Lecture 2d: Choice over Time
An Alternative Model: Present Bias

EC 404: Behavioral Economics

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Motivation

Exponential discounting implies constant discounting:

$$\frac{D(0)}{D(1)} = \frac{D(1)}{D(2)} = \frac{D(2)}{D(3)} = \ldots = \frac{1}{\delta}.$$

But the evidence suggests more discounting in the short run than in the long run:

$$\frac{D(0)}{D(1)} > \frac{D(1)}{D(2)} > \frac{D(2)}{D(3)} > \ldots.$$

A Simplified Model

A simplified model: "β, δ preferences" or "present bias"

Period-t intertemporal utility is

$$U^t \ = \ u_t \ + \ \beta \ * \sum_{x=1}^{T-t} \ \delta^x \ u_{t+x}.$$

In other words, the discount function is:

$$D(x) = \begin{cases} 1 & \text{if } x = 0 \\ \beta * \delta^x & \text{if } x > 0. \end{cases}$$

Hence, under β, δ preferences:

$$\frac{D(0)}{D(1)} \ = \ \frac{1}{\beta\delta} \ > \ \frac{1}{\delta} \ = \ \frac{D(1)}{D(2)} \ = \ \frac{D(2)}{D(3)} \ = \ ....$$

A Simplified Model

β, δ preferences capture in the simplest way possible that a person has a time-inconsistent preference for immediate gratification.

People who assume β, δ preferences use many different names:

- present bias (present-biased preferences)
- hyperbolic discounting
- quasi-hyperbolic discounting
- preference for immediate gratification
- self-control problems

Example to Illustrate Time Inconsistency

Suppose there is a task that you must complete on one of the next three days. To complete this task, you incur costs as follows:

- If you complete the task in period 1, the cost is 3.
- If you complete the task in period 2, the cost is 5.
- If you complete the task in period 3, the cost is 8.

Suppose there is no reward, that you value costs linearly, and that you have $\beta = 1/2$ and $\delta = 1$.

Example to Illustrate Time Inconsistency

Recall:

- If you complete the task in period 1, the cost is 3.
- If you complete the task in period 2, the cost is 5.
- If you complete the task in period 3, the cost is 8.

^^^

Your preferences from a period-1 perspective are:

- If complete the task in period 1, your utility is
- If complete the task in period 2, your utility is
- If complete the task in period 3, your utility is

Hence:

Example to Illustrate Time Inconsistency

Recall:

- If you complete the task in period 1, the cost is 3.
- If you complete the task in period 2, the cost is 5.
- If you complete the task in period 3, the cost is 8.

^^^

Conditional on not doing it in period 1, your preferences from a period-2 perspective are:

- If complete the task in period 2, your utility is
- If complete the task in period 3, your utility is

Hence:

Example to Illustrate Time Inconsistency

To summarize, your period-1 preferences are

$$\text{(period 2)} \succ \text{(period 1)} \succ \text{(period 3)}$$

while your period-2 preferences are

$$\text{(period 3)} \succ \text{(period 2)}.$$

Note the time inconsistency:

- As time passes, your preference between period 2 vs. period 3 flips.

The Importance of Awareness

An important issue: Are you aware of your future self-control problems (of your future present bias)?

Reminder: Your period-1 preferences are

$$\text{(period 2)} \succ \text{(period 1)} \succ \text{(period 3)}$$

while your period-2 preferences are

$$\text{(period 3)} \succ \text{(period 2)}.$$

If you were asked to commit yourself in period 1, you'd commit yourself to do the task in period 2.

Suppose instead that in period 1 you only choose whether or not to do the task then. Then your choice will depend on what you expect to do in period 2 (if you were to wait).

The Importance of Awareness

Reminder: Your period-1 preferences are

$$\text{(period 2)} \succ \text{(period 1)} \succ \text{(period 3)}$$

while your period-2 preferences are

$$\text{(period 3)} \succ \text{(period 2)}.$$

Suppose you are **fully aware** of future self-control problems — that is, you correctly predict your period-2 preferences.

- If so, you correctly predict that if you wait now, then in period 2 you'll prefer to wait again.
- Hence, you compare completing the task now to completing the task in period 3, and you prefer the former.

$\Longrightarrow$ Complete task in period 1.

The Importance of Awareness

Reminder: Your period-1 preferences are

$$(\text{period } 2) \succ (\text{period } 1) \succ (\text{period } 3)$$

while your period-2 preferences are

$$(\text{period } 3) \succ (\text{period } 2).$$

Suppose you are **fully unaware** of future self-control problems — that is, you incorrectly think that you'll feel the same way in period 2 as you do now.

- If so, then since you currently prefer period 2 to period 3, you think that if you wait now, you'll just complete the task in period 2.
- Hence, you wait in period 1 planning to complete the task in period 2.
- Of course, when period 2 arrives, you'll change your mind and decide to wait.

$\Longrightarrow$ End up completing task in period 3.

Sophistication vs. Naivete

More generally:

Two extreme assumptions about people's awareness of their own future self-control problems:

- *Sophisticates* are **fully aware** of their future self-control problems and thus correctly predict future behavior.
- *Naifs* are **fully unaware** of their future self-control problems and thus expect to behave in future exactly as they currently would like themselves to behave in future.

Sophistication vs. Naivete

To solve for naifs:

- Each period, derive the optimal lifetime path, and follow this period's component. But when next period arrives, reassess this plan.
- **Note:** Naifs may not stick to their plans.

To solve for sophisticates:

- Treat each period-self as a separate agent, and solve for the subgame-perfect Nash equilibrium to the game played between these agents (use backward induction — start at the end, and work backward).
- Note: Sophisticates always stick to their plans.
- . . . they just never plan to do something they won't later carry out.

Example 1

Suppose there is a task that you must complete on one of the next four days. To complete this task, you incur costs as follows:

- If you complete the task in period 1, the cost is 3.
- If you complete the task in period 2, the cost is 5.
- If you complete the task in period 3, the cost is 8.
- If you complete the task in period 4, the cost is 13.

Suppose there is no reward, that you value costs linearly, and that you have $\beta = 1/2$ and $\delta = 1$.
^^

From a prior perspective, the best time is

Naifs complete the task in

Sophisticates complete the task in

Example 1

Some features of Example 1:

- For an onerous task that involves immediate costs, a preference for immediate gratification implies a tendency to procrastinate — to delay beyond the best time.
- Sophistication mitigates procrastination — if expect future delay, then do it now to prevent this future delay.
- Naifs suffer a bad outcome (under essentially any measure of bad).

Example 2

Suppose there is an enjoyable activity that you get to do on one of the next four days. The reward generated by this activity is as follows:

- If you do the activity in period 1, the reward is 3.
- If you do the activity in period 2, the reward is 5.
- If you do the activity in period 3, the reward is 8.
- If you do the activity in period 4, the reward is 13.

Suppose there is no cost, that you value rewards linearly, and that you have $\beta = 1/2$ and $\delta = 1$.
^^

From a prior perspective, the best time is

Naifs complete the activity in

Sophisticates complete the activity in

Example 2

Some features of Example 2:

- For enjoyable activities with immediate rewards, a preference for immediate gratification implies a tendency to preproperate — to do it before the best time.
- Sophistication exacerbates preproperation — if expect future preproperation, more incentive to preproperate now.
- Sophisticates suffer a bad outcome.

Fibonacci's Fine Arts Cinema

- Week 1: mediocre movie, 3 utils
- Week 2: good movie, 5 utils.
- Week 3: great movie, 8 utils.
- Week 4: **Fast and Furious** movie, 13 utils.

Assume $\delta = 1$, $\beta = \frac{1}{2}$.

- Suppose you must *miss* one movie, and thus get 0 utils that day.

Your (cinematic) life choices are $(u_1, u_2, u_3, u_4) =$

- $(0, 5, 8, 13)$ or $(3, 0, 8, 13)$ or $(3, 5, 0, 13)$ or $(3, 5, 8, 0)$.

You cannot commit to which movie to miss—you must decide incrementally each week whether to see that movie or skip it.

(This assumption **matters**.)

- What movie should you miss?
- What movie *will* you miss?

Have to consider two cases: naif vs sophisticate decision-maker.

Case 1: What will a sophisticate do?

- Because $8 + \frac{1}{2}0 > 0 + \frac{1}{2}13$, the sophisticate won't skip Week 3.
- Because $0 + \frac{1}{2}(8 + 13) > 5 + \frac{1}{2}(8 + 0)$, the sophisticate *will* skip Week 2 (if she has not already skipped Week 1).
- Because $3 + \frac{1}{2}(0 + 8 + 13) > 0 + \frac{1}{2}(5 + 8 + 13)$, the sophisticate *won't* skip Week 1.

Hence: The sophisticate will miss the 2^{nd} movie.

Case 2: What will a naif do?

- Because $8 + \frac{1}{2}0 > 0 + \frac{1}{2}13$, the naif won't skip Week 3.
- Because $5 + \frac{1}{2}(0 + 13) > 0 + \frac{1}{2}(8 + 13)$, *won't* skip Week 2.
- Because $3 + \frac{1}{2}(0 + 8 + 13) > 0 + \frac{1}{2}(5 + 8 + 13)$, won't skip Week 1.

Hence: The naif will miss the Fast and Furious movie.

- As before: **awareness** of self-control can matter a lot.

Note that even given $\beta = \frac{1}{2}$, all four selves agree that missing Vin Diesel is a bad thing to happen. Yet the naif does so.

- Despite substantial "disagreement" among "different selves", they all agree missing either the 1st movie or the 2nd movie is better than missing the 4th.
- Yet she misses the 4th.
- In many applications, "pareto dominance" most common outcome.

Aside: Let us see what we would infer from the observed behavior if we were an anachronistic economist who believed in $\beta = 1$.

An exponential discounter would have to have a *weekly* discount factor $\widetilde{\delta} \leq Min[\sqrt[3]{\frac{3}{13}}, \sqrt[2]{\frac{5}{13}}, \frac{8}{13}] \approx .61$ to be willing to miss F&F.

	Letting $\beta < 1$ $(= \widehat{\beta})$	Insisting $\beta = 1$
Week 1 weight on u_2 vs. u_1	.61	.61
Week 1 weight on u_4 vs. u_1	.61	.23

And if we observed somebody missing the 52nd week (Fast and Furious marathon?) at the Fibonacci's Fine Arts Cinema with utilities (3,5,8,13,21,34,55...)

	Letting $\beta < 1$ $(= \widehat{\beta})$	Insisting $\beta = 1$
Week 1 u_2 vs. u_1	$\approx .61$	$\approx .61$
Week 1 u_{52} vs. u_1	$\approx .618$	$\approx .618^{52} \approx 1.36 \times 10^{-11}$

Lesson: Some behavior looks more (absurdly) impatient if (mis)interpreted through the lens of exponential discounting.

- But less so through the lens of present-biased discounting.

Now suppose: Person can go to only one movie, and must skip 3 of them. Same preferences as above.

- So life utility profiles are $(u_1, u_2, u_3, u_4) =$
- $(3, 0, 0, 0)$ or $(0, 5, 0, 0)$ or $(0, 0, 8, 0)$ or $(0, 0, 0, 13)$.

What will the sophisticate do?

- Because $8 > \frac{1}{2}(13)$, if she has not seen it yet, the sophisticate will see the movie in Week 3.
- Because $5 > \frac{1}{2}(8)$, if she has not seen it yet, the sophisticate will see the movie in Week 2.
- Because $3 > \frac{1}{2}(5)$, the sophisticate will see the movie in Week 1.

So, despite being sophisticated, she experiences the worst fate of seeing the mediocre movie in Week 1.

Example 1

Suppose there is a task that you must complete on one of the next four days. To complete this task, you incur costs as follows:

- If you complete the task in period 1, the cost is 3.
- If you complete the task in period 2, the cost is 5.
- If you complete the task in period 3, the cost is 8.
- If you complete the task in period 4, the cost is 13.

Suppose there is no reward, that you value costs linearly, and that you have $\beta = 1/2$ and $\delta = 1$.
^^

From a prior perspective, the best time is period 1.

Naifs complete the task in period 4.

Sophisticates complete the task in 1.

Formal Welfare Implications

Our welfare criterion: A person's "long-run utility" — which reflects how she feels from a prior perspective — is given by

$$U^0 \ = \ \sum_{\tau=1}^{T} \ \delta^\tau \ u_\tau .$$

^^

<u>In Example 1</u>:
Long-run utility from best option (do it in period 1) is -3.
Long-run utility for sophisticates (who do it in period 2) is -5.
Long-run utility for naifs (who do it in period 4) is -13.

Welfare loss for sophisticates is 2.
Welfare loss for naifs is 10.

In this simple "do-it-once" environment, for onerous tasks, naifs can suffer large harm, sophisticates cannot.

Welfare Implications

In Example 2:
Long-run utility from best option (do it in period 4) is 13.
Long-run utility for naifs (who do it in period 3) is 8.
Long-run utility for sophisticates (who do it in period 1) is 3.

Welfare loss for naifs is 5.
Welfare loss for sophisticates is 10.

In this simple "do-it-once" environment, for pleasurable tasks, sophisticates can suffer large harm, naifs cannot.

^^

In richer, real-world environments, sophistication is most likely better than naivete, because sophisticates will make use of commitment devices to overcome their self-control problems.

Procrastination: Doing It . . . Tomorrow

- Procrastination involves the "immediate gratification" of not doing something optimally onerous
- Often the main "cost" of doing some beneficial task is primarily the opportunity cost of doing something gratifying.
- Procrastination is in fact a wonderful vice: You can, and — ideally — should do it concurrently with other vices!
- Note: quitting smoking, etc. qualitatively similar to procrastination.

But what *is* it?

- Not just delaying unpleasant tasks, which is often right thing to do.
- It is delaying beyond when you yourself want to complete them.

Procrastination

Important example of unpleasant task we procrastinate on: learning.

- Learning how to do something better is pervasive example of something with long-term benefits.
- Many people recognize the enormous benefits of financial planning and literacy. And so want to do so. And plan to do so.

  ... tomorrow.

Procrastination Example

Suppose that, with 120 minutes of effort today, you could reduce the effort by 10 minutes needed to undertake a task every day for rest of your life.

- E.g., learn some short cuts or tricks with your word-processing package, or "fix" some annoying problem in the current user set-up.
- So, within 2 weeks, you will on net save time. In a year, 58 hours, and in a decade, 600 hours.

Suppose that value of time the same each day. No deadlines, no commitment devices.

- Do you do the task? If so, when?

Procrastination

If do the task today your intertemporal well-being is:

$$U^t = -120 + \beta\delta \cdot 10 + \beta\delta^2 \cdot 10 + \beta\delta^3 \cdot 10 + ...$$
$$= -120 + \beta\frac{\delta}{1-\delta}10,$$

relative to the utility you would get from doing nothing.

Procrastination

Suppose time consistent, no taste for immediate gratification.

- E.g., $\beta = 1$, $\delta = .999$. Then:

$$U^t(\textit{fix today}) = -120 + \tfrac{.999}{1-.999}10 = 9,870.$$

$$U^t(\textit{fix tomorrow}) = .999(-120 + \tfrac{.999}{1-.999}10) = 9,861$$

$$U^t(\textit{fix next day}) = .999^2(-120 + \tfrac{.999}{1-.999}10) = 9,852$$

$$\ldots$$

$$U^t(\textit{never}) = 0$$

So: Person will do it right away.

Procrastination

The Fundamental Theorem of TC (that is, non-present-biased) Task-Assessment in Stationary Environments: Either

- $U^t(today) \succ$
- $U^t(tomorrow) \succ$
- $U^t(day\ after\ tomorrow) \succ$
- $... \succ$
- $U^t(never)$

or

- $U^t(never) \succ$
- $... \succ$
- $U^t(day\ after\ tomorrow) \succ$
- $U^t(tomorrow) \succ$
- $U^t(today)$.

Procrastination

This is the combination we are interested in:

- $U^t(\mathit{fix\ today}) \succ U^t(\mathit{never})$, but $U^t(\mathit{fix\ tomorrow}) \succ U^t(\mathit{fix\ today})$.
- This would never happen for a time-consistent person, by the FT-TC-TASE.
- In a stochastic or non-stationary environment, could be that a TC person happens to not want to do it today
- But the systematic congruence of these two inequalities is the feature of interest for present bias.
- If a task is worth doing, it is worth doing right away.
- Day-to-day variation in opportunity cost, etc., then there may be particular reason to do tomorrow than today
- or today rather than tomorrow.
- But no systematic tendency to put off tasks.

Procrastination

Suppose some taste for immediate gratification (present bias).

- E.g., $\beta = .9$, $\delta = .999$.

$$U^t(\textit{fix today}) = -120 + .9\frac{.999}{1-.999}10 = 8,871$$

$$U^t(\textit{never}) = 0$$

Even with a taste for immediate gratification:

- Feels to you like you are saving about 150 hours in the future with the two hours today.
- Indeed, you would prefer doing the task today to never doing it even if it would take you 24 hours, not just 2 hours.

Procrastination

So ...

- Do you do the task?
- If so, When?

If your choices were Today vs. Never, then:

- Do today.

But you could also plan to do the task tomorrow:

- $U^t(\textit{fix tomorrow}) = .9 \cdot .999(-120 + \frac{.999}{1-.999}10) = 8,874$

You'd prefer to learn tomorrow rather than today.

Procrastination

Intuition: Disadvantage of doing tomorrow is that you will delay the 10-minute savings by a day.

- But 2 hours tomorrow "feels like" 12 minutes less work than today.
- You'd prefer to put off the task for one day.

So: Your preferences are:

- $U^t(\textit{fix tomorrow}) \succ U^t(\textit{fix today})$
- $U^t(\textit{fix today}) \succ U^t(\textit{never})$

Also:

- $U^t(\textit{fix today}) \succ U^t(\textit{fix two days hence})$

So, repeat the question: Do you do the task?

Procrastination

Answer: It depends.

- If you think that not doing today means you will do tomorrow, then
  ... Don't do today.
- If you think (for instance) that not doing today means you will never do, then
  ...Will do today.
- So what you do depends on your beliefs about own future behavior.
  - What will you believe?

Procrastination

Recall:

- If $\beta = \frac{9}{10}$: $U^t(\textit{fix tomorrow}) \succ U^t(\textit{fix today}) \succ U^t(\textit{never})$
- If $\beta = 1$: $U^t(\textit{fix today}) \succ U^t(\textit{fix tomorrow}) \succ U^t(\textit{never})$

So if naively think that tomorrow you will have a $\beta = 1$, then you will not do today *believing* will do tomorrow.

- But when tomorrow comes:
  - You will not do, planning to do the next day.
- And when the next day comes:
  - You will not do, planning to do the day after ...
- You will (in this extreme example) procrastinate forever—always planning to do the task the next day.

Procrastination

Sophisticates are (in this example) trickier to solve.

- Solution: would do the task either today or tomorrow.
- In both outcomes, their plan is to do it every other day (if they haven't yet done it).
    - Logic a bit complicated, but basic intuition simple.
- If aware of self-control problem, then properly nervous that you won't do it tomorrow, but delay it two or more days.
- Now you see choice not between today and two days hence.
- So (with the numbers at hand) you do it today.
- (But okay also to plan to do it tomorrow and follow through)

So: Sophistication helps overcome procrastination.

- The absurd (yet realistic) procrastination because of not just self-control problem itself, but of naivety/overoptimism about future conduct.

Procrastination

The Fundamental Theorem of Present-Biased Task-Assessment in Stationary Environments:

- Either
  - $U^t(tomorrow) \succ U^t(day\ after\ tomorrow) \succ ... \succ U^t(never)$
- or
  - $U^t(never) \succ ... \succ U^t(day\ after\ tomorrow) \succ U^t(tomorrow)$.
- (But where $U^t(today)$ gets inserted into this preference ordering depends on the specific parameter values.)

Procrastination

In this example, it happens to be that

- $U^t(tomorrow) \succ U^t(today) \succ U^t(day\ after\ tomorrow)$.

This implies:

- If think will do the task tomorrow, you will *not* do it today.
- If think you won't do tomorrow, you *will* do it today.

The naif will never do the task

- (but always tell herself she'll do it tomorrow ...)

Procrastination

General principle: *Severe* procrastination for “one-shot” tasks requires some naivety.

- Intuition?

Simple style of rationality argument in economics.

- Sophisticates predict their future behavior correctly, and always have one simple action available to them ... doing the action now.
- That means their utility from their now perspective is bounded below by the utility of doing it right away.

Procrastination

A mispecification/calibration exercise:

- A "deltoid" will never do task only if $-120 + \frac{\delta}{1-\delta}10 \leq 0$, so she would never do the task *only* if $\delta \leq \frac{12}{13} \Rightarrow \delta^{365} \leq .000000000002$.
- Hence, to reconcile behavior with the exponential model if we are confident in our assessment of the disutilities of effort, we would need a yearly $\widetilde{\delta} \leq (\frac{12}{13})^{365} = .000000000002$.
- By contrast, we're explaining this with very modest (first-)yearly discounting.

Procrastination

Of course, effort costs probably increasing rather than linear.

- And we shouldn't assume we know utility function when inferring discount factors.
- Suppose we didn't know $\widetilde{\mu} = \frac{u(120 \text{ minutes})}{u(10 \text{ minutes})}$.

[?] What locus of $(\widetilde{\delta}, \widetilde{\mu})$ would explain avoiding 2 hours of effort immediately to save 10 minutes every day rest of your life?

- This is challenging, but worth exploring for "fun". Impress your friends and neighbors!

New Example:

- Consider $\beta = .9$, $\delta = .999$ naif again.
- But now:
- Suppose that the only choice available is "quick fix": 1 minute of effort today $\Longrightarrow 9\frac{1}{2}$ minutes saved each day forever.
- Would she do this? If so, when? Answer: Yes, she would. No temptation to put off the 1 minute of work until tomorrow.

$$U^t(\textit{quick fix today}) = -1 + .9\frac{.999}{1-.999}9.5 = 8540$$

$$U^t(\textit{quick tomorrow}) = .9 \cdot .999(-1 + \frac{.999}{1-.999}9.5) = 8532$$

Procrastination

Now suppose **both** the 120/10 task and 1/9.5 task are available. Assume could do both sequentially, but don't save time on days when "fixing".

- The naif will compare her four choices:
  - $U^t(quick\ fix\ today) = 8540$
  - $U^t(quick\ tomorrow) = 8532$
  - $U^t(full\ fix\ today) = 8871$
  - $U^t(full\ tomorrow) = 8874$

So she'll perpetually *plan* to do the full fix tomorrow—and meanwhile *never do either of them*.

- The unfortunate guiding credo of the naif:

  "If you are going to do something, do it right . . . tomorrow."

Procrastination

Suppose now naif has both the 120/10 and 1/9.5 options available—but that each only saves effort on 10% of days rest of her life. Then:

- $U^t(\textit{quick fix today}) = -1 + .9\frac{.999}{1-.999}\frac{9.5}{10} = 853$
- $U^t(\textit{quick tomorrow}) = .9 \cdot .999(-1 + \frac{.999}{1-.999}\frac{9.5}{10}) = 852$
- $U^t(\textit{full fix today}) = -120 + .9\frac{.999}{1-.999}\frac{10}{10} = 779$
- $U^t(\textit{full tomorrow}) = .9 \cdot .999(-120 + \frac{.999}{1-.999}\frac{10}{10}) = 790$

So: She'll do the quick fix immediately.

- Naif makes a (quick) fix when it is **less** important/beneficial that she do so, but not if **more** important/beneficial.
- Maybe not **despite** its importance that we never do something, but **because** of its importance.

Procrastination

Note:

- Somebody who is unwilling to take 120 minutes of effort to save 10 minutes *or* to take 1 minute of effort to save $9\frac{1}{2}$ minutes every day for the rest of her life seems, *interpreted through the lens of exponential discounting*, as if she is discounting at rate of

$\widetilde{\delta}_{yearly} <$ .0000000000 0000000000 0000000000 0000000000 0000000000 0000000000 0000000000 0000000000 0000000000 00000000001.

- Acknowledging the possibility that $\beta < 1$, $\widehat{\beta} > \beta$ reconciles such behavior to reasonable long-term patience.

April is the Cruelest Month

Cumulative Procrastination

- Suppose you *must* read 30 pages in 30 days—$\sum_{t=1}^{30} p_t \geq 30$. If you spend h_t hours reading on day t, then $u_t = -h_t$, and get $p_t = \sqrt{h_t}$ pages read.
- Key feature: *It is more efficient to spread out work regularly rather than doing it all in the space of a few days.*
  - Other models with this qualitative feature would yield similar results.

Consider first: *June Mae*: $\delta = \beta = \widehat{\beta} = 1$.

- June Mae will read 1 hour each day, for a total of 30 hours.

Consider *April Mae*: $\delta = \widehat{\beta} = 1$, $\beta = \frac{1}{2}$.

- Day 1: April Mae will *Max* $_{h_1}$ $U^1 \equiv -h_1 + \frac{1}{2}\left[-29\left(\frac{30-\sqrt{h_1}}{29}\right)^2\right]$. If she reads h_1 hours on Day 1, she'll need to read $\frac{30-\sqrt{h_1}}{29}$ pages each remaining day, spending $\left(\frac{30-\sqrt{h_1}}{29}\right)^2$ hours each day.
- Day 1: April Mae reads for $15\frac{1}{2}$ minutes (planning to read 62 minutes each of the remaining 29 days). She is planning to increase future h by 58 minutes to decrease h today by 45 minutes.

Procrastination

- Day 2: $Max_{\ h_2}\ U^2 \equiv -h_2 + \frac{1}{2}\left[-28\left(\frac{29.5-\sqrt{h_2}}{28}\right)^2\right]$ Day 2: April Mae reads for 16 minutes (and plans to read 64 minutes each day from now on).
- Day 3: ... 17 minutes ... (and ... 67 minutes ...).
- Day 10: ... 22 minutes (and ... 90 minutes ...).

With a week left: Has read 16 pages in 11 hours.

- Day 24: 72 minutes (and ... more than 4 hours ...).
- Day 30: April Mae reads for $23\frac{3}{4}$ hours. (an "all-nighter").

Procrastination

So:

June Mae: 30 hours total.

April Mae: 51 hours total.

Consider *September "Sally" Mae*: $\delta = 1$, $\beta = \widehat{\beta} = \frac{1}{2}$.

- Solution (to a fairly tedious problem):
- Sally Mae will read 39 hours total.
- Note that the stark contrast between sophisticates and naifs, and the strong limits on harm done to sophisticates in, that we observed in one-shot situation has gone away.

Procrastination

Suppose April Mae and June Mae enjoy studying together; E.g., $u_t = -.99h_t$ if study together.

- But must schedule in advance to do so.
- The enjoyment of studying together would serve as a serendipitous commitment for naifs.
- Suppose $u_t = -1.01h_t$ from studying together:
  But again must be planned in advance (where backing out of agreeing to study with somebody is more costly than refraining from planned studying)
- A principle: Providing "incremental incentives" may help combat "cumulative procrastination".
- Another principle: Providing deadlines may help combat "simple" procrastination.

Procrastination: Final Comments

Details Matter

- Micro-structure of choices and incentives matter in a way that we don't ever need to worry about when $\beta = 1$.
- Return to example: Can spend 120 minutes fixing your word-processor to make a 10-minutes-a-day saving.
- Change one detail: You can't do the 120 minutes each day.
- Only can do (say) every friday. E.g., it is a weekly seminar, free to attend on your own time. You cannot do this on your own.

Procrastination

- Now you think your choice is between doing it this friday vs. next friday—seven days later, not tomorrow:

$$U^t(\textit{this friday}) = -120 + .9\tfrac{.999}{1-.999}10 = 8871$$
$$U^t(\textit{next friday}) = .9 \cdot .999^7(-120 + \tfrac{.999}{1-.999}10) = 8821$$

- Now you will do it this friday.
  - Intuition: Now you realize that waiting $\Longrightarrow$ waiting a week
  - Cost you 70 minutes extra work, not just 10 minutes. Not worth it.
- Changing switching opportunities from every day to every week can dramatically change (and improve) the outcome.

Optimal design of incentives:

- Convince employees need help to improve word-processing, and schedule seminars/assistance so that they can't do it any time?
- Change cost from 120 minutes to 0 minutes by giving immediate time off from those who invest in self-improvement?
- The two big methods to combat procrastination:
  - Defaults
  - Deadlines