

# **Applications of Time- Inconsistency: Procrastination**

**Behavioral Economics**

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# Quasi-Hyperbolic

Recall that exponential discounting implies a constant discount factor each period:

$$D(1) / D(0) = D(2) / D(1) = D(3) / D(2) = \delta$$

However, people are more impatient and discount the short-run more heavily than the long-run:

$$D(1) / D(0) < D(2) / D(1) < D(3) / D(2)$$

# Quasi-Hyperbolic

Rather than using the more complicated hyperbolic functional forms, we can simplify our life with the following approximation:

Suppose intertemporal utility is given by:

$$U(c_t, c_{t+1}, \dots, c_T) = u(c_t) + \beta[\delta u(c_{t+1}) + \delta^2 u(c_{t+2}) + \dots + \delta^{T-t} u(c_T)]$$

In other words, the discount function  $D(t) =$

$$\begin{array}{ll} 1 & \text{if } t = 0 \\ \beta\delta^t & \text{if } t > 0 \end{array}$$

The parameter  $\beta$  captures present-bias. If  $\beta = 1$ , the above discount function is simply exponential discounting.

# Quasi-Hyperbolic

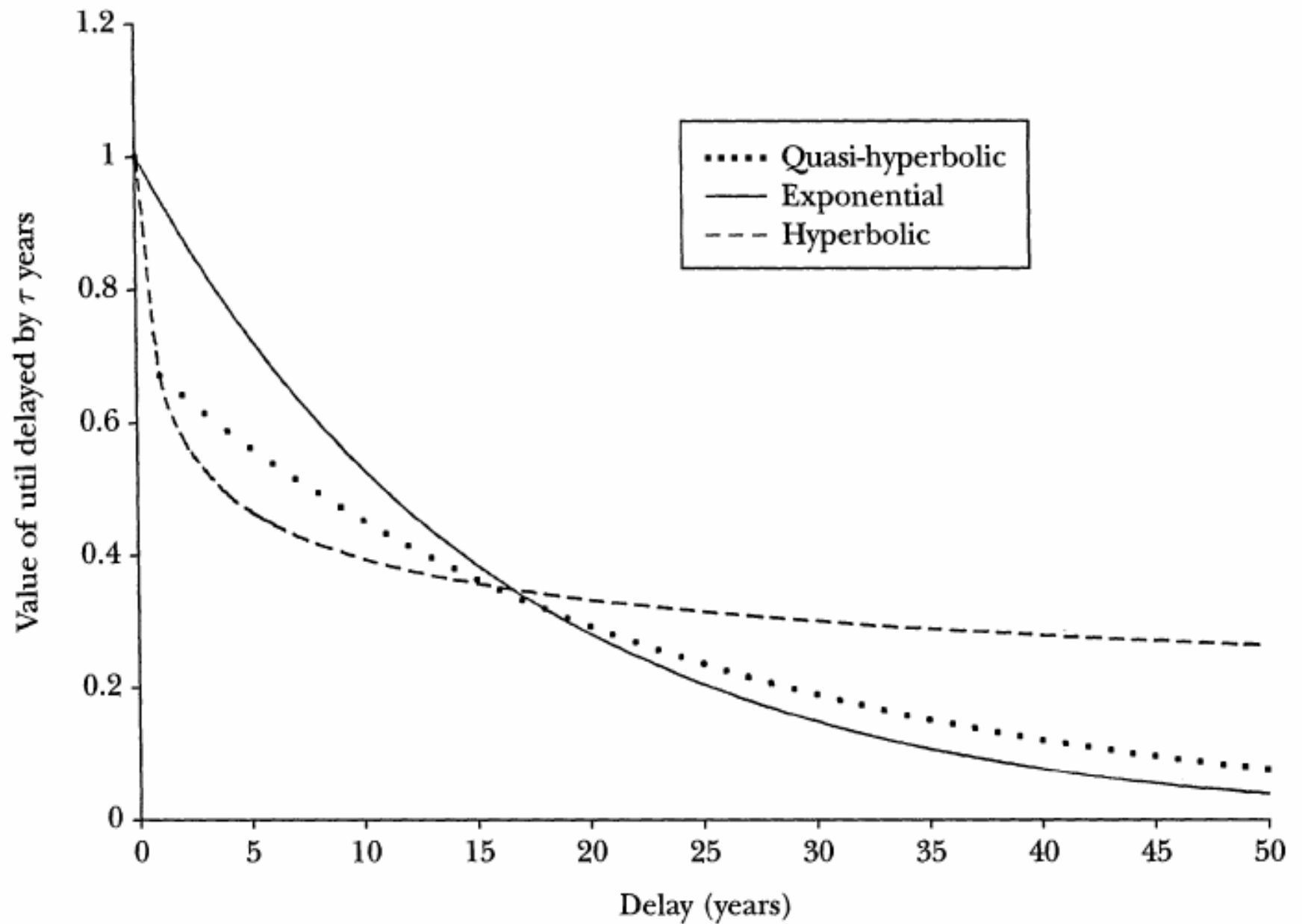
However,  $\beta < 1$  implies a present bias. All future periods are uniformly worth less than the present period.

Note that  $D(1) / D(0) = \beta\delta < \delta = D(2) / D(1) = D(3) / D(2)$

Because this is an approximation of true hyperbolic discounting, this is known as quasi-hyperbolic discounting. This captures time-inconsistent preferences in the simplest possible way.

This is also sometimes known as present-biased preferences.

## Discount Functions



# Quasi-Hyperbolic

Consider how someone feels between two arbitrary future periods, say period 5 and period 6:

$D(6) / D(5) = \beta\delta^6 / \beta\delta^5 = \delta$  That is, one util in period 6 would be worth  $\delta$  in period 5

Now suppose 5 periods have passed, and the above “period 5” is now the present. Due to the present bias, one util in the next period is only worth  $\beta\delta$ .

At every single period of the agent’s life, his intertemporal MRS was at rate  $\delta$ .

However, when that period actually rolls around, present bias kicks in and now it is at rate  $\beta\delta$

# Quasi-Hyperbolic

**This is the essence of quasi-hyperbolic discounting. Between any two *future* periods, an agent has time-consistent preferences.**

**However, when one of the periods involved is the present, the agent disagrees and experiences present-bias. The person gives more relative weight to period  $x$  at period  $x$  than he did in every single period prior to  $x$ .**

**Because the present is a “moving target”, this causes time-inconsistency.**

**Another way of thinking about it is that there are multiple selves: our future selves, who are all in agreement with each other about the right plan of action, and our present self who wants immediate gratification.**

# Procrastination

**We'll now turn to an all too familiar application of time-inconsistent preferences: procrastination.**

**1<sup>st</sup> case: Immediate Costs, Delayed Benefits**

**Suppose you must devote one of 4 weekends to some boring onerous task.**

**The task has no reward (or more generally, some fixed reward  $v$ ).**

**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.**

# Procrastination

For simplicity, assume  $\delta = 1$ .

When would a time-consistent person complete the task?

From the perspective of period 1:

Complete at time 1, get utility: -3

Complete at time 2, get utility: -5

Complete at time 3, get utility: -8

Complete at time 4, get utility: -13

# Procrastination

Now consider someone with time-inconsistent quasi-hyperbolic preferences. Suppose  $\beta = \frac{1}{2}$  and  $\delta = 1$ .

As we'll see, an important point is whether someone is aware that they have time-inconsistent preferences.

First, let's consider someone with a naïve present bias. She experiences a present bias, but *thinks* that she won't experience the bias in the future.

More formally,  $\beta = \frac{1}{2}$ , but she *thinks* that in the future  $\beta$  will equal 1. However, when the new period comes around,  $\beta = \frac{1}{2}$  again.

# Procrastination

Given the cost structure (3, 5, 8, 13), when will a naïve quasi-hyperbolic discounter with  $\beta = \frac{1}{2}$  complete the task?

From the perspective of period 1:

Complete at time 1, get utility: -3

Complete at time 2, get utility:  $\frac{1}{2} * -5 = -2.5$

Complete at time 3, get utility:  $\frac{1}{2} * -8 = -4$

Complete at time 4, get utility:  $\frac{1}{2} * -13 = -6.5$

Thus, at time 1, she decides to put it off 1 period, planning to do it in period 2.

# Procrastination

What happens in period 2? Now the choice becomes:

Complete at time 2, get utility: -5

Complete at time 3, get utility:  $\frac{1}{2} * -8 = -4$

Complete at time 4, get utility:  $\frac{1}{2} * -13 = -6.5$

So at time 2, she decides to put it off again, and plans to do it in time 3.

At time 3, it's:

Complete at time 3, get utility:  $-8 = -4$

Complete at time 4, get utility:  $\frac{1}{2} * -13 = -6.5$

So she puts it off until period 4, incurring cost 13.

# Procrastination

Now consider someone with a sophisticated present-bias. They experience a present-bias, and they are also aware that they will continue to do so in the future as well.

A sophisticate knows how he will behave in the future. So, we need to “work backwards” to figure out optimal behavior today.

Consider again someone with quasi-hyperbolic preferences facing the cost structure (3, 5, 8, 13).  $\beta = \frac{1}{2}$  and  $\delta = 1$ , but this time the agent is sophisticated.

If the sophisticate gets to period 3, he knows that he will procrastinate:

Complete at time 3, get utility: -8

Complete at time 4, get utility:  $\frac{1}{2} * -13 = -6.5$

# Procrastination

So, the sophisticate knows that if he lets it get to period 3, that ultimately will yield -13 in period 4.

From the perspective of period 2:

Complete at time 2: -5

Complete at time 3: (realizes that this won't happen)

Complete at time 4:  $\frac{1}{2} * -13 = -6.5$

The sophisticate, anticipating the procrastination problem in period 3, would thus prefer to do it in period 2 rather than do it in period 4.

# Procrastination

The sophisticate knows that if he lets it get to period 2, that he would end up doing it in period 2.

From the perspective of period 1:

Complete at time 1: -3

Complete at time 2:  $\frac{1}{2} * -5 = -2.5$

Complete at time 3: (realizes that this won't happen)

Complete at time 4: (realizes that this won't happen, would have already done it in period 2)

Thus, our sophisticate will procrastinate for 1 period, and end up doing the task in period 2.

# Procrastination

**A time-consistent agent solves the problem by maximizing intertemporal benefits minus costs.**

**Time-consistent agents always stick to their plans.**

**Each period, a naif solves for the optimal lifetime path, and then acts on this period's command. However, when the next period arrives, the naif re-assesses and solves for a new plan.**

**Thus, naifs may not stick to their original plans.**

**Sophisticates use backward induction – start at the end, and work backwards, to determine solve how all “future selves” will behave.**

**Sophisticates always stick to their plans ; they never plan to do something that they wouldn't carry out.**

# Procrastination

**Naifs incorrectly predict that they will not procrastinate in the future.**

**Hence, they consequently under-estimate the cost of procrastinating now.**

**Sophisticates do correctly estimate that their future selves will have self-control problems.**

**As such, they can at least mitigate some of the present bias by acting now.**

# Procrastination

## Summary:

**Time consistent:** do it in period 1, utility = -3

**Sophisticate:** do it in period 2, utility = -5

**Naif:** do it in period 4, utility = -13

**With immediate costs and delayed benefits, (using long-run welfare as the criterion) welfare is:**

**Naifs  $\leq$  Sophisticates  $\leq$  Time Consistent**

**It's also possible to prove that naifs will always act later than they "should"**

**For sophisticates, it's ambiguous. They may even end up acting earlier than they should.**

# Preoperation

Suppose you have a coupon for a massage and can use it on one of 4 weekends.

If you use the coupon in period 1, the benefit is 3.

If you use the coupon in period 2, the benefit is 5.

If you use the coupon in period 3, the benefit is 8.

If you use the coupon in period 4, the benefit is 13.

Suppose  $\delta = 1$ . When would a time consistent person use the coupon?

# Preproperation

Consider a naif with  $\beta = \frac{1}{2}$  and  $\delta = 1$ . Facing benefit structure  $v = (3, 5, 8, 13)$ , when will he use the massage coupon?

From the perspective of period 1:

Use the coupon in period 1: get utility 3

Use the coupon in period 2: get utility  $\frac{1}{2} * 5 = 2.5$

Use the coupon in period 3: get utility  $\frac{1}{2} * 8 = 4$

Use the coupon in period 4: get utility  $\frac{1}{2} * 13 = 6.5$

So, the naif will not use it in period 1, instead planning to use it in period 4.

# Preoperation

**In period 2, the choice becomes:**

**Use the coupon in period 2: get utility 5**

**Use the coupon in period 3: get utility  $\frac{1}{2} * 8 = 4$**

**Use the coupon in period 4: get utility  $\frac{1}{2} * 13 = 6.5$**

**Although now the naif would prefer to use it in period 2 over period 3, waiting to use it in period 4 is still better, and thus he'll wait.**

# Preproperation

In period 3, the choice becomes:

Use the coupon in period 3: get utility  $8 = 8$

Use the coupon in period 4: get utility  $\frac{1}{2} * 13 = 6.5$

Thus the naif will crack and use the coupon in period 3, one period earlier than is optimal.

# Preproperation

**We saw that with procrastination, sophistication helps ameliorate some of the harmful effects of present bias. What happens with immediate benefits?**

**For a sophisticate with  $\beta = \frac{1}{2}$  and  $\delta = 1$ , with  $v = (3, 5, 8, 13)$ , when will he use the massage coupon?**

**If it gets to period 3, she knows that she will preproperate:**

**Use the coupon in period 3: get utility  $8 = 8$**

**Use the coupon in period 4: get utility  $\frac{1}{2} * 13 = 6.5$**

# Preoperation

**So from the perspective of period 2, the choice is between:**

**Use the coupon in period 2: get utility 5**

**Use the coupon in period 3: get utility  $\frac{1}{2} * 8 = 4$**

**Use the coupon in period 4: impossible to happen**

**Knowing that she would crack next period anyways, she'll prefer to indulge this period.**

# Preproperation

And from the perspective of period 1, the choice is between:

Use the coupon in period 1: get utility 3

Use the coupon in period 2: get utility  $\frac{1}{2} * 5 = 2.5$

Use the coupon in period 3: impossible to happen

Use the coupon in period 4: impossible to happen

Knowing that she'll crack in period 2, she'll prefer to indulge this period.

Thus, the sophisticate ends up using preproperation and using the massage coupon immediately.

“I know I'll get addicted tomorrow, so I might as well use today.”

# Preproperation

**Summary:**

**Time consistent:** Wait until period 4, utility = 13

**Naif:** Wait until period 3, utility = 8

**Sophisticate:** Wait until period 1, utility = 3

**With immediate benefits and delayed costs, the welfare is:**

**Sophisticates  $\leq$  Naifs  $\leq$  Time Consistent**

**Now, naifs will always act earlier than they “should”**

**Sophisticates will always act at least as early as naifs. With procrastination, this was a good thing; with preproperation, it's a bad thing.**

**Immediate costs, delayed benefits:**

- Watch less TV**
- Exercise**
- Save more for retirement**
- Quit smoking**
- Improve diet**
- Mail in rebate forms**

**Immediate Benefits, delayed costs:**

- drugs**
- risky sex**
- consumption splurges – food, vacation**

**According to standard economic theory, people are overweight because they've weighed the intertemporal costs and benefits, and it's rational to do so; the price is worth it. Behavioral economics offers the alternative answer of present bias.**

# Commitment

**For both procrastination and preproperation, naifs and sophisticates do worse than time-consistents.**

**If you have to be time-inconsistent, is it better to be naïve or sophisticated?**

**It depends. Sophisticates do better than naifs for immediate costs/ delayed benefits**

**But naifs do better than sophisticates for immediate benefits/delayed costs**

**However, sophisticates have one big advantage - since they are aware of their self-control problems, they can take actions to limit the problem**

# Commitment

**In the procrastination example, suppose there were a way to commit yourself to doing it in period 1. This restriction of choice would be welfare-improving.**

**Naifs would never sign up for it though. They expect to always be time-consistent in the future, and think that they won't have self-control problems.**

**Sophisticates, however, may employ self-control mechanisms and commitment devices.**

# Commitment

- cell phones that block numbers after midnight
- pouring the alcohol down the drain, throwing away the cigarettes
- forced or automatic saving (Social Security)
- know I'll be tempted by crème brulee, I avoid the restaurant in the first place.
- setting rules – write 10 pages a day, always go to bed by 11
- X3: A service for pornography addicts that emails web pages visited over the past 14 days to a randomly chosen person
- Alarm clocks that roll off the dresser, or fly into the air. The SnuzNLuz alarm clock is connected by Wifi to your bank account and will donate to a charity you hate every time you hit the snooze button

# **Commitment**

**Wertenbroch – Consumers prefer to buy tempting goods in small packages, forgoing volume discounts**

**“Consumers pay more for less of what they like too much”**

**Wertenbroch –  $\frac{1}{2}$  of students were allowed to set their own binding deadlines for when to turn in 3 class papers.**

**The other  $\frac{1}{2}$  was simply given exogenous, evenly spaced deadlines**

**The “rational choice” would be to set all deadlines for the last day, and then have the flexibility of setting your own deadlines.**

**However, the majority of deadlines were set before the last day, suggesting that students do indeed demand commitment.**

# Commitment

**Interestingly, performance was higher under the exogenous imposed deadlines than under the self-imposed ones.**

**2<sup>nd</sup> experiment: Students proofread papers (created with a postmodern text generator) that contained errors.**

**“If one examines capitalist submaterial theory, one is faced with a choice: either reject neopatriarchial conceptualist theory or conclude that sexual identity has intrinsic meaning. It could be said that Foucault uses the term ‘capitalist submaterial theory’ to denote not dematerialism as such, but predematerialism. The premise of the postsemiotic paradigm of context implies that sexuality is part of the paradigm of truth.”**

# Commitment

**3 conditions: Exogenous evenly spaced deadlines, exogenous all at the end deadline, self-imposed deadlines**

**Again, people did indeed demand commitment, choosing to self-impose costly deadlines.**

**The number of errors detected (and thus total earnings) was highest in the exogenous evenly spaced deadlines , followed by the self-imposed deadlines condition, and worst in the end deadline condition.**

# Extensions

**Choice and Procrastination - Suppose a person has several different tasks to complete, and must choose which one to work on**

**A person's choice of WHICH task to work on is driven by the expected surplus: benefits - costs**

**A person's choice of WHEN to work on the task is driven by its particular cost structure**

**A person might forgo an attractive option because she plans to work on an even more attractive option, but then never actually do it. Thus more choices might make someone worse off**

**For example, a person might immediately invest in her company's 401(k) if there is one option, but if given several options, she might plan to research which is the best one but procrastinate**

# Extensions

**Procrastination on long-term projects: Suppose there are 2 separate stages of costs to a project that must be completed before yielding future benefits**

**A person might begin the first stage, expecting to complete the 2<sup>nd</sup> stage; but then when the 2<sup>nd</sup> stage costs are immediate, procrastinate and never complete it**

**This is extra inefficient - not only does he miss out on an efficient project, but he incurs a sunk cost of the 1<sup>st</sup> stage.**

**This problem is more likely when later periods are more costly**