \{1.5, 1.25, 1, 0.75, 0.5\}$
- Decide on Day 0 and then again on Day 2

Day 0
Allocate at R_1 (prob 0)
Allocate at R_2 (prob 1/2)
Allocate at R_3 (prob 0)
Allocate at R_4 (prob 0)
Allocate at R_5 (prob 0)

Treatment: certain price, certain day

- Allocate real effort between Day 2 and Day 9
  - $e_i^{\text{Day 2}} + R_i e_i^{\text{Day 9}} = 360$
  - Choose for each possible trade-off rate (price) $R_i \in \{1.5, 1.25, 1, 0.75, 0.5\}$
- Decide on Day 0 and then again on Day 2

Day 0
Allocate at R_1 (prob 0)
Allocate at R_2 (prob 1/2)
Allocate at R_3 (prob 0)
Allocate at R_4 (prob 0)
Allocate at R_5 (prob 0)

- Just before Day 2 decisions, informed that a coin flip has selected only the Day 2 decision to matter

Treatment: certain price, certain day

- Allocate real effort between Day 2 and Day 9
  - $e_i^{\text{Day 2}} + R_i e_i^{\text{Day 9}} = 360$
  - Choose for each possible trade-off rate (price) $R_i \in \{1.5, 1.25, 1, 0.75, 0.5\}$
- Decide on Day 0 and then again on Day 2

Day 0	Day 2
Allocate at R_1 (prob 0)	Allocate at R_1 (prob 0)
Allocate at R_2 (prob 1/2)	Allocate at R_2 (prob 1)
Allocate at R_3 (prob 0)	Allocate at R_3 (prob 0)
Allocate at R_4 (prob 0)	Allocate at R_4 (prob 0)
Allocate at R_5 (prob 0)	Allocate at R_5 (prob 0)

- Just before Day 2 decisions, informed that a coin flip has selected only the Day 2 decision to matter

Treatment: certain price, certain day

- Allocate real effort between Day 2 and Day 9
  - $e_i^{\text{Day 2}} + R_i e_i^{\text{Day 9}} = 360$
  - Choose for each possible trade-off rate (price) $R_i \in \{1.5, 1.25, 1, 0.75, 0.5\}$
- Decide on Day 0 and then again on Day 2

Day 0	Day 2
Allocate at R_1 (prob 0)	Allocate at R_1 (prob 0)
Allocate at R_2 (prob 1/2)	Allocate at R_2 (prob 1)
Allocate at R_3 (prob 0)	Allocate at R_3 (prob 0)
Allocate at R_4 (prob 0)	Allocate at R_4 (prob 0)
Allocate at R_5 (prob 0)	Allocate at R_5 (prob 0)

- Just before Day 2 decisions, informed that a coin flip has selected only the Day 2 decision to matter
- This one decision is implemented with certainty

Overview of treatments

- Allocate real effort between Day 2 and Day 9
  - $e_i^{\text{Day 2}} + R_i e_i^{\text{Day 9}} = 360$
  - Choose for each possible trade-off rate (price) $R_i \in \{1.5, 1.25, 1, 0.75, 0.5\}$
- Decide on Day 0 and then again on Day 2

Treatment	Day 0	Day 2
Risky Price, Risky Day	Allocate at R_1 (prob 1/10)	Allocate at R_1 (prob 1/10)
	Allocate at R_2 (prob 1/10)	Allocate at R_2 (prob 1/10)
	Allocate at R_3 (prob 1/10)	Allocate at R_3 (prob 1/10)
	Allocate at R_4 (prob 1/10)	Allocate at R_4 (prob 1/10)
	Allocate at R_5 (prob 1/10)	Allocate at R_5 (prob 1/10)
Risky Price, Certain Day	Allocate at R_1 (prob 1/10)	Allocate at R_1 (prob 1/5)
	Allocate at R_2 (prob 1/10)	Allocate at R_2 (prob 1/5)
	Allocate at R_3 (prob 1/10)	Allocate at R_3 (prob 1/5)
	Allocate at R_4 (prob 1/10)	Allocate at R_4 (prob 1/5)
	Allocate at R_5 (prob 1/10)	Allocate at R_5 (prob 1/5)
Certain Price, Risky Day	Allocate at R_1 (prob 0)	Allocate at R_1 (prob 0)
	Allocate at R_2 (prob 1/2)	Allocate at R_2 (prob 1/2)
	Allocate at R_3 (prob 0)	Allocate at R_3 (prob 0)
	Allocate at R_4 (prob 0)	Allocate at R_4 (prob 0)
	Allocate at R_5 (prob 0)	Allocate at R_5 (prob 0)
Certain Price, Certain Day	Allocate at R_1 (prob 0)	Allocate at R_1 (prob 0)
	Allocate at R_2 (prob 1/2)	Allocate at R_2 (prob 1)
	Allocate at R_3 (prob 0)	Allocate at R_3 (prob 0)
	Allocate at R_4 (prob 0)	Allocate at R_4 (prob 0)
	Allocate at R_5 (prob 0)	Allocate at R_5 (prob 0)

Overview of treatments

- Allocate real effort between Day 2 and Day 9
  - $e_i^{\text{Day 2}} + R_i e_i^{\text{Day 9}} = 360$
  - Choose for each possible trade-off rate (price) $R_i \in \{1.5, 1.25, 1, 0.75, 0.5\}$
- Decide on Day 0 and then again on Day 2
- Probability of implementation of e_2 made that day:

Treatment	On Day 0	On Day 2
Risky Price, Risky Day	$1/10$	$1/10$
Risky Price, Certain Day	$1/10$	$1/5$
Certain Price, Risky Day	$1/2$	$1/2$
Certain Price, Certain Day	$1/2$	1

Results

Results: subject retention

- 220 subjects completed a comprehension check

Results: subject retention

- 220 subjects completed a comprehension check
- 208 completed Day 0

Results: subject retention

- 220 subjects completed a comprehension check

- 208 completed Day 0
- 192 completed Day 2

Results: subject retention

- 220 subjects completed a comprehension check

- 208 completed Day 0
- 192 completed Day 2
- 180 completed Day 9

Results: subject retention

- 220 subjects completed a comprehension check

- 208 completed Day 0
- 192 completed Day 2
- 180 completed Day 9

- Retained 87% of subjects from Day 0 to Day 9

Results: subject retention

- 220 subjects completed a comprehension check

- 208 completed Day 0
- 192 completed Day 2
- 180 completed Day 9

- Retained 87% of subjects from Day 0 to Day 9

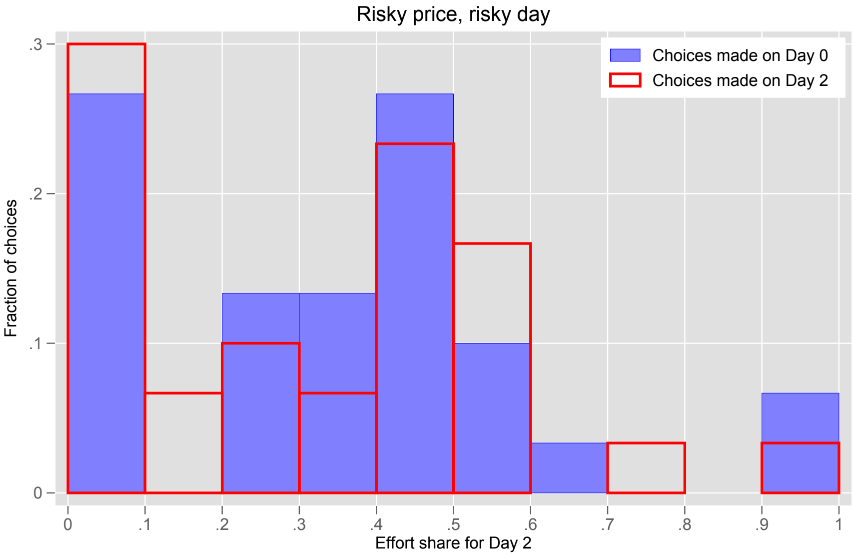
- No evidence of selective attrition

Results: extent of present bias by treatment

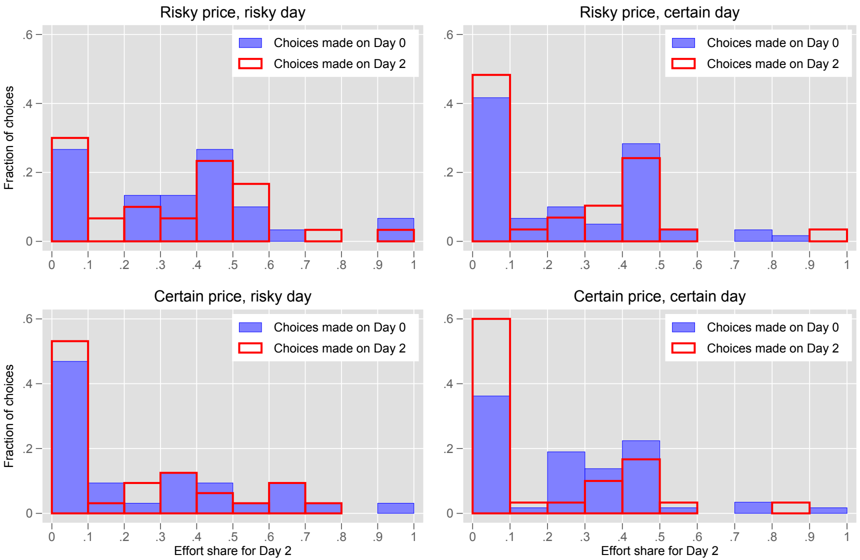
- Compare only choices made at the $R_2 = 1.25$ price ratio:

Number of present-biased subjects		
Treatment	Risky Day	Certain Day
Risky Price	12 of 30	6 of 29
Certain Price	9 of 32	9 of 30

Results: effort-share chosen at $R_2 = 1.25$ by treatment



Results: effort-share chosen at $R_2 = 1.25$ by treatment



Results: treatment effects by day

	Effort-share choices $\varphi_{i,d}$	
	On Day $d = 0$	On Day $d = 2$
Certain Price	-0.1747^{**}	-0.2154^{***}
	(0.0806)	(0.0811)
Certain Day	-0.0436	-0.0512
	(0.0368)	(0.0493)
Certain Price and Day	0.0669	-0.0231
	(0.0908)	(0.1166)
$\ln R_i$	-0.6848^{***}	-0.5907^{***}
	(0.0738)	(0.0869)
Constant	0.4887^{***}	0.4451^{***}
	(0.0339)	(0.0344)
N (Decisions)	540	357
G (Subjects)	180	121
N_l (Left-censored)	92	68
N_u (Uncensored)	391	257
N_r (Right-censored)	57	32

Notes: All attrited subjects are excluded. Standard errors are clustered on subject, using a two-limit Tobit regression model.
$^{***}p < 0.01$ $^{**}p < 0.05$ $^{*}p < 0.10$

Model

- Assume Expected Utility with Quasi-Hyperbolic Discounting (ANS 2015)

Model

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- Simply compare present bias factor β between treatments

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- CRRA periodic convex effort costs: $c(e) = (e + 10)^{\alpha}$

Model

- Assume Expected Utility with Quasi-Hyperbolic Discounting (ANS 2015)
- Simply compare present bias factor β between treatments
- CRRA periodic convex effort costs: $c(e) = (e + 10)^{\alpha}$
- On decision-day d, minimize quasi-hyperbolic-discounted effort costs:

$$\min_{e_{i,d}^{t}} \beta^{\mathbb{1}(d=0)}(e_{i,d}^{\text{Day 2}} + 10)^{\alpha} + \beta\delta^{7}(e_{i,d}^{\text{Day 9}} + 10)^{\alpha}, \text{ s.t. } e_{i}^{\text{Day 2}} + R_i e_{i}^{\text{Day 9}} = 360$$

Model

- Assume Expected Utility with Quasi-Hyperbolic Discounting (ANS 2015)
- Simply compare present bias factor β between treatments
- CRRA periodic convex effort costs: $c(e) = (e + 10)^{\alpha}$
- On decision-day d, minimize quasi-hyperbolic-discounted effort costs:

$$\min_{e_{i,d}^{t}} \beta^{\mathbb{1}(d=0)} (e_{i,d}^{\text{Day 2}} + 10)^{\alpha} + \beta\delta^{7} (e_{i,d}^{\text{Day 9}} + 10)^{\alpha}, \text{ s.t. } e_{i}^{\text{Day 2}} + R_i e_{i}^{\text{Day 9}} = 360$$

- Euler equation:

$$\left(\frac{e_{i,d}^{\text{Day 2}} + 10}{e_{i,d}^{\text{Day 9}} + 10} \right)^{\alpha - 1} = \frac{\beta^{\mathbb{1}(d=2)} \delta^{7}}{R_i}$$

Model

- Assume Expected Utility with Quasi-Hyperbolic Discounting (ANS 2015)
- Simply compare present bias factor β between treatments
- CRRA periodic convex effort costs: $c(e) = (e + 10)^{\alpha}$
- On decision-day d, minimize quasi-hyperbolic-discounted effort costs:

$$\min_{e_{i,d}^{t}} \beta^{\mathbb{1}(d=0)}(e_{i,d}^{\text{Day 2}} + 10)^{\alpha} + \beta\delta^{7}(e_{i,d}^{\text{Day 9}} + 10)^{\alpha}, \text{ s.t. } e_{i}^{\text{Day 2}} + R_i e_{i}^{\text{Day 9}} = 360$$

- Euler equation:

$$\left(\frac{e_{i,d}^{\text{Day 2}} + 10}{e_{i,d}^{\text{Day 9}} + 10}\right)^{\alpha-1} = \frac{\beta^{\mathbb{1}(d=2)}\delta^{7}}{R_i}$$

- Reduced form:

$$\underbrace{\ln \frac{e_{i,d,s}^{\text{Day 2}} + 10}{e_{i,d,s}^{\text{Day 9}} + 10}}_{E_{i,d,s}} = \underbrace{\frac{\ln \delta}{\alpha - 1}}_{\theta_{\text{delay}}} 7 + \underbrace{\frac{-1}{\alpha - 1}}_{\theta_{\text{lnrate}}} \ln R_i + \underbrace{\frac{\ln \beta}{\alpha - 1}}_{\theta_{\text{present}}} \mathbb{1}(d = 2) + \varepsilon_{i,d,s}$$

Model

- Assume Expected Utility with Quasi-Hyperbolic Discounting (ANS 2015)
- Simply compare present bias factor β between treatments
- CRRA periodic convex effort costs: $c(e) = (e+10)^\alpha$
- On decision-day d, minimize quasi-hyperbolic-discounted effort costs:

$$\min_{e^t_{i,d}} \beta^{\mathbb{1}(d=0)}(e^{\text{Day 2}}_{i,d} + 10)^\alpha + \beta\delta^7(e^{\text{Day 9}}_{i,d} + 10)^\alpha, \text{ s.t. } e^{\text{Day 2}}_i + R_i e^{\text{Day 9}}_i = 360$$

- Euler equation:

$$\left(\frac{e^{\text{Day 2}}_{i,d} + 10}{e^{\text{Day 9}}_{i,d} + 10}\right)^{\alpha-1} = \frac{\beta^{\mathbb{1}(d=2)}\delta^7}{R_i}$$

- Reduced form:

$$\underbrace{\ln\frac{e^{\text{Day 2}}_{i,d,s} + 10}{e^{\text{Day 9}}_{i,d,s} + 10}}_{E_{i,d,s}} = \underbrace{\frac{\ln\delta}{\alpha-1}}_{\theta_{\text{delay}}} 7 + \underbrace{\frac{-1}{\alpha-1}}_{\theta_{\text{lnrate}}} \ln R_i + \underbrace{\frac{\ln\beta}{\alpha-1}}_{\theta_{\text{present}}} \mathbb{1}(d=2) + \varepsilon_{i,d,s}$$

- Recovery:

$$\alpha = 1 - \theta^{-1}_{\text{lnrate}}, \quad \beta = \exp(-\theta_{\text{present}}\theta^{-1}_{\text{lnrate}}), \quad \delta = \exp(-\theta_{\text{delay}}\theta^{-1}_{\text{lnrate}})$$

Model: pooled estimation

- Let's allow for different treatment-by-day effects:

$$\begin{aligned}E_{i,d,s} = {} & \theta_{\mathsf{delay}} 7 + \theta_{\mathsf{lnrate}} \ln R_i + \theta_{\mathsf{present}} \mathbb{1}(\mathsf{pr})_d + \theta_{\mathsf{pr\text{-}cp}} \mathbb{1}(\mathsf{pr})_d \mathbb{1}(\mathsf{tr\text{-}cp})_s \\ & + \theta_{\mathsf{pr\text{-}cd}} \mathbb{1}(\mathsf{pr})_d \mathbb{1}(\mathsf{tr\text{-}cd})_s + \theta_{\mathsf{pr\text{-}cp\text{-}cd}} \mathbb{1}(\mathsf{pr})_d \mathbb{1}(\mathsf{tr\text{-}cp})_s \mathbb{1}(\mathsf{tr\text{-}cd})_s \\ & + \theta_{\mathsf{tr\text{-}cp}} \mathbb{1}(\mathsf{tr\text{-}cp})_s + \theta_{\mathsf{tr\text{-}cd}} \mathbb{1}(\mathsf{tr\text{-}cd})_s + \theta_{\mathsf{tr\text{-}cp\text{-}cd}} \mathbb{1}(\mathsf{tr\text{-}cp})_s \mathbb{1}(\mathsf{tr\text{-}cd})_s + \varepsilon_{i,d,s}\end{aligned}$$

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\end{aligned}
$$

- This will permit recovery of different β and δ for each treatment:

$$
\begin{aligned}
\alpha &= 1 - \theta_{\text{lnrate}}^{-1} \\
\delta &= \exp \frac{\theta_{\text{delay}}}{-\theta_{\text{lnrate}}} & \delta_{\text{cp}} &= \exp \frac{\theta_{\text{delay}} + \theta_{\text{tr-cp}}}{-\theta_{\text{lnrate}}} \\
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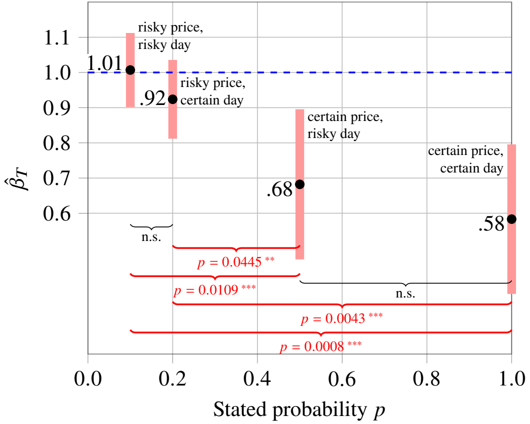
Param. θ	Estimate	H_0: $\theta = 1$
β	1.0069	$p = 0.8965$
β_{cd}	0.9237	$p = 0.1766$
β_{cp}	0.6822	$p = 0.0033$
$\beta_{\text{cp-cd}}$	0.5833	$p = 0.0001$
δ	0.9857	$p = 0.0006$
α	1.2824	$p = 0.0000$

Notes: $N = 897$ observations from $G = 180$ clusters, with $N_l = 160$ left- and $N_r = 89$ right-censored observations. Standard errors are clustered on subject, using a two-limit Tobit regression model.



Results from unrestricted pooled model

Param. θ	Estimate	H_0: $\theta = 1$
β	0.9283	$p = 0.0294$
β_{cd}	0.8978	$p = 0.0558$
β_{cp}	0.8873	$p = 0.2314$
$\beta_{\text{cp-cd}}$	0.6882	$p = 0.0020$
δ	0.9970	$p = 0.7603$
δ_{cd}	0.9415	$p = 0.3417$
δ_{cp}	0.6822	$p = 0.0136$
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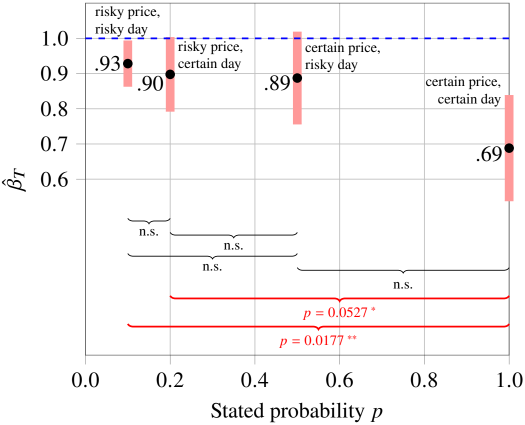

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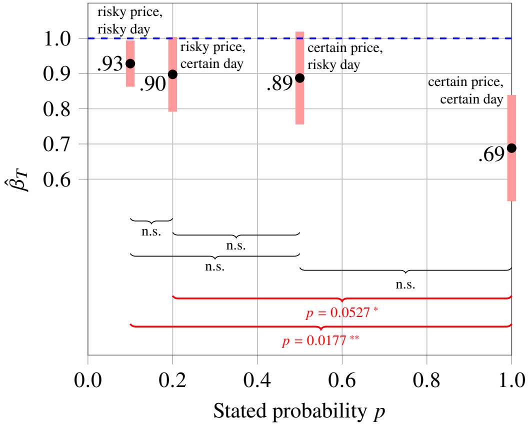

- Suggests a significant interaction between immediacy and certainty

Results: attrition and continuation probability

- Of subjects who completed Day 2, 93.75% completed Day 9
- Pooled estimate of $\hat{\delta^7} = 90.39\%$, 95% CI of $(85.15\%, 95.63\%)$
- Fail to reject that subjects are sophisticated regarding their own attrition

Model: within-subject estimation of β_s and δ_s

- Reduced form:

$$\underbrace{\ln \frac{e_{i,d,s}^{\text{Day 2}} + 10}{e_{i,d,s}^{\text{Day 9}} + 10}}_{E_{i,d,s}} = \underbrace{\frac{\ln \delta_s}{\alpha - 1}}_{\theta_{\text{delay},s}} 7 + \underbrace{\frac{-1}{\alpha - 1}}_{\theta_{\text{lnrate}}} \ln R_i + \underbrace{\frac{\ln \beta_s}{\alpha - 1}}_{\theta_{\text{present},s}} \mathbb{1}(d = 2) + \varepsilon_{i,d,s}$$

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- Recovery:

$$\alpha = 1 - \theta_{\text{lnrate}}^{-1}, \quad \beta_s = \exp(-\theta_{\text{present},s}\theta_{\text{lnrate}}^{-1}), \quad \delta_s = \exp(-\theta_{\text{delay},s}\theta_{\text{lnrate}}^{-1})$$

Results: within-subject estimation of β_s

Number of subjects with $\hat{\beta}_s < 1$		
Treatment	Risky Day	Certain Day
Risky Price	15 of 29	12 of 29
Certain Price	7 of 30	9 of 29

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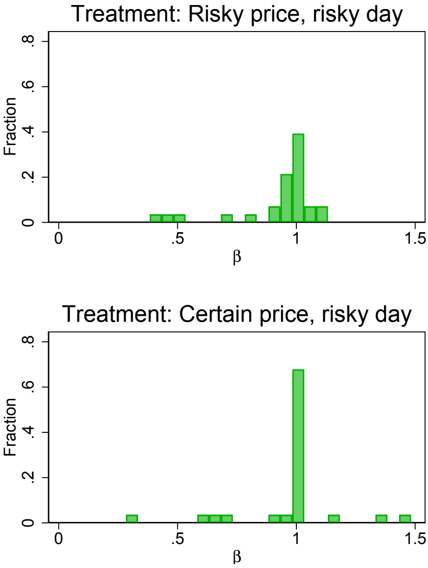

Result robustness

$$E_{i,d} \coloneqq \ln \frac{e_{i,d}^{\text{Day 2}} + \omega}{e_{i,d}^{\text{Day 9}} + \omega}, \quad \text{with background effort } \omega$$

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- On average, subjects prefer to smooth effort between days

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- Slightly underpowered to find differences for intermediate levels of risk

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Thank you!

Please send any comments to `reddinger@ucsb.edu`