MIT 14.13 Spring 2020 – Problem Set 1

Please answer each of the questions below. In each of your answers, concisely explain the reasoning that lead you to this answer. Writing only a numeric answer to the question is *not* enough to receive full credit!

Total: 60 points.

Question 1: Estimating Yearly Discount Factors (10 Points)

In this question you should assume that δ is defined for a year and that a year is 365 days. You should also assume that β is defined for a time unit of a day, so that anything that is in the future for the purpose of the question is discounted by β (be it a day from now or a year from now), times the relevant amount of δ (i.e. $\delta^{time\ in\ years}$).

Paul is a human being. Richard is a behavioral economist trying to understand Paul's preferences. Richard asks Paul: how much money tomorrow makes you indifferent with 10 dollars right now? Paul answers: 11 dollars.

1. (2 points) First, Richard makes the assumption that Paul has very simple preferences over time: he assumes that Paul is an exponential discounter. What is Paul's implied yearly discount factor δ given his answer?

   Solution: His discount rate is given by $\delta = \left(\frac{10}{11}\right)^{365} \approx 7.8 \times 10^{-16}$.

2. (2 points) Next, Richard assumes that Paul is a quasi-hyperbolic discounter with $\beta = 0.91$. What is Paul's implied yearly discount factor δ given his answer?

   Solution: His discount rate is given by $\delta = \left(\frac{10}{11\times\beta}\right)^{365} \approx 0.69$.

   When Richard gets back to his office, he regrets not having asked Paul: how much money two years from now makes you indifferent with 100 dollars one year from now?

3. (2 points) What would Paul have answered if he was in fact an exponential discounter?

   Solution: Paul's answer must be consistent with the first one. I.e. his answer x is such that $\left(\frac{100}{x}\right)^1 = \delta$. This yields $x = \frac{100}{\left(\frac{10}{11}\right)^{365}} \approx 1.28 \times 10^{17}$ dollars, which is a lot of money.

4. (2 points) What would Paul have answered if he was in fact a quasi-hyperbolic discounter with $\beta = 0.91$?

Solution: Paul's answer must be consistent with the first one. These two options are in the future so β cancels out. I.e. his answer x is such that $\left(\frac{100}{x}\right)^1 = \delta$. This yields $x = \frac{100}{\left(\frac{10}{11\times\beta}\right)^{365}} \approx 144$ dollars, which sounds a lot more plausible.

5. (2 points) After this thought exercise, what do you think is a more plausible model of Paul's time preferences (or of anyone who is indifferent between 10 dollars right now and 11 dollars tomorrow)?

Solution: We can always speculate but most likely Paul would have answered something closer to 144 dollars than 10^{17} dollars. Hyperbolic discounting thus does a better job at explaining preferences of someone who is indifferent between 10 dollars today and 11 dollars the next day!

Problem 2: Optimal laptop policy in class (20 Points)

In Lecture 1, I introduced a policy problem: "What is the socially optimal policy regarding laptops (and other electronic devices) in 14.13?" I'll refer to this in shorthand as the 'laptop policy.' Note that we are only deciding about the laptop policy for our own course, 14.13. Assume that all other courses have their own (independent) laptop policies.

For the purposes of this problem set, let's use a Utilitarian criterion for social optimality (where the targets of the Utilitarian analysis are MIT students). In other words, the socially optimal laptop policy is the policy that maximizes the average welfare of all MIT students. As you analyze the laptop problem, remember that you are contemplating any possible laptop policy in 14.13, not necessarily the one that was actually chosen.

1. (5 points) Explain why a laptop policy in 14.13 has potential welfare implications for MIT students who end up dropping the class rather than only for the ones who actually enroll in the class. Why might we concern ourselves with students who do not end up enrolling in the class? Why does the existence and behavior of these non-enrollees influence the socially optimal laptop policy?

Solution: The key issue here is *selection* into enrollment. Frank cares about the welfare of all students who are *potentially interested* in taking the course to the extent that a laptop policy may affect who ends up taking the course from among those students.

- On the one hand, the policy may deter some of these students (e.g., students who have a strong preference for using a laptop in class). For example, suppose a student hurt her thumb during the winter break, so she can only take notes using a laptop. If the laptop policy of the course prohibits any use of laptops, the student will have to drop the course even though she is very interested in the course material.
- On the other hand, the policy may attract additional students (e.g., students who have particularly strong self-control problems *and* are aware they have these problems).

If we only look at the welfare impact of the policy on students who enroll in the course, we will miss the welfare loss due to selection into (or out of) the course. Therefore, the socially-optimal laptop policy in 14.13 should maximize the welfare of all students who are interested in taking the course (i.e. all potential enrollees).

[The sign of the selection effect is unclear, for two reasons. First, the policy might induce students to select into or out of the course. Second, students might be better or worse off by taking 14.13 compared to their outside option (i.e. taking another class, or just taking one less class).]

Let us now consider the following potential polices:

(a) Laissez-faire, i.e. no restrictions – let students do whatever they wish to do.
(b) Ban laptops for everyone.
(c) Make the no-laptop section the default and allow students to opt out (of the no-laptop section).
(d) Make the laptop section the default and allow students to opt out (of the laptop section).
(e) Set up an active choice between the laptop and no-laptop sections.

2. (10 points) Select your most and least preferred policy and discuss, for each of them, one classical economics and one psychological reason for or against them, as opposed to the course actual policy.

Solution: Many answers are possible here. Let us first discuss a few of the economic or psychological effects of different policies:

(i) **'Classical economics' effect 1:** Some students find it useful to take notes using a laptop, or they might even be able to successfully multitask (e.g., doing psets for other classes while listening to the 14.13 lecture). These students will personally benefit from policies that allow the use of laptops in class.

(ii) **'Classical economics' effect 2:** Some students might care about the environment. Using laptops in class will increase power use, but (perhaps) save some paper.

(iii) **'Psychological' effect 1:** There might be attention-related externalities from laptop use for other students. That is, some students might find it distracting if students around or in front of them use laptops during class. These students will personally benefit from policies that do not allow the use of laptops in class (as this reduces such distractions for them).

(iv) **'Psychological' effect 2:** Some students face self-control problems while taking notes on their laptops. They might want to start checking their Facebook pages, or chat with their friends in class. Such students will generally benefit from policies that reduce laptop use in class. Sophisticated quasi-hyperbolic discounters will commit not to use laptops in class in the future (if that is an option). In contrast, naive hyperbolic students might allow their future selves to use laptops, since they underestimate the negative effects of having distracting options available to them (since they overestimate their future level of self-control).

(v) **'Psychological' effect 3:** A similar, but distinct effect is that some students might underestimate the negative impact that multi-tasking in class has on them. That is, these students might think that they are perfectly able to do a pset for another class while listening to lectures at the same time, while in fact that's very difficult to do.

(vi) **'Psychological' effect 4:** People are generally opposed to 'hard paternalism'. That is, they might prefer any given outcome more if they have chosen this outcome themselves (e.g. if they chose not to use laptops) compared to a situation in which the outcome is imposed on them (e.g. by a laptop ban).

Let us now briefly discuss the different policies in light of these effects:

(a) **Laissez-faire** has no effect on exponential discounting students, but will it hurt quasi-hyperbolic discounters or students who underestimate the negative impact of multi-tasking for other reasons. Students like Bob and Carol will have self-control problem and will be tempted to use the laptops at the cost of future grade decreases. Moreover, even in the absence of psychological effects, laissez-faire will not lead to the social optimum of laptop use since students will likely not internalize the externalities they impose on others. That is, some students might choose to use a laptop in class because it is good for them personally, and ignore any negative impact on other students.

(b) **A laptop ban** will hurt exponential discounters who value the use of laptops in class. However, relative to laissez-faire, it will help students who underestimate the negative impact of laptops on them. Moreover, it will help students who suffer from the externalities caused by others' laptop use. Finally, it might also be good for the environment, depending on the environmental damage caused by laptop power use vs. printing.

(c) **A laptop default** will help conquer the shortcomings of both policies above as it allows students to sort into the section that might be best for them. Moreover, some students might appreciate the ability to choose for themselves compared to hard paternalism. However, there might be sub-optimal sorting given that some students will forget to opt out. Moreover, quasi-hyperbolic discounters might not opt out due to present bias, given that opting out entails (small) upfront costs, but yields only delayed benefits. Naive students might not opt out, given that they don't understand the benefits of doing so (plus there is a small cost to opting out). Finally, students who are particularly affected by externalities can now sort to the other side of the classroom (the no-laptop section).

(d) **A no-laptop default** is very similar to a laptop default. The difference here is that students who miss the sign-up deadline will end up in the no-laptop section. Moreover, naive students might not sign up to avoid incurring the small immediate costs, which may turn out to be good for them. Students might also interpret the default as a suggested choice and therefore stick with that choice (regardless of whether it is good for them). If we think that laptop use is inefficiently high due to the externality, choosing a no-laptop default might be preferred to a laptop default.

(e) **Active choice** is quite similar to the two previous default options. Students are now forced to make a choice now, and none of the two options is a priori favored by the small opt-out costs. However, this policy might be hard to implement since some of the students may not respond, in which case the TA will not know what their choices are.

3. (5 points) How would you go about measuring the effects of your preferred policy relative to the course's actual policy or other potential policies? Assume that you have unlimited resources for this policy evaluation exercise.

Solution: With unlimited resources, we could conduct a randomized-controlled trial to measure the degree of success of the different policies.

To do so, we can randomly divide a sample of students into two groups, force all students to stay in the course (so as to avoid selection issues), teach the course to the two groups with different laptop policies, and measure the outcomes of interest. To increase the sample size, we could run this experiment for many years or at different schools.

Outcomes of interest could be grades (in 14.13 and perhaps other courses), student satisfaction with the course (from course evaluations), and student happiness (from surveys).

If we wanted to understand the selection margin (and if forcing students to take the course is not possible), we'd have to randomize the *offer* to take 14.13 with different policies, and then measure students' outcomes among students who are offered the class under a particular policy compared to students' outcomes among students who are offered the class under a different policy.

Question 3: Procrastination of 14.13 problem sets (30 Points)

Amy, Jack, Bob and Carol are students in 14.13. Suppose the deadline for their first problem set is approaching —it is due in 3 days from today, so they can do the problem set on any of four days, $t = 1, 2, 3, 4$

(where $t = 1$ is today).

The instantaneous utility costs of doing the problem set in periods $t = 1$, 2, 3, and 4 are 9, 20, 30, and 40 utils, respectively, as shown in Table 1 (note that all these are negative). Assume that the problem set takes only one day to complete, late submissions are not an option, and the world ends if the problem set is not finished at all, i.e. at the beginning of day $t = 4$, if the problem set is finished by then, the student will begin, finish, and turn it in on day $t = 4$.

Period t	$u(\text{Pset}_t = 0)$	$u(\text{Pset}_t = 1)$
1	0	-9
2	0	-20
3	0	-30
4	0	-40

Table 1: Instantaneous utility of (not) doing the problem set

Each student's utility function is as follows:

$$U_t = \begin{cases} u(\text{Pset}_t) + \beta \sum_{\tau=t+1}^{4} \delta^{\tau-t} u(\text{Pset}_\tau) & \text{for } 1 \leq t \leq 3, \\ u(\text{Pset}_t) & \text{for } t = 4. \end{cases} \tag{1}$$

where $u(\text{Pset}_t)$ is the (negative) instantaneous utility of doing the problem set on day t with $\text{Pset}_t = 1$ if the student works on the problem set in period t and $\text{Pset}_t = 0$ if the student does not work on the problem set in period t.

1. (2 points) Briefly explain this utility function. What do the parameters β and δ measure? What do we typically assume about these parameters?

Solution: The student's utility comes from the costs of doing the problem set. She can incur these costs in the present if she does the problem set today, or in the future if she does the problem set in the future. Notably, the student does not care about costs incurred in the past.

β is the short-term discount factor and captures the student's degree of present bias. δ is the long-term discount factor. A large body of evidence suggests that people are more patient in tradeoffs involving only future periods than in tradeoffs that involve the present.

We usually assume both β and δ are between 0 and 1, with $\beta < 1$ for present-biased individuals, and $\beta = 1$ for exponential discounters. δ is usually assumed to be close to 1.

2. (2 points) Amy is an exponential discounter with $\beta = 1, \delta = 1$, i.e. she does not discount the future at all. When will Amy do the problem set?

Solution: Amy will do the problem set at $t = 1$.
At $t = 1$, Amy's choice set is to do the problem set at $t = 1$, 2, 3, or 4. Because she is an exponential discounter, she knows that her future selves will follow through with whatever choice she makes at $t = 1$. As a result, she can simply choose whatever option maximizes U_1, i.e. she chooses doing the pset at $t = 1$.

Do the pset at	$t = 1$	$t = 2$	$t = 3$	$t = 4$
U_1	-9	-20	-30	-40

3. (2 points) Jack is an exponential discounter with $\beta = 1, \delta = 1/2$. When will Jack do the problem set? Explain in words why Jack and Amy do the problem set at different times.

Solution: Jack will do the problem set at $t = 4$.
At $t = 1$, Jack's choice set is to do the problem set at $t = 1$, 2, 3, or 4. Because he is an exponential discounter, he knows that her future selves will follow through with whatever choice he makes at $t = 1$ (you can check that by computing his choice problem at each subsequent time). As a result, he can simply choose whatever option maximizes U_1, i.e. he chooses doing the pset at $t = 4$, he vastly discounts the future cost of doing the pset.

Do the pset at	$t = 1$	$t = 2$	$t = 3$	$t = 4$
U_1	-9	-10	-7.5	-5

Jack heavily discounts the future, in a time-consistent way. Even though the instantaneous cost increases over time, these increments in cost are not steep enough to make him want to do the pset until Day 4. He simply chooses to do the pset on Day 4 in the first place and stick to this plan. Amy does not discount the future at all so she does the pset at the lowest-cost period, which is Day 1.

4. (3 points) Bob is a fully naive hyperbolic discounter with $\beta = \frac{1}{4}$, $\delta = 1$, and $\hat{\beta} = 1$. That is, Bob is present-biased, but he does not take into account his future present bias when making decisions. When will Bob do the problem set?

Solution: Bob will do the problem set at $t = 4$.

Bob is a fully-naive hyperbolic discounter. In each period, starting at $t = 1$, he solves his utility maximization problem, assuming that he will stick to his choices in the future.

Bob's $t = 1$ self discounts all future disutilities. As a result, he plans to do the pset at $t = 2$:

Do the pset at	$t = 1$	$t = 2$	$t = 3$	$t = 4$
U_1	-9	-5	-7.5	-10

Similarly, Bob's $t = 2$ self discounts all future disutilities (from the perspective of $t = 2$). Since the costs of doing it at $t = 2$ are not discounted anymore, he now prefers to do the pset at $t = 3$. This is because in contrast to $t = 2$, $t = 3$ is still in the future and therefore Bob discounts the instantaneous utility from this period using β. As a result, Bob surprises himself by *not* doing the pset at $t = 2$ as planned. Bob is time-inconsistent.

Do the pset at	$t = 1$	$t = 2$	$t = 3$	$t = 4$
U_2	–	-20	-7.5	-10

The same thing happens $t = 3$. Bob now doesn't discount the costs of doing it immediately (at $t = 3$) anymore, such that he now prefers to wait until $t = 4$. As a result, he doesn't do it at $t = 3$ and ends up doing it at $t = 4$.

Do the pset at	$t = 1$	$t = 2$	$t = 3$	$t = 4$
U_3	–	–	-30	-10

5. (2 points) On day 0 (before day 1), if you ask Bob when he'll get the problem set done, what will he predict – assuming that he is too busy on day 0 so that day 0 itself is not an option?

Solution:

At day 0, all possible dates of completion are in the future and they are therefore discounted all equally. Bob would thus plan to do the problem set on day 1 (but will surprise himself not doing so).

Do the pset at	$t = 1$	$t = 2$	$t = 3$	$t = 4$
U_0	-2.25	-5	-7.5	-10

6. (3 points) Carol is a fully sophisticated hyperbolic discounter with $\beta = \frac{1}{4}$, $\delta = 1$, and $\hat{\beta} = \beta = \frac{1}{4}$. That is, Carol is present-biased, but she fully takes into account her future present bias when making decisions. When will Carol do the problem set? Explain in words why Carol and Bob do the problem set at different times.

Solution:

Carol will do it at $t = 1$.

Carol is a fully-sophisticated hyperbolic discounter. She has a rational expectation, i.e. she fully understands her future present bias. Taking into account her future choice, she solves her utility maximization problem by backward induction.

At $t = 4$, she has no choice but to do the problem set then (since otherwise the world will end).

Do the pset at	$t = 1$	$t = 2$	$t = 3$	$t = 4$
U_4	–	–	–	-40

At $t = 3$, she heavily discounts the future (period $t = 4$), so she prefers to do the pset at $t = 4$. That is, she doesn't do it at $t = 3$.

Do the pset at	$t = 1$	$t = 2$	$t = 3$	$t = 4$
U_3	–		-30	-10

Similarly, at $t = 2$, she heavily discounts the future, i.e. periods $t = 3$ and $t = 4$. If she could be sure that she'd actually do the pset at $t = 3$, she would prefer to wait until then. However, she anticipates her choice at $t = 3$ (which is to wait until $t = 4$) correctly, such that, effectively, at $t = 2$ she chooses between doing the pset at $t = 2$ or at $t = 4$. Waiting until $t = 4$ is still preferrable from her point of view, thus she does not do it at $t = 2$.

Do the pset at	$t = 1$	$t = 2$	~~$t = 3$~~	$t = 4$
U_2	–	-20	~~-7.5~~	-10

Anticipating her future choices, at $t = 1$, she effectively chooses between doing the pset at $t = 1$ or at $t = 4$, so she decides to do it at $t = 1$.

Do the pset at	$t = 1$	~~$t = 2$~~	~~$t = 3$~~	$t = 4$
U_1	-9	~~-5~~	~~-7.5~~	-10

Bob and Carol do the problem set at different times because Bob is naive while Carol is sophisticated. Bob's naiveté means that in period 1, he wrongly anticipates to do the pset in period 2, and thus is happy to procrastinate. Carol, instead, realized she would also procrastinate in period 2 and would really only do the pset in period 4. Armed with this correct prediction, she prefers to do the pset right away on Day 1.

7. (4 points) Marlon is a partially naive hyperbolic discounter with $\beta = \frac{1}{4}$, $\delta = 1$, and $\hat{\beta} = \frac{4}{5}$. Marlon is present-biased and has illusions about his amount of present bias at future periods. When will Marlon do the problem set? *(Hint: According to the partial naiveté model, at each period Marlon predicts his future behavior to be that of a fully sophisticated hyperbolic discounter with discount factor $\hat{\beta}$.*

Solution:

Marlon will do it at $t = 4$.

Marlon also solves his utility maximization problem by backwards induction, but he reasons about his future self as if he was going to become "Super Marlon" with $\beta = \frac{4}{5}$.

At $t = 4$, True Marlon and Super Marlon would both have no choice but to do the problem set then (since otherwise the world will end).

Do the pset at	$t=1$	$t=2$	$t=3$	$t=4$
U_4	–	–	–	-40

At $t = 3$, True Marlon heavily discounts the future (period $t = 4$), so he prefers to do the pset at $t = 4$. That is, he doesn't do it at $t = 3$.

Do the pset at	$t=1$	$t=2$	$t=3$	$t=4$
U_3	–		-30	-10

However at $t = 3$, Super Marlon would do the pset:

Do the pset at	$t=1$	$t=2$	$t=3$	$t=4$
$\hat{U}_3$	–		-30	-32

At $t = 2$, True Marlon heavily discounts the future, i.e. periods $t = 3$ and $t = 4$. He thinks that if he waits, he will become Super Marlon in period 3 and do the pset then. Thus his decision now is doing the pset in period 2 VS doing the pset in period 3 (he does not realize that if he waits, he will actually only do it in period 4). Waiting until $t = 3$ is preferable from True Marlon's point of view, thus he does not do it at $t = 2$.

Do the pset at	$t=1$	$t=2$	$t=3$	$t=4$
U_2	–	-20	-7.5	-10

At $t = 2$, Super Marlon would not discount the future as much. Super Marlon would prefer to do the pset immediately than to wait. (Note that this is not relevant here, but Super Marlon anticipates to be Super Marlon in subsequent periods, so he is comparing doing the pset now VS in period 3. This is because Super Marlon from period 2 is just a fiction in the mind of True Marlon of period 1, who believes he will be Super Marlon forever.)

Do the pset at	$t = 1$	$t = 2$	$t = 3$	$t = 4$
$\hat{U}_2$	–	-20	-24	-32

At $t = 1$, True Marlon is considering doing the pset now VS doing it in period 2, since he thinks he will then become Super Marlon. Marlon thus waits, and surprises himself in period 2 by not doing the pset, and then again in period 3.

Do the pset at	$t = 1$	$t = 2$	$t = 3$	$t = 4$
U_1	-9	-5	-7.5	-10

Suppose now that a big snowstorm is announced for days 3 and 4. Doing the pset during the snowstorm is even worse because everybody else can go skiing/snowshoeing. Only Marlon is unaffected because he misses the warm weather of Sicily and hates going out in the snow, thus we will ignore him for this question. For everyone else, the instantaneous utility costs of doing the problem set in periods $t = 1, 2, 3, 4$ is now 9, 20, 84 and 88, and everyone perfectly anticipates these utility costs from Day 0.

8. (2 points) When will Bob do the problem set?

Solution: Bob will do the problem set at $t = 2$.

Bob's $t = 1$ self discounts all future disutilities. He plans to do the pset at $t = 2$.

Do the pset at	$t = 1$	$t = 2$	$t = 3$	$t = 4$
U_1	-9	-5	-21	-22

At $t = 2$, because the snowstorm makes future pset prospects much worse, he actually stick to this plan. Making the future worse helps him overcome procrastination.

Do the pset at	$t = 1$	$t = 2$	$t = 3$	$t = 4$
U_1	-9	-20	-21	-22

9. (2 points) Does the snowstorm affects Bob's long-term utility, as evaluated by his period $t = 0$ self? In what direction? No action can be taken in period $t = 0$ – think of period $t = 0$ as a very busy day.

Solution: Without the snowstorm, Bob did the pset in period 4 and got -40 utils. In period-0 utility, that is -10 utils. With the snowstorm, Bob does the pset in period 2, getting -20 utils. In period-0 utility, that is -5 utils. Hence Bob is better off. The snowstorm has only made things worse or unchanged each day, but because it helps Bob overcome his procrastination problems, it makes him better off.

10. (2 points) When does Carol do the pset? How is her long-term utility (from day 0) affected by the snowstorm? Why?

Solution:

Carol will now do it at $t = 2$.

Carol is a fully-sophisticated hyperbolic discounter. She has a rational expectation, i.e. she fully understands her future present bias. Taking into account her future choice, she solves her utility maximization problem by backward induction.

At $t = 4$, she has no choice but to do the problem set then (since otherwise the world will end).

Do the pset at	$t = 1$	$t = 2$	$t = 3$	$t = 4$
U_4	–	–	–	-88

At $t = 3$, she heavily discounts the future (period $t = 4$), so she prefers to do the pset at $t = 4$. That is, she doesn't do it at $t = 3$.

Do the pset at	$t = 1$	$t = 2$	$t = 3$	$t = 4$
U_3	–		-84	-22

At $t = 2$, she heavily discounts the future, i.e. periods $t = 3$ and $t = 4$. If she could be sure that she'd actually do the pset at $t = 3$, she would prefer to wait until then. However, she anticipates her choice at $t = 3$ (which is to wait until $t = 4$) correctly, such that, effectively, at $t = 2$ she chooses between doing the pset at $t = 2$ or at $t = 4$. Waiting until $t = 4$ is worse from her point of view, thus she does the pset at $t = 2$.

Do the pset at	$t = 1$	$t = 2$	~~$t = 3$~~	$t = 4$
U_2	–	-20	~~-21~~	-22

Anticipating her future choices, at $t = 1$, she effectively chooses between doing the pset at $t = 1$ or at $t = 2$, so she decides to wait until $t = 2$.

Do the pset at	$t = 1$	$t = 2$	~~$t = 3$~~	$t = 4$
U_1	-9	-5	~~-21~~	-22

The snowstorm makes Carol delay her effort! Procrastinating until Day 2 is now credible because of the threat of the snowstorm. This snowstorm actually makes her worse off even though she won't be directly affected by it (she won't be working on days 3 and 4), because it has enabled some amount of procrastination. With no snowstorm (or the longer one), she was getting -2.25 Day-0 utils. With this shorter snowstorm, she gets -5 Day-0 utils.

Now suppose that a Californian tech startup, SnowBiz, can trigger or prevent a snowstorm for a fee.

11. (2 points) On day 0, SnowBiz goes and asks Bob whether he wants to pay them to create the snowstorm described in question 8. Is Bob willing to pay anything for this snowstorm? What could SnowBiz do to increase his willingness to pay?

Solution: Bob is unaware of his procrastination problem and thinks he will do the pset in period 1. Therefore he does not value the snowstorm at all. SnowBiz could inform him about his procrastination problem.

12. (2 points) On day 0, SnowBiz goes and asks Carol whether she wants to pay them to *prevent* the snowstorm. How much is Carol willing to pay? Assume that 1 util in day 0 is worth 1 dollar.

> **Solution:** Carol, on day 0, does not like this snowstorm: she knows it would make her procrastinate the pset until day 2. She is willing to pay 2.75 dollars to *avoid* it.

13. (2 points) Why are things so different for Carol and Bob? Think of the snowstorm as a commitment device. Why is it the case that it helps Bob but it hurts Carol? What is the lesson here about commitment devices?

> **Solution:** Bob is naive. His naiveté leads him to procrastinate the pset until the last minute, absent the snowstorm. The snowstorm helps as a commitment device: by making the pset much worse in days 3 and 4, it makes Bob put in the effort on day 2.
> Carol is sophisticated. Anticipating future procrastination, she does the pset on Day 1 if there is no snowstorm. But the snowstorm hurts her Day-0 self, since it makes Carol procrastinate until Day 2. Day 1-Carol knows that, with the snowstorm, she will have no choice but to do the pset on Day 2, and Day 1-Carol is happy with this small delay, which however her long-term self (her in period 0) does not like.
> The lesson here is that commitment devices can help or hurt depending on the degree of sophistication. They can hurt when they credibly prevent procrastination in the medium term, which may allow procrastination in the short term.