Procrastination and Impatience*

Ernesto Reuben,† Paola Sapienza,‡ and Luigi Zingales§

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Abstract

We use a combination of lab and field evidence to study whether preferences for immediacy and the tendency to procrastinate are connected as in O'Donoghue and Rabin (1999a). To measure immediacy, we have participants choose between smaller-sooner and larger-later rewards. Both rewards are paid by check to control for transaction costs. To measure procrastination, we record how fast participants cash their checks and complete other tasks. We find that individuals with a preference for immediacy are more likely to procrastinate. We also find evidence that individuals differ in the degree to which they anticipate their own procrastination.

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†Northwestern University, e-mail: ereuben@northwestern.edu

‡Northwestern University, NBER, and CEPR, e-mail: Paola-Sapienza@northwestern.edu

§University of Chicago, NBER, and CEPR, e-mail: Luigi.Zingales@chicagogsb.edu

A growing number of studies show that people tend to procrastinate, that is, to defer actions or tasks to a later time with counterproductive consequences (Ariely and Wertenbroch, 2002; DellaVigna and Malmendier, 2006; Choi et al., 2006). A majority of psychologists and the popular press attribute this behavior to anxiety, low self-esteem, and a self-defeating mentality (see e.g., Chissom and Iran-Nejad, 1992; Schouwenburg, 1992; Bandura, 1997; Sapadin and Maguire, 1997; Burka and Yuen, 2008). Most economists, by contrast, view this behavior as a rational consequence of a high level of impatience.[1] Highly impatient individuals weigh immediate costs more and delayed benefits less and thus rationally postpone activities where costs are upfront and indulge in activities where costs are delayed (O'Donoghue and Rabin, 1999a,b, 2001).[2]

While this view is increasingly popular among economists (e.g. see, Frederick et al., 2002; Bernheim and Rangel, 2005; Loewenstein and O'Donoghue, 2005), there is no behavioral evidence supporting it, let alone document how important it is in explaining the pervasiveness of procrastinating behavior. In this paper we use data collected under controlled conditions to test the existence of a link between procrastination and impatience. Furthermore, we do so for a group of relevant decision makers, namely, University of Chicago MBA students, who are as sophisticated as you can get in the world of business.

To elicit the degree of impatience, we asked an entire cohort of these MBA students, who previously earned between $0 and $300, whether they wanted to receive their earnings immediately or a higher amount in two weeks. Instead of paying them in cash, as is common in the experimental economics literature, we choose to pay them by check. This procedure enables us not only to keep the delivery method constant, but also to track when they cash the check. In this way, we get a measure of their degree of procrastination with actual behavior. We then complement this measure with other indicators of procrastination: the date they applied to graduate school and the week they participated in a game with a reward that decreased over time.

The use of monetary rewards to elicit discount rates has been criticized (Besharov and Coffey, 2003; Cubitt and Read, 2007) because access to credit may disassociate money from consumption, and thus rational individuals who can borrow should discount monetary rewards at the borrowing rate, independently of their own time preference. Recent studies, however, do suggest that money can be used to observe time preferences. Neurological evidence shows that individuals experience a

[1] In line with the economist view, a growing number of psychologists support the discounting explanation for procrastination (see Steel, 2007).

[2] For an alternative explanation see Akerlof (1991) who derives procrastination from the saliency of current costs, not from a discounting problem.

similar "utility jolt" when they receive a carrier of a reward (i.e., money) and when they receive a good they can consume (Knutson et al., 2001). Furthermore, there is activation in the same limbic areas of the brain when an intertemporal choice includes an immediate monetary reward (McClure et al., 2004) or an immediate consumption good (McClure et al., 2007; Kable and Glimcher, 2007). Since the delivery of a carrier of reward elicits the same neurological responses as the delivery of a consumption good, we think that money can be used to infer an individual's degree of impatience. We corroborated this hypothesis in a separate experiment where we find a positive and statistically significant correlation between the discount rate for a monetary reward and the discount rate for a primary reward (chocolate) (Reuben et al., 2009).[3]

Thinking of the check as a carrier of reward, however, introduces an additional decision. After the immediate gratification of receiving a check, participants have to cash the check to actually enjoy the ultimate benefits of it. Hence, the cashing of the check becomes a chore with an immediate cost (walking to the ATM machine) but no immediate benefit (bank rates are close to zero and access to credit means consumption is not restricted by the cashing of the check). The only benefit is long term: the check is not lost and the funds will be there in case the individual needs them.

On the one hand, this tension between short-term cost and long-term benefits makes this task suitable for identifying an individual's tendency to procrastinate. On the other hand, the existence of a cost associated with delaying the chasing of the check affects the value of receiving the reward at different points in time, impacting the observed discount rate. This tension is not unique to our setting, but it is common to all the experiments where discount rates are elicited by paying subjects with a carrier of reward that cannot be immediately consumed (e.g., coupons, gift certificates, checks).

To account for this problem, we derive the equilibrium cashing policy as a function of the amount of the prize and individual characteristics, adapting Carroll et al. (2009) to our context. Consistent with O'Donoghue and Rabin (1999a), the model predicts that participants with a strong present bias are more likely to postpone the unpleasant task of cashing the check. This model explains why the same people who forfeited an 1800% annual return in order to receive their check two weeks earlier subsequently took on average four weeks to cash them.

Once we compute the equilibrium cashing policy, we study how it affects the initial decision

[3] This effect is not present for participants who are not hungry and/or do not like chocolate. This evidence suggests that money is not only suitable for the study of time preferences, but actually more reliable than primary rewards given the confounding effects associated with the use of primary rewards (e.g., differences in taste, hunger, possible satiation, and divisibility problems).

of when to accept the check, and consequently, the observed degree of impatience. On average, participants with a strong present bias value more the psychological benefit of receiving the check immediately. Nevertheless, our model points out that choosing an immediate delivery of the check is not necessarily evidence of a high degree of impatience: an extremely low realization of the transaction cost (e.g., a participant already planned to go to the bank for another reason) can induce even a patient individual to ask for an immediate delivery of the check to take advantage of the low cost of cashing it today. This misclassification causes an attenuation bias in the estimated relationship between impatience and check-cashing behavior.

When we test the relationship between impatience and procrastination using the check-cashing behavior we find a positive, but not significant, correlation. This lack of significance could be due to the attenuation bias caused by unobserved heterogeneity in the risk of losing the check or in the cost of going to the next ATM, which induces a negative correlation between the measured level of impatience and the cash-checking behavior.

To address this problem, we use two other measures of procrastination that are not affected by these costs. Eighteen months after the first experiment, we launched an online game with the same students. The game lasted 20 minutes and students had four weeks to participate in it. The game consisted of identifying, using old facebook pictures, the most successful alumni of the University of Chicago MBA program. The student with the highest score received a $1500 prize. Crucially, for each of the first three weeks of the game, an additional prize was randomly awarded to one of the students who had participated up to that point. The declining benefit of participation was designed to induce patient individuals to participate early. Thus, the week a student participates measures her degree of procrastination. As a second measure, we use the date these students applied to the MBA program. Each year, students have three separate time periods, each with a specific deadline, in which to apply to the program. The benefit of early application is an early response, which can save the candidate the cost of other applications. Consequently, we can use the application period as a measure of procrastination.

When we use the online game to measure procrastination, we find a strong and positive correlation between impatience and procrastination. When we use the application period, we find again a positive, albeit not statistically significant, relationship with impatience. Most importantly, when we instrument the check-cashing measure of procrastination with the other two to eliminate the attenuation bias created by the measurement errors, we find a positive and significant relationship between impatience in receiving the check and procrastination in cashing it. This result supports the conclusion of O'Donoghue and Rabin (1999a) that impatience and procrastination are the outcome of the same phenomenon.

An important insight of O'Donoghue and Rabin (1999a) is the distinction between naïve and sophisticated individuals. Not anticipating their future procrastination, naïve participants overestimate the likelihood that they will cash the check in the near future and, in so doing, they overestimate the future value of a check. This overestimation induces them to choose to receive the check at a later date, even when their current cost of cashing the check is very low. Consequently, a counterintuitive prediction emerges from our model: sophisticated players will appear as having a higher level of impatience than naïve ones.

To test this prediction, we develop a proxy of sophistication by comparing the participants' behavior when delay is costly and when it is not. A naïve subject who does not anticipate his future procrastination, will not behave differently when procrastination is costly, since he does not expect to incur that cost. By contrast, a sophisticated subject does.

To this purpose we compare response behavior in a class survey, for which there was no penalty to delay or advantage to fill it in early, and the online game, where a delayed response was costly, since delayers missed some chances to be drawn. Thus, participants who waited until the last minute to complete the survey, but participated in the online game during the first week exhibit a high degree of sophistication in their response to incentives. When we use this measure as a proxy for sophistication we find that more sophisticated participants do exhibit a higher degree of short-term bias as predicted by our model. This can be seen as an additional validation of the link between these two aspects.

The rest of the paper proceeds as follows: Section 1 describes the data used; Section 2 models the decision to accept the money today or tomorrow when there are costs involved in cashing the check; Section 3 tests the predictions of the model by using our data; Section 4 concludes.

1 Data

In this paper, we utilize data from the Templeton-Chicago MBA longitudinal study (TCMLS). As part of a long-term research project on individual characteristics and economic success, the TCMLS collects data from the 2008 MBA cohort at the University of Chicago Graduate School of Business (see Reuben et al., 2008). Although we collected data from the entire cohort, the Institutional Review Board at the University of Chicago required that participants have the opportunity to opt out of the study by not consenting to the use of (parts of) their data for research purposes. Out of 550 MBA students, 475 (86.36%) consented to the use of the data analyzed in this paper. The data sources as well as the subject pool are described below.

1.1 Measuring Impatience

To measure impatience, we use the participants' short-term discount rate, which was elicited in a laboratory experiment run in October 2006. The experiment consisted of two lotteries, four games and an auction. The games were played in the following order: lottery with losses, asset market game, trust game, competition game, chocolate auction, social dilemma game, and lottery without losses. The games were programmed in z-Tree (Fischbacher, 2007) and played in four groups in four large classrooms. In order to give students an incentive to take their decisions seriously, they were paid according to their performance. One of the games was randomly drawn and participants were paid according to their earnings in that game. In total, 544 MBA students participated in the experiment and earned on average \$78.32 in addition to a \$20 show-up fee, which was paid in cash at the beginning of the session. In this paper we concentrate on a task designed to measure short-term discount rates. A short summary of the procedures and the instructions of this task are available in Appendix A. For a description of the other games see Reuben et al. (2008).

We elicit discount rates by giving participants a series of simple choices of the following type: receive x dollars today or receive $(1 + r)x$ dollars in two weeks, where x equaled each participant's earnings in the abovementioned experiment. Each participant answered thirteen questions, with r varying from 0 to 0.12 in steps of 0.01. At the end, one of the questions was randomly selected and implemented. Only the 495 participants who earned a positive amount were given this choice. Of these 495, 432 consented to the use of all the data analyzed in this study. Hence, the maximum number of observations in our sample is 432. Additional constraints to the sample will be explained as necessary.

If, for a given r and x, a participant prefers x dollars today, we can infer that she is willing to sacrifice at least r% of earnings in order to receive the payment today instead of in two weeks. Thus, by varying r and observing the point where participants switch from payment today to payment in two weeks, we get a precise measure of each individual's discount rate. We chose this procedure because it is incentive compatible and simple to understand. In this sense, it is encouraging that, even though we did not restrict the participants' choices, none switched in the "wrong" direction (from late to early delivery).

Due to its fungibility, the use of money to infer time preferences has been criticized (e.g., Cubitt and Read, 2007).[4] To validate our monetary measure, we ran a smaller follow-up study with MBA students from the Kellogg School of Management. We presented them with a similar set of choices as the one described above. In addition, we also gave them a set of choices using the same format but between a small amount of chocolate today and larger amounts of chocolate in the future. We chose small chocolate squares, which could be easily divided. As we discuss in Reuben et al. (2009), for people who like chocolate and were hungry at the time of the decision, we find a positive and statistically significant correlation between the discount rate for the monetary reward and the discount rate for the chocolate: 0.553 ($p = 0.012$).

This result is consistent with recent neurological data, which shows that, when making intertemporal choices, individuals display similar activation patterns in their brain irrespective of whether the choice involves monetary (McClure et al., 2004) or primary rewards (McClure et al., 2007)—in particular, the ventral striatum, the medial prefrontal cortex and the posterior cingulate cortex (Kable and Glimcher, 2007). This evidence suggests that, regardless of the time of the actual consumption, participants enjoy receiving the carrier of reward (Knutson et al., 2001), and hence, they can show impatience toward the carrier itself. Thus, in the paper, we use the discount rate for the monetary reward as our measure of impatience.

Figure 1 plots the discount rate (over two weeks) at which students switched towards the late delivery. Roughly one third of the students switch at 1%, which, in the absence of other considerations, is the level a rational exponential discounter is expected to choose. However, two thirds exhibit a larger discount rate with roughly 10% of the students not switching even at the 12% rate, which in annual terms corresponds to a discount rate of 3,686%. Table 1 reports the summary statistics for this variable, where we impose a discount rate equal to 13% on all the students who did not switch (even for $r = 12\%$).

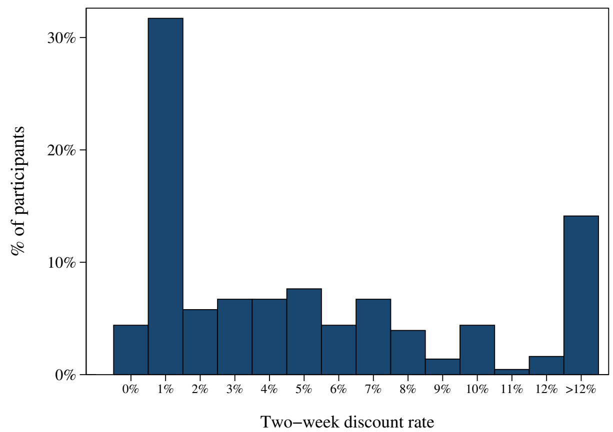
1.2 Measuring Procrastination

We use three measures of procrastination, each derived from actual behavior in a task where participants face a short-term cost that delivers a long-term benefit, and this benefit decreases with delay. Each variable is described below.

[4] We tried to obviate this problem within this sample by running the same day of the experiment an auction for chocolate delivered at different moments (see Reuben et al., 2007). Unfortunately, as a result of an endowment effect and possible dislike for chocolate, we obtained 148 zero bids, which made impossible for us to compute the proper discount rate.

Figure 1: Discount rates

Distribution of the the participants' elicited two-week discount rate.



Time to cash a check

In order to keep the transaction costs constant over both delivery times, we paid participants by putting a check in their mailfolder. Checks were distributed either the day of the experiment or two weeks later at the same time of day. Note that payment was always done on a day participants attend class and thus have to be present on campus. Mailfolders are easily accessed and are usually checked on a daily basis. This delivery method, moreover, provides a natural measure of procrastination: the number of days an individual takes to cash the check.

The values for this variable are reported in Figure 2. On average, it takes 3.71 weeks for a student to cash the check. The last check was cashed after 29.29 weeks. In total, 27 students (6.25%) did not cash the check. A priori, it is not clear how to treat this 6.25%. Are they people who lost the check or are they the most extreme form of procrastinators? Probably a combination of both, as shown by the large fraction of them with extreme present-biased preferences (29.63% do not switch even with a 12% rate) and the large fraction who behave as exponential discounters (25.93%). For this reason, we will analyze the robustness of our results to including this set of participants. When we do so, we set their cashing date at 30 weeks.

The time to cash a check is a good measure of procrastination in so much as we have a clear indication, for each participant, of what the long-term benefit is: getting a specific amount of money in their bank account. However, it has the disadvantage that we do not have precise information of the short-term cost (i.e., the transaction cost of cashing the check) nor of how much the benefit

Table 1: Summary statistics

This table reports the summary statistics for the variables used in this paper.

	Mean	**Median**	**Std. Dev.**	**Min**	**Max**	**Obs.**
Measures of Impatience						
Two-week discount rate	4.98	4.00	4.37	0.00	13.00	432
Two-week discount rate ≤ 1	0.36	0.00	0.48	0.00	1.00	432
Measures of Procrastination						
Weeks to cash check	3.71	2.00	4.41	0.00	29.29	405
Days before application deadline	85.26	71.23	44.19	0.05	170.59	432
Application deadline	1.82	2.00	0.63	1.00	3.00	432
Days before online game deadline	20.73	20.83	7.28	-0.10	28.48	284
Week of online game participation	1.70	2.00	0.83	1.00	4.00	284
Days before survey deadline	7.11	5.79	5.13	-1.93	16.77	432
Other variables						
Money at stake	83.44	77.75	54.67	2.00	260.00	432
Female	0.30	0.00	0.46	0.00	1.00	432
CRT score	2.49	3.00	1.31	0.00	4.00	432
Trust	0.54	1.00	0.50	0.00	1.00	432

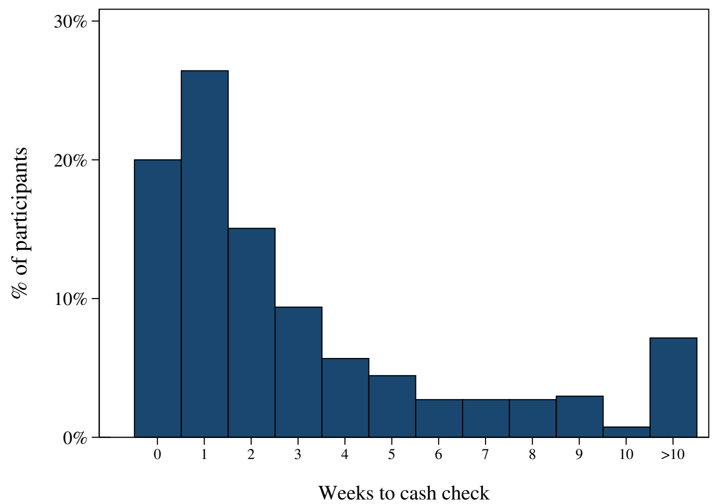
decreases with delay (i.e., the increased likelihood that the check will be lost as time passes). Moreover, as we will discuss later on, these costs might vary between participants, which might cloud the relationship between procrastination and impatience.

The Online Game

As a second measure of procrastination, we utilize the time it took participants to complete an online game. In March 2008, an online game with the same cohort of students was launched. Participants had to guess, by looking at old facebook pictures, who were the most successful alumni of the University of Chicago MBA program. The participant with the highest number of correct answers received a $1500 prize. Participants had four weeks to complete the 20-minute game. More importantly for this paper, at the end of each of the first three weeks of the game, an additional prize (a free iPhone worth $500) was randomly awarded to one of the participants who had completed

Figure 2: Cashing the check

Distribution of the weeks taken to cash the check.



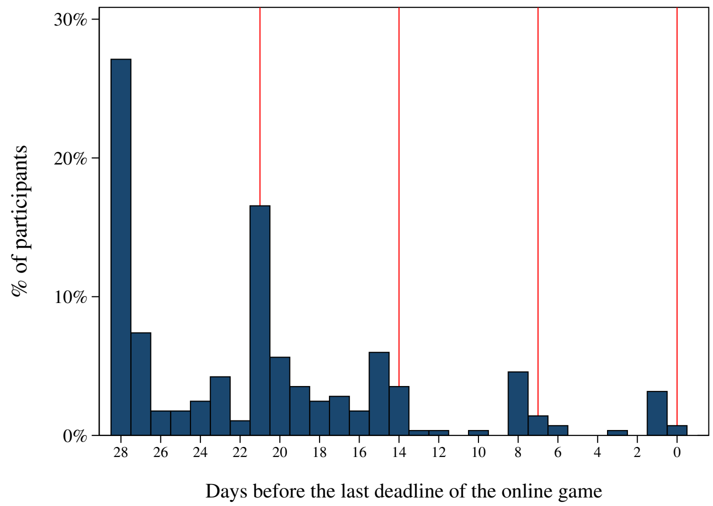
the game up to that date (each participant had an equal chance of winning and winners were not excluded from future draws). Thus, participants who completed the game in the first week took part in three draws, those who completed it in the second week took part in two draws, and those who completed it in the third week took part in one. This declining benefit of participation was designed to separate, to some degree, participants who procrastinate from participants who do not.

In total 284 participants completed in the online game. As we can see from Figure 3, a disproportionate number of them (86.27%) completed the game in the first two weeks: 48.59% in the first week and another 37.68% in the second one. If the cost of participation is constant over time, there is no reason for a participant who chose not to participate in week one to participate in week two. Even allowing for variation in the participation cost, later-week participants are more likely to have suboptimally postponed the costly decision to take part in the game than first-week participants.

As cashing a check, this task has the advantage that we have a measure of the long-term benefit (i.e., the chance of winning $1500 and iPhones) and the disadvantage that we do not know the value of the short-term cost (i.e., the cost of taking part in the game). However, in this case, we do have a clear indication of how much the benefit decreases with delay, and importantly, we know that the decrease is the same for all participants. The problem with this variable is that not all participants took part in the game, and we do not know whether those who did not take part were simply not interested in the game, or they were people who procrastinated to the point that they missed the

Figure 3: Online game participation

Distribution of the day in which participants participated in the online game. Days are measured from the last deadline, which was May 14 2008. The red vertical lines indicate the four deadlines.



last deadline.

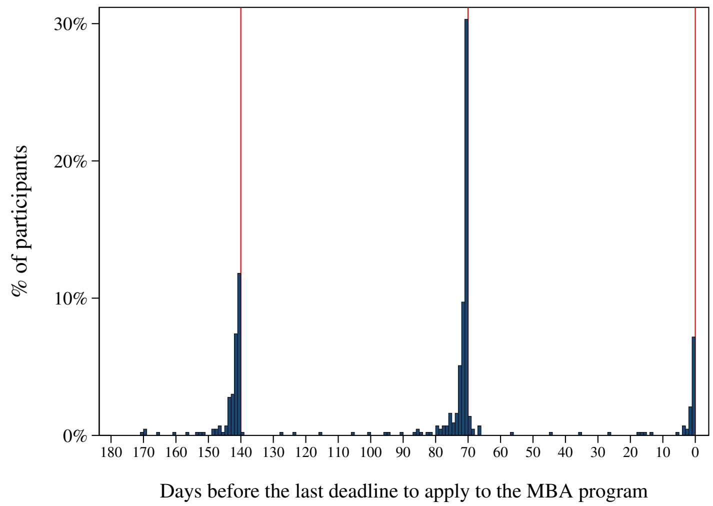
Application timing

As in many other schools, prospective students to the University of Chicago MBA program have three separate time periods to apply to the program. Each period has a specific deadline: one in the middle of October, the second at the beginning of January, and the third in the middle of March. The advantage of an early application is an early response. Most students who apply at the earlier deadlines receive an answer before the next deadline. This gives them the opportunity to adjust their application strategy and save application costs. As Figure 4 shows, 30.32% of the applicants adhere to the first deadline, 57.64% to the second, and 12.04% adhere to the last.

The MBA application is an attractive measure as it constitutes a very important decision in the life of these students. Moreover, compared to the online game, we have data for all participants. However, it has the disadvantage that we have a lot less control concerning the costs and benefits. For example, some students might have applied to other schools first and might have been waiting to hear from them before applying to the University of Chicago. Furthermore, we have no way to know whether a delay between the first two deadlines has the same cost as a delay between the

Figure 4: Applications to the MBA program

Distribution of the days in which participants submitted their applications to the MBA program. Days are measured from the last deadline, which was March 15 2006. The red vertical lines indicate the three deadlines.



second and the third (and final) deadline.

1.3 Other variables

The remaining data was collected in an online survey, which was part of a required class. The survey was made available in mid August 2006 and students were given 18 days to complete it. The survey was designed to acquire demographic data and measure various personality traits (the questions used are available in Reuben et al., 2008). In this paper we concentrate only on three variables: trust, cognitive ability, and gender.

We want to control for trust because it is possible that distrustful individuals will trust the experimenters less and therefore will be less willing to wait two weeks for payment. Trust was measured using the standard question from the World Values Survey: the answer "Most people can be trusted" to the question "Generally speaking, would you say that most people can be trusted or that you can't be too careful in dealing with people?"[5] Table 1 shows sample statistics for this variable: 54.40% of the students responded that most people can be trusted.

Frederick (2005) and Benjamin et al. (2006) show that cognitive reflection is related to discount

[5]The other answers are "Can't be too careful" and "Don't know".

rates. Consequently, in our analysis, we also control for cognitive reflection. Following Frederick (2005), we measure cognitive abilities using the Cognitive Reflection Test (CRT). To simplify the test, we conducted a pilot study using University of Chicago MBAs and PhDs and selected the four most challenging questions of the ten suggested by Frederick (2005). These four questions were then administered to the entire study sample.[6] Sample statistics for the CRT scores are in Table 1: the average student answered 2.49 out of 4 questions correctly.

Lastly, we also control for gender as there is some evidence that women exhibit lower degrees of impatience in tasks such as the one used in this paper (e.g., Kirby and Maraković, 1996; Coller and Williams, 1999; McLeish and Oxoby, 2007). As seen in Table 1, 30.01% of our sample are women.

2 Model

Approximately two out of three students in the sample gave up a very attractive rate of return to receive their check right away. These students did this, in spite of the fact that, once they received the check, they took an average of 3.71 weeks to cash it. It would be tempting to dismiss this apparently inconsistent behavior with lack of understanding by the participants. However, these are intelligent MBA students who seem to respond well to incentives (see the different timing of responses between the survey and the online game). It is not a small stake issue either, since we observe the same behavior with participants who won more than $100.

To understand this behavior we have to distinguish between the immediately rewarding sensation of receiving a check and the delayed need to cash it. As Knutson et al. (2001) show, participants experience a "utility jolt", as measured by increased brain activity, in anticipation of a monetary reward (see also Kable and Glimcher, 2007). Thus, independent of the utility from consuming this reward, participants also enjoy receiving the reward itself. Consistent with these findings we assume that the carrier of reward is the check itself.

Once participants have received their check (and enjoyed the associated utility), they are confronted with the decision of when to cash it. Given the near-zero return on checking accounts and the fact that participants do not need to cash the check to consume their earnings (e.g., they all have a credit card), cashing the check has no immediate reward. It has, however, an immediate

[6]The questions are "1. A bat and a ball cost $1.10 in total. The bat costs $1.00 more than the ball. How much does the ball cost?"; "2. If you flipped a fair coin 3 times, what is the probability that it would land heads at least once?"; "3. If it takes 5 machines 5 minutes to make 5 widgets, how long would it take 100 machines to make 100 widgets?"; "4. Two cars are on a collision course, traveling towards each other in the same lane. Car A is traveling 70 miles an hour. Car B is traveling 80 miles an hour. How far apart are the cars one minute before they collide?"

cost: participants have to walk to the closest bank or ATM and complete the process of cashing a check. The benefit of cashing the check is only long term: once the check has been cashed it cannot be lost and the money is readily available.

In order to analyze the participants' decision to cash their check, we model their behavior as a manifestation of present-biased preferences a la O'Donoghue and Rabin (1999a). The novel aspect of our problem is that the check-cashing equilibrium strategy has an effect on the initial decision of when to receive the payment (and thus on the measured impatience). Anticipating when they will cash the check, rational individuals will alter their trade-off between the check today and the check in two weeks. This aspect will provide additional empirical implications.

Solving the model by backward induction, we first analyze the decision to cash the check. Thereafter, we analyze the decision of when to receive the check depending on whether participants are sophisticated or naïve.

2.1 Cashing the check

Building on the model of 401(k) enrollment of Carroll et al. (2009), we model the decision of when to cash the check as the result of a dynamic optimization problem in which the individual decides whether to incur the cost of cashing the check today or at some future date.

As in Laibson (1994), we assume individuals have quasi-hyperbolic preferences so that their discount function is $D(t) = 1$ if $t = 0$ and $D(t) = \beta\delta^t$ if $t \geq 1$. We further assume that $\delta = 1$ for two reasons. First, long-term discounting ought to be negligible in the timeframe considered here. Second, at the time of the experiment, bank interest rates were extremely low (less than 1% per annum for a checking account), making the cost of the interest forgone trivial.

Given the absence of a significant interest forgone, we model the cost of not cashing the check as the probability $0 < p < 1$ of losing it. We believe this modeling choice is very realistic given that 6.25% of the checks were never cashed.

Finally, we assume that cashing the check has a cost c_t drawn at the beginning of each period t from a uniform distribution with support $[0, \bar{c}]$. As a result, when making her decision in period t, an individual knows the value of c_t, but not its future realizations. This assumption is meant to capture two characteristics of cashing checks. First, that there is some variability in the cost of cashing. For example, the day a participant has to go to the bank for other reasons or visit the bookstore (which is opposite a bank), her cost of cashing can be trivial (even zero). However, when she is studying for an exam or very busy in other social activities, her cost may be very high. Second, that the cost of cashing in the future is less certain than the cost of cashing in the present.

Note that these costs can also be interpreted as the possibility that individuals forget to cash their check in a given day. Hence, for example, an individual that wants to cash the check today because she knows there is a high chance that she will forget to do so for a while would correspond to a very low c_t.

After receiving the check, in each period t an individual has to decide between cashing the check that period, which implies incurring the immediate cost c_t, and delaying their decision to the next period, which implies incurring the risk of losing the check.[7] In other words, after receiving the check for an amount $S > 0$, an individual minimizes the following current discounted loss function V:

$$V = \begin{cases} c_t & \text{if check is cashed} \\ \beta[pS + (1-p)L] & \text{if check is not cashed} \end{cases} \tag{1}$$

where L is the individual's undiscounted expected future costs of cashing the check if she does not cash it in period t, and p is the probability of losing the check.

As we show in Appendix B, this problem can be solved with a cutoff rule. An individual cashes the check in period t if the realized cost in that period is smaller than c^*; otherwise she postpones the decision until the next period.

Lemma 1 *The equilibrium cutoff rule is given by*

$$c^*(\beta, p, S, \bar{c}) = \frac{\sqrt{(p\bar{c})^2 + 2(1-p)p(2-\beta)\beta S\bar{c}} - p\bar{c}}{(1-p)(2-\beta)} \tag{2}$$

Proof. See Appendix B.

Given $c^* \leq \bar{c}$ we can calculate the expected number of periods τ that the individual takes to cash a check received in $t = 0$ conditional on the fact that only checks that are not lost are cashed

$$\tau^* = \frac{\bar{c} - c^*}{c^* + p(\bar{c} - c^*)}. \tag{3}$$

The following proposition follows:

[7] Although checks are invalid after six months, and hence a model with a finite horizon could be used, we opt for a continuous model because it considerably simplifies the analysis and the six-month deadline seems to be irrelevant given that: (i) it is not strictly enforced (e.g., three participants cashed their check after six months), and (ii) the vast majority of checks are cashed significantly before six months (e.g., 96.30% of cashed checks are cashed within three months).

Proposition 1 *If the check is not too big, the lower β is (i.e, the more impatient the individual is) and the smaller the size of the check S, the more time an individual takes to cash the check.*

Proof. See Appendix B.

The main intuition is the same as in O'Donoghue and Rabin (1999a) and Carroll et al. (2009). When choosing between cashing today and cashing tomorrow, an impatient individual will discount heavily the cost of cashing tomorrow, so she will resort to cashing the check today only for very low realization of c. Hence, on average, an impatient individual will cash the check later. In contrast, the higher the amount of the check, the higher is the cost of losing it. This risk will lead an individual to cash the check earlier.[8]

The reason why the result is not true for very high values of S—specifically, when S is big enough so that $c^* \geq \bar{c}$ holds—is that, when the check is too valuable to lose, everyone cashes it immediately even if they are very impatient. Given that we observe positive cashing times and a negative relation between the cashing time and the size of the check, we argue that the condition for Proposition 1 is satisfied in our sample. This relationship can be seen in Figure 2A and 2B, in which we plot the check-cashing time on the size of the check and the logarithm of the size of the check, respectively. As predicted by Proposition 1, participants with larger checks have shorter cashing times. As Figure 2B shows, a better fit is obtained using the logarithm of the size of the check. This impression is confirmed by a formal regression test (not reported).

2.2 Getting the check

Having derived the optimal check-cashing behavior, we now analyze how participants choose the timing of the reward as a function of their present bias. At the end of the experiment, participants choose to receive either a check for S right away or a check for $S(1+r)$ the following period, where for simplicity, we assume each period lasts two weeks. Clearly, the value of receiving the check today versus a period from now depends upon the optimal cashing behavior.

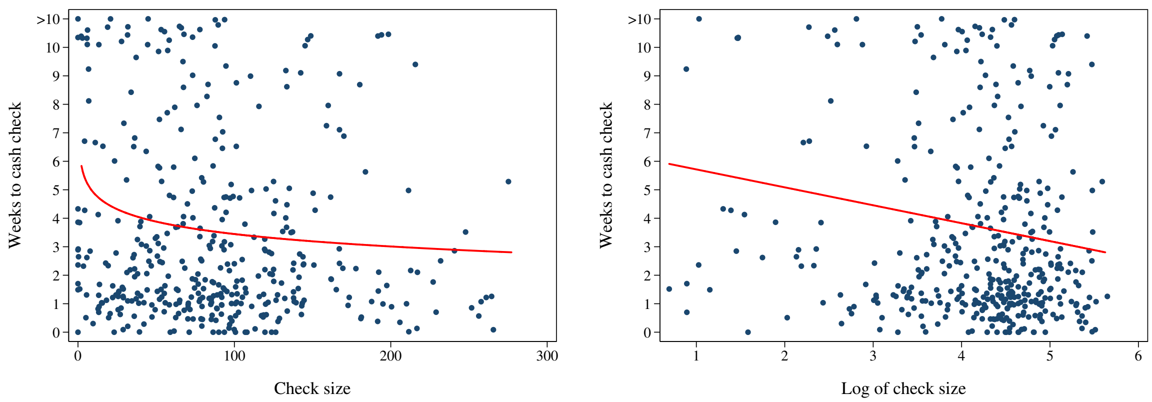
Sophisticated participants

We start by analyzing the choice of a sophisticated individual—that is, an individual who is aware of the degree to which she will postpone the decision to cash the check in the future. For the

[8]A similar result could be obtained with a model utilizing exponential discounting function. However, to explain the observed cashing behavior, it would require an unrealistically high discounting parameter (see Fischer, 2001). Or participants do not seem to discount their future that heavily—as evidenced by their investment of time and money in getting an MBA degree—and hence, we think a model with a present-bias is more appropriate in our setting.

Figure 5: Check cashing

Scatter plots between the time to cash the check and the size of the check. The red line indicates the best-fitting polynomial regression of degree 1.



(A) Weeks to cash the check and check size

(B) Weeks to cash the check and the log of check size

calculations below, it is useful to denote $L^*(S)$ as the undiscounted expected future costs of cashing the check if an individual does not cash it in a given period, given her optimal cutoff rule c^*.

If an individual takes the check and cashes it in $t = 0$, she receives $S - c_0$. If she takes the check in $t = 0$ but does not cash it right away, she receives $S - \beta L^*(S)$. Finally, if she takes the check in $t = 1$, she receives $\beta[S + rS - L^*(S + rS)]$. Therefore an individual will choose a smaller check in period 0 rather than a larger check in period 1 if and only if

$$\beta < \frac{S}{S + rS - [L^*(S + rS) - L^*(S)]} \quad \text{or} \quad \beta < \frac{S - c_0}{S + rS - L^*(S + rS)}. \tag{4}$$

Conditions (4) illustrate that there are two reasons to prefer a check today. The first reason is that the individual might have a very high bias toward the present (i.e., a very low β). Indeed, from (4) we obtain the following proposition:

Proposition 2 *The lower the interest rate offered, r, and the lower β is (i.e, the more impatient an individual), the higher the probability that an individual will prefer a check now rather than in the next period.*

Proof. See Appendix B.

Proposition 2 confirms the validity of our method to elicit the degree of present bias in preferences. The interest rate at which an individual switches is a function of her β. The intuition is straightforward. A higher β makes the delayed delivery more valuable as does a higher r.

In contrast, the relationship between the delivery timing and the amount of money at stake is not so straightforward. In fact, we have:

Corollary 1 *For high interest rates r there is a negative relationship between the amount of money at stake S and the probability of accepting a check right away. For low interest rates, this relationship is positive.*

Proof. See Appendix B.

For high interest rates, the relationship is as expected. Higher amounts make delaying the reward more valuable (because it yields a higher interest) and so make the delayed choice more likely. This result is no longer true for small interest rates because the probability of losing the check becomes relatively more important than the interest accumulated on the check.

The second reason an individual might choose to receive the check right away is that today's realization of the cost c_0 is so low that she wants to get the check and cash it now when her cost is low, rather than wait to receive it in the future—where she expects the cost of cashing to be much higher, and she risks the cost of losing it. In other words, if a participant knows she has to go to the bank today, she will prefer to get the check today and cash it—rather than wait for two weeks and run the cost of losing it—even if by waiting the two weeks she receives a slightly larger amount. This intuition is not unique to participants with a present bias, but it is common to rational exponential discounters. So we have

Corollary 2 *Even if offered a positive interest rate r, an individual with $\beta = 1$ will not necessarily delay receiving the check.*

Corollary 2 is important since it is not unique to this setting. It applies to all situations where participants have to incur a cost to receive or consume the delayed reward, which includes most experiments designed to elicit discount rates. The time series variability in this cost may generate the appearance of impatience, even among patient individuals. Corollary 1 also applies more generally and implies a relationship between the size of the reward and the elicited discount rate. This is consistent with numerous studies that vary the size of the reward and find that bigger rewards are discounted less than smaller ones (see references in Frederick et al., 2002). In other words, this corollary suggests that the so-called "magnitude effect" could be due to transaction costs and is not a property of discount function per se.

Naïve participants

All the above results are derived under the assumption that participants are aware of their degree of present bias (i.e., they are sophisticated). However, some individuals can be naïve: they have a $\beta \leq 1$ in all future periods, but being unaware of their own present bias, they think that in the future they will behave as if they had a $\beta = 1$.

A naïve individual will choose immediate delivery over a delayed delivery if and only if

$$(5) \qquad \beta < \frac{S}{S + rS - [L_e^*(S + rS, \beta_e) - L_e^*(S, \beta_e)]} \quad \text{or} \quad \beta < \frac{S - c_0}{S + rS - L_e^*(S + rS, \beta_e)},$$

where $L_e^*(S, \beta_e)$ equals the undiscounted expected future costs of not cashing the check in a given period, given a belief β_e an individual has about her own future level of impatience and her perceived cutoff rule c_e^*. Comparing (5) with (4) leads to the following proposition.

Proposition 3 *For reasonable parameters in this study, if $\beta < 1$, the probability that a naïve individual prefers a check right away is less than the probability of a sophisticated individual with the same characteristics. All the other comparative statics are the same as for sophisticated individuals.*

Proof. See Appendix B.

At first, this result seems counterintuitive, because it says that the sophisticated exhibit behavior that is more impatient than the naïve. Note, however, that it is not saying that the sophisticated are more impatient than the naïve. It simply states that, if we measure impatience from the interest rate at which they switch from delivery now to delivery in two weeks, the sophisticated will switch at a higher rate. The reason is that the naïve, not internalizing their future procrastinating behavior, will think that they will cash the check much sooner than they actually do. Thus, even if they are faced with a low realization of today's cost, they are willing to postpone receiving it until a later date. By contrast, the sophisticated are aware of their future delays in cashing the check and thus are more likely to take advantage of a low realization of the cashing cost by requesting an immediate delivery of the check. Once again, this effect is not unique to our setting, but it is likely to be present in all cases in which discount rates are elicited via a task that requires participants to incur a cost in the future if they want to receive the delayed reward.

3 Regression Results

The model predicts that there should be a correlation between the rate of impatience inferred from the time a student chooses to receive her check and her degree of procrastination, as computed by the delay in cashing the check. Table 2 tests this hypothesis with out data.

Table 2: Impatience and procrastination

In columns A, B, and C, the dependent variable is the participants' two-week discount rate, and the table presents interval regressions censoring at $r \leq 1$ and $r \geq 13$. In Columns D and E, the dependent variable indicates whether a participant chose the check today (= 1) or in two weeks (= 0), and the table presents Probit regressions clustering on individual participants. Robust standard errors are in parentheses. *,**,*** indicate statistical significance at the 10, 5, and 1 percent level.

	A	**B**	**C**	**D**	**E**
Weeks to cash the check	0.014	0.034	0.052	0.006	0.005
	(0.078)	(0.077)	(0.049)	(0.007)	(0.007)
Money at stake	-2.434***	-2.404***	-2.484***	-0.386***	-0.036
	(0.493)	(0.488)	(0.459)	(0.064)	(0.061)
Female		-1.368*	-1.531**	-0.254**	-0.257**
		(0.760)	(0.756)	(0.114)	(0.116)
CRT Score		-0.954***	-0.960***	-0.146***	-0.152***
		(0.261)	(0.263)	(0.039)	(0.040)
Trust		-1.520**	-1.385**	-0.232**	-0.240**
		(0.720)	(0.705)	(0.104)	(0.106)
Interest Rate				-19.619***	5.305*
				(0.920)	(2.900)
Interest Rate $\times$ Money at stake					-6.248***
					(0.778)
Constant	13.298***	16.713***	16.960***	2.868***	1.462***
	(2.190)	(2.393)	(2.282)	(0.335)	(2.304)
Wald χ^2	24.466	40.190	47.595	461.943	443.517
Log pseudolikelihood	-854.627	-846.777	-903.091	-2884.069	-2830.045
Obs.	405	405	432	5616	5616

In column A, we regress each student's subjective two-week discount rate on a measure of procrastination.[9] Since each value of the discount rate falls within a range of values (e.g., between 4% and 5%) and, at the extremes, is censored from below at $r \leq 1\%$ and above at $r \geq 13\%$, we estimate these regressions with an interval regression (robust standard errors are reported in

[9] We use the discount rate as the dependent variable as this is more in line with the way the model is constructed. However, all the results in the paper hold if instead we run the regressions with the measure of procrastination as the dependent variable.

parentheses, White, 1980). As proxy for procrastination, in this specification we use the number of weeks it took a student to cash her check—excluding the 27 students who never cashed it (and consented to the study). In addition, we control for the amount of money at stake since the model also predicts that this variable correlates with the elicited discount rate. In fact we use the logarithm of the money at stake as this gives a better fit.

As column A shows, students who delayed cashing the check have a higher discount rate, but this effect is both economically small and statistically insignificant. One extra week's delay in cashing the check is associated with only a 0.01 percentage point increase in their discount rate. In contrast, in line with the model, we do find a significant effect for the money at stake.[10] A one standard deviation increase in the amount of money at stake (which equals approximately $55) is associated with a decrease of 2.23 percentage points in the elicited discount rate. The effect is statistically significant at the 1% level.

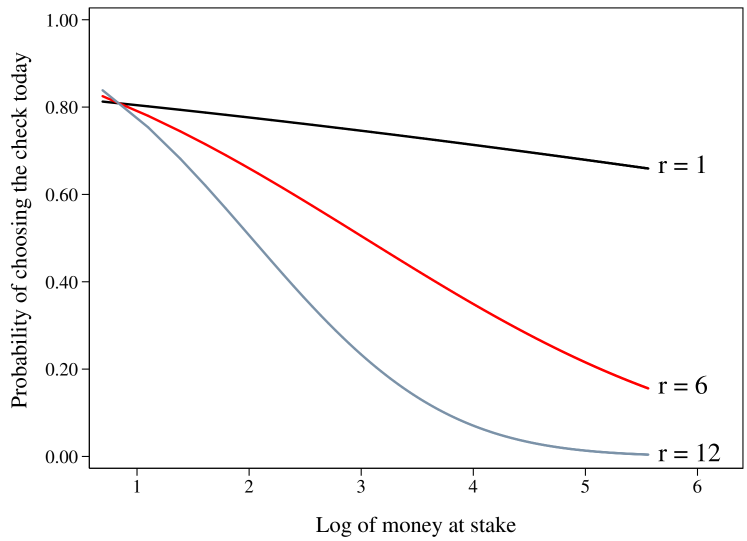
Since the amount of money at stake is determined by events in the experiment, one might worry that its effect is driven by the ability of participants to play the experimental games. We think this is unlikely as the payment method introduces a very large random component. Nevertheless, in order to test whether this conjecture is true, we calculated the students' expected earnings—that is, their earnings if they played against the average actions of others and faced the expected value of the random draws. When we introduce this variable into our regression (not reported), it does not have a statistically significant effect ($p = 0.416$) and it does not affect the coefficients of the other variables.

In column B, we control for several other potential determinants of the intertemporal trade-off. The first variable is gender: women appear to be 27.93% more patient than men and this effect is statistically significant at the 10% level. The second one is cognitive ability. In experimental research, measures of IQ have been linked to patience and delayed gratification (Mischel, 1974; Shoda et al., 1990; Benjamin et al., 2006). It is possible that individuals with higher cognitive abilities understand the question (implied interest rates) better than individuals with lower cognitive abilities. Alternatively, the causality could be reversed, as Mischel (1974) and Shoda et al. (1990) seem to suggest: patient individuals may work harder at answering test questions and achieve higher

[10]There can be other explanations for the effect of money at stake. For example, if participants think more carefully about a problem when the monetary stakes are high (as suggested by, Camerer and Hogarth, 1999), and more deliberation leads to more rational behavior, then we should see a shift to later delivery options. Also, if participants perceive the delayed delivery as more risky, then a higher than expected reward can induce participants to "gamble" (Arkes et al., 1995; Cherry, 2001), which in our context means choosing the delayed delivery.

Figure 6: Interaction between the interest rate and the money at stake

Probability that a participant chooses an to receive the check today as a function of the money at stake and selected interest rates. Estimated with the regression in column E in Table 2.



grades. Consistent with Frederick (2005), we find that students with higher cognitive ability have lower discount rates.[11] We also control for the World Values Survey measure of trust. We hoped that by equating the reward's delivery method at both delivery dates would eliminate any trust considerations. Nevertheless, we find that more trustful participants have lower discount rates. As distrustful individuals will see the later reward as more uncertain, this effect is consistent with models that predict high short-term discount rates as a consequence of uncertainty in the future (Halevy, 2008). All these controls do not substantially change our coefficient of interest.

In column C, we repeat the previous regression including also the students who have not cashed their check, with a value of delay equal to the maximum one (30 weeks). The coefficient of the cashing time remains economically small and statistically insignificant.

An interesting and non-obvious prediction of the model is that the relationship between impatient behavior and the amount of money at stake varies with the offered interest rate r. This

[11] Frederick (2005) suggests an alternative interpretation of this correlation between patience and cognitive abilities. Namely, some CRT questions have an "intuitive" answer that is incorrect, and therefore, if impatient individuals are more likely to respond impulsively, they will end up making more mistakes. To test for this effect, instead of using all four questions of the CRT, we only use the question without an intuitive incorrect answer (the question of two cars crashing, see footnote 6). We obtain the same result.

relationship cannot be tested with the specification used in columns A through C. Therefore, we run two additional regressions where the dependent variable is a dummy variable indicating whether, for a given r, a participant takes the check today ($= 1$) or in two weeks ($= 0$). Given that we have a binary dependent variable we use Probit estimates. Moreover, since each participant makes 13 such decisions, in addition to controlling for the value of r,[12] we allow for intragroup correlation in the standard errors by clustering on individual participants.

In column D, we run the equivalent regression reported in column C using the new specification. We obtain the same qualitative results. Namely, a positive but insignificant effect of weeks to cash the check and a significantly negative effect for the money at stake. In column E, we run the same regression including the interaction between the interest rate and the money at stake. In accordance with the model, the coefficient of the interaction variable is negative and statistically significant. The effect of the interest rate on the relationship between the money at stake and the probability of choosing an immediate delivery of the check can be seen in Figure 6. For low interest rates the effect of the money at stake is close to zero whereas for high interest rates it is significantly negative.

3.1 Alternative measures of procrastination

Table 2 fails to show an economic and statistically significant relationship between procrastination and impatience. One possible interpretation is that this lack of significance reflects the true nature of the data. Procrastination and impatience might not, in fact, be linked. On the other hand, this outcome might be simply the result of noise in the data. In the model, we assume that all individuals have the same risk of losing the check (p) and the same distribution of costs in cashing the check (uniform between 0 and $\bar{c}$).

In reality, participants are likely to possess different distributions of costs of cashing checks and/or differ in their absent-mindedness (i.e., in the probability of losing the check). Introducing this type of heterogeneity not only adds more noise, which could make the relationship between procrastination and impatience harder to detect, but can also generate a negative correlation between the elicited discount rate and the time to cash the check.[13] In other words, unobserved

[12]The table reports the best fit, which is obtained with $\ln(1 + r)$.

[13]In particular, whereas the model exhibits a positive relationship between the probability of choosing the check today—denoted as Π in Appendix B—and p (namely the partial derivative $\partial\Pi/\partial p$), the relationship between the time to cash the check conditional on cashing it τ^* and p (i.e., $\partial\tau^*/\partial p$) is negative for some parameter values and positive for others. Hence, *ceteris paribus*, differences in p or a combination of differences in p and $\bar{c}$ can produce a negative relationship between Π and τ^*.

heterogeneity can induce an attenuation bias in our estimated correlation between impatience and procrastination.

This issue is not unique to our setting. The choice between a good today and more of the same good tomorrow reflects impatience only under the assumption that the valuation for the good is constant between today and tomorrow. However, subjects always have more information about the utility of the good today than tomorrow: for a consumption good, they know whether they are hungry today, for a check they know the cost of going to the ATM, and for cash they know the value today of not having to go to the ATM to withdraw some other cash. In these experiments, very hungry people, or people with a very low cost of going to the ATM today, or people with a very high need of cash today will behave as if they are extremely impatient, even if they are not.

To address this issue, we use other measures of procrastination that do not suffer from these problems. As we have explained, these measures have problems of their own, but these are likely to be orthogonal to the probability of losing the check or the cost of cashing it.

Our first alternative measure of procrastination is the week in which students participated in the online game. As mentioned, the main problem with this variable is that not all students chose to participate. Since we do not know whether non-participants are extreme procrastinators or simply people who were not interested in the competition, we restrict the analysis to the 284 students who did participate.

In column A of Table 3, we report the interval regression of two-week subjective discount rates on the week in which students participated in the online game, plus the other control variables used in Table 2, columns B and C. Students who participated in the online game in later weeks have higher discount rates and this effect is statistically different from zero at the 5% level. Each week of delay in participation in the online game is related to an increase of 1.08 percentage points in the discount rate.

To check that this result is due to the difference in the measure of procrastination and not to a difference in the sample, in column B we re-ran the basic regression in Table 2, restricting it to the sample of students who participated in the online game. The estimates are similar to those in Table 2, which suggests that the observed result is due to the use of a different measure of procrastination and not to the sample.

In column C, we use as the measure of procrastination the deadline the students adhered to when they applied to the MBA program. As discussed in Section I, since we do not know whether a delay between the first two deadlines has the same cost as a delay between the last two deadlines, we inserted two dummy variables, one for students who adhered to the second deadline and another

Table 3: Impatience and alternative measures of procrastination

The dependent variable is the participants' two-week discount rate. The table presents interval regressions (A-C) and a Tobit regression with endogenous regressors (D); in all cases censoring at $r \leq 1$ and $r \geq 13$. Robust standard errors are in parentheses. *,**,*** indicate statistical significance at the 10, 5, and 1 percent level.

	A	**B**	**C**	**D**
Week of online game participation	1.082**			
	(0.487)			
Weeks to cash check		0.042		1.944*
		(0.056)		(1.088)
Application on 2nd deadline			0.031	
			(0.766)	
Application on 3rd deadline			0.846	
			(1.226)	
Money at stake	-2.621***	-2.421***	-2.549***	-1.230
	(0.497)	(0.502)	(0.458)	(1.130)
Female	-0.424	-0.554	-1.535**	-1.093
	(0.839)	(0.848)	(0.761)	(1.620)
CRT Score	-0.428	-0.501	-0.946***	-0.465
	(0.308)	(0.311)	(0.264)	(1.585)
Trust	-1.650**	-1.753**	-1.355*	-3.767**
	(0.836)	(0.851)	(0.705)	(1.609)
Constant	14.489***	15.568***	17.338***	5.117
	(2.507)	(2.489)	(2.327)	(7.281)
Wald χ^2	37.153	31.489	44.504	12.537
Log pseudolikelihood	-599.615	-601.994	-903.422	-1364.626
Obs.	284	284	432	269

for those who adhered to the third (i.e., the omitted category corresponds to students who complied with the first deadline).

As expected, later applicants have a higher discount rate. However, for students who adhered to the second deadline this effect is economically small and not statistically different from zero. For students who adhered to the third deadline, the effect is economically large: they exhibit a discount rate that is 0.85 percentage points higher (about 16% higher) than the other students. This effect, however, is not statistically significant, possibly for the paucity of students in this category (only 12%).

If it is true that the reason we do not find a relationship between the discount rate and cashing behavior is because of unobserved differences in the cost of cashing the check and in the probability of losing it, instrumenting the cashing behavior with the timing of participation in the online game and the deadline for the MBA application should solve the problem.

This is the approach we use in column D. We re-estimate the basic specification of Table 2, using these two instruments. The results show a positive and significant relationship between procrastination and impatience. Consistent with the attenuation bias hypothesis—which should be reduced or eliminated by the instrumental variables—the effect is quantitatively much bigger. A one standard deviation increase in the time to cash the check (which corresponds to 4.97 weeks) is associated with an increase of 9.65 percentage points in the subjective discount rate. The effect is statistically significant at the 10% level.

Overall, these results provide support to the link between procrastination and impatience, hypothesized in O'Donoghue and Rabin (1999a,b, 2001).

3.2 Sophistication

One of the main contributions of O'Donoghue and Rabin (1999a) is to model the difference between the naïve impatient and the sophisticated impatient. The existence of naïve participants and their relative frequency is extremely important when we try to draw welfare conclusions. Unfortunately, this aspect of O'Donoghue and Rabin (1999a) is difficult to observe empirically. First, the differences between the behavior of the naïve impatient, the sophisticated impatient, and non-impatient individuals are often too subtle to be identifiable in the data. Second, we lack reliable proxies to differentiate between the sophisticated and the naïve.[14]

Our context enables us to partly overcome both of these hurdles. First, our model delivers a very counterintuitive prediction about sophisticated individuals (they are more likely to switch at a higher discount rate), which is difficult to rationalize in any other way. Second, the possibility of observing the participants performing different tasks makes it easier to develop a proxy for sophistication. In particular, we use the difference in response behavior between the survey answered at the beginning of the MBA program and the online game played eighteen months later. The

[14] The best way of identifying sophistication is to observe whether individuals are willing to pay to bind their future behavior (for evidence of precommitment see, Wertenbroch, 1998; Ariely and Wertenbroch, 2002). However, as in our case, in many situations of interest these type of commitment devices are not available.

Table 4: Impatience and sophistication

The dependent variable is the participants' two-week discount rate. The table presents Tobit regressions with endogenous regressors and censoring at $r \leq 1$ and $r \geq 13$. Robust standard errors are in parentheses. The symbols *,**,*** indicate statistical significance at the 10, 5, and 1 percent level.

	A	**B**
Weeks to cash the check	2.165*	2.197*
	(1.152)	(1.194)
Sophistication I	7.237**	
	(3.377)	
Sophistication II		3.616
		(2.594)
Money at stake	-1.005	-0.992
	(1.211)	(1.253)
Female	-1.038	-0.931
	(1.742)	(1.769)
CRT Score	-0.453	-0.427
	(0.630)	(0.639)
Trust	-4.094**	-4.124**
	(1.687)	(1.717)
Constant	3.318	3.027
	(7.812)	(8.224)
Wald χ^2	17.223	14.033
Log pseudolikelihood	-1360.700	-1363.250
Obs.	269	269

survey was a requirement for a course, and therefore, there was no penalty to wait until the last minute to complete it.[15] By contrast, we designed the online game so that there is a clear cost to

[15]The time taken to complete the survey could be considered as a measure of procrastination. We do not include it as such because there is no explicit cost to delay. However, if we regress the subjective discount rate on the number of days participants took to answer the survey plus the control variables (not reported). We find a positive coefficient that is significantly different from zero at the 10% level. We also re-ran the regression with endogenous regressors including the time to answer the survey as an additional instrument. The regression's results are unchanged.

procrastination. Every week of delay, the value of participating dropped by roughly one-fourth.

Individual with present-biased preferences—irrespective of whether they are sophisticated or naïve—are more likely to delay completing the survey until the last minute. In the online game, however, sophisticated individuals are more likely to anticipate future procrastination and avoid the loss associated with it by completing the game before the first deadline. Hence, sophisticated individuals with present-biased preferences are more likely to display a drastic change in behavior between the two tasks.[16] To capture this pattern, we created a dummy variable equal to one for all participants who completed the survey on the last day and participated in the online game during the first week. For robustness, we also created an equivalent dummy variable for participants who completed the survey in the last two days.

Table 4 reports the result of inserting these measures of sophistication in the regression with endogenous regressors of column D of Table 3. In column A, as predicted by the model, the coefficient of sophistication (measured using survey completions in the last day) is positive and statistically significant. The effect is economically large—in fact bigger than what the model calibrated with reasonable parameters predicts. A sophisticated procrastinator has a discount rate that is 7.24% higher than a naïve one.

In Column B, we use the less restrictive definition of sophistication—based on completing the survey in the last two days. The effect is positive, but it is quantitatively half of what it was before and it is not statistically significant at conventional levels ($p = 0.16$).

The insertion of this control does not reduce the coefficient on the procrastination variable. In fact, consistent with our empirical specification capturing more of the features of the model, the coefficient of procrastination on impatience increases by 10%.

4 Conclusions

One of the main contributions of behavioral economics to the study of human behavior is its *reductio ad unum*—its attempt to explain several phenomena that has been classified as distinct on the basis of a common underlying principle. Nowhere has this attempt been more successful than in the case of the relationship between present-bias preferences and procrastination. This correlation,

[16] As mentioned above, one can argue that in a stochastic world there is an opportunity-cost of delay in completing the survey. However, as long as sophisticated and naïve individuals face the same cost distribution, it is still that case that individuals who filled the survey in the last minute and completed the game before the first deadline are more likely to be sophisticated.

however, had not been tested using actual behavior. In this paper, we use a combination of field and laboratory data to address this gap in the literature. We find compelling evidence in support of this relationship.

The distinction between sophisticated and naïve individuals is another important contribution of recent behavioral economics research (O'Donoghue and Rabin, 1999a). While extremely appealing, the empirical validity of this distinction is hard to test in the absence of commitment devices. This paper introduces an empirical proxy to identify the sophisticated: comparing their behavior in two situations with different incentives. Contrary to simple intuition, but as predicted by theory, we find that the observed degree of impatience is higher for the sophisticated.

Lastly, our paper validates the pervasiveness of high degree of impatience, even among highly sophisticated individuals.

A Instructions and Experimental Procedures

A.1 Experimental procedures

The experiment was run during Tuesday, October 3rd and Thursday, October 5th, 2006. Students were randomly assigned to participate on one of the two days. Two sessions were run each day in the afternoon, one starting at 1 pm and the other one at 3 pm. Due to scheduling conflicts with other activities, all national students (US citizens) participated in the 1 pm sessions and international students in the 3 pm sessions.

Upon arrival, students received a set of materials, which included their $20 show-up fee and a unique randomly assigned number that is used to identify each student. Once all students were seated, the experimenter reminded them not to communicate with one another and that their interaction with others would remain anonymous. Thereafter, students were asked to sign various consent forms. Consenting to the different aspects of the study was voluntary and participants have the option to opt out of the study at any time. The experiment was run with computers and programmed in zTree (Fischbacher, 2007). Each session lasted around one and a half hours.

A.2 Instructions for the payment choice

As your last choice, you decide when to receive your payment. For each row below, choose the amount and timing of your payment. If you choose to be paid *now*, a check will be delivered to your mailfolder by the *end of the day*. If you choose to be paid *later*, the check will be delivered to your mailfolder in *two weeks time*. One of the rows will be randomly selected by the computer and that choice will be implemented.

[Example with earnings of $80]

1. Receive $80.00 today or receive $80.00 in two weeks
2. Receive $80.00 today or receive $80.80 in two weeks
3. Receive $80.00 today or receive $81.60 in two weeks
4. Receive $80.00 today or receive $82.40 in two weeks
5. Receive $80.00 today or receive $83.20 in two weeks
6. Receive $80.00 today or receive $84.00 in two weeks
7. Receive $80.00 today or receive $84.80 in two weeks
8. Receive $80.00 today or receive $85.60 in two weeks
9. Receive $80.00 today or receive $86.40 in two weeks
10. Receive $80.00 today or receive $87.20 in two weeks
11. Receive $80.00 today or receive $88.00 in two weeks
12. Receive $80.00 today or receive $88.80 in two weeks
13. Receive $80.00 today or receive $89.60 in two weeks

A.3 Instructions for the online game

Complete the "Face of Success" survey and participate in a lottery to win an iPhone! Each week we will draw a winner from those of you who have completed the survey. The winner will receive a brand new 16GB iPhone. Note that, winning in a given week does not exclude you from participating in subsequent lotteries. Hence, if you complete the survey by noon Tuesday, April 23, you will take part in three lotteries and you can win up to three iPhones.

iPhone lotteries will take place the following days at noon:

- 1st lottery: April 23
- 2nd lottery: April 30
- Last lottery: May 7

In addition, if you are the best at spotting the true Face of Success you can win our grand prize: a $1,500 value that you can spend on either a dinner at Alinea restaurant, airplane tickets, or a Macbook Air. The contest ends on May 14. Log on and compete! To take the 20-minute survey click here.

B Proofs

Lemma 1 *The equilibrium cutoff rule is given by*[17]

$$c^*(\beta, p, S, \bar{c}) = \frac{\sqrt{(p\bar{c})^2 + 2(1-p)p(2-\beta)\beta S\bar{c}} - p\bar{c}}{(1-p)(2-\beta)}$$

Proof. At the cutoff point c^* the individual is indifferent between cashing the check in the current period or delaying the decision:

$$c^* = \beta[pS + (1-p)L(c^*)]. \tag{6}$$

Since the probability that an individual cashes the check in a given period is $c^*/\bar{c}$, and if she does, she pays an average cost of $c^*/2$, we can write $L(c^*)$ as[18]

$$L(c^*) = \sum_{k=0}^{\infty}\left(1-p\right)^k\left(1-\frac{c^*}{\bar{c}}\right)^k\left[\frac{c^*}{\bar{c}}\frac{c^*}{2} + \left(1-\frac{c^*}{\bar{c}}\right)pS\right] \tag{7}$$

$$L(c^*) = \frac{(c^*)^2 + 2p(\bar{c}-c^*)S}{2c^* + 2p(\bar{c}-c^*)}. \tag{8}$$

Note that β does not appear in L as the individual is evaluating trade-offs between future periods only. Substituting (7) into (6) and solving for c^* gives (2)[19] ■

Proposition 1 *If the check is not too big, the lower β is (i.e, the more impatient the individual is) and the smaller the size of the check S, the more time an individual takes to cash the check.*

Proof. The time to cash the check is positive as long as $c^* < \bar{c}$, which holds if

$$S < \frac{2-(1-p)\beta}{2p\beta}\bar{c}. \tag{9}$$

Since the right hand side of the equation is decreasing in β, it means that more impatient individuals satisfy (9) more easily and thus are less likely to always cash the check in period 0.

Furthermore, since the partial derivative of τ with respect to c^*, which is

$$\frac{\partial\tau}{\partial c^*} = -\frac{\bar{c}}{(c^* + p(\bar{c}-c^*))^2}, \tag{10}$$

[17]We do not attempt to identify all solutions to the problem. We are concentrating on the unique solution in the space of stationary pure strategies.

[18]Note that $c^* > 0$ otherwise the individual never cashes the check and eventually losses it incurring a cost $S > 0$.

[19]The substitution gives a quadratic equation. We use the upper root so that $c^* > 0$.

is always negative, and the partial derivatives of $c^*(.)$ with respect to S and β, which equal

$$\text{(11)} \qquad \frac{\partial c^*}{\partial S} = \frac{p\beta\bar{c}}{\sqrt{(p\bar{c})^2 + 2(1-p)p(2-\beta)\beta S\bar{c}}}$$

$$\text{(12)} \qquad \frac{\partial c^*}{\partial \beta} = \frac{p\bar{c}\left(p\bar{c} + 2(1-p)(2-\beta)S - \sqrt{(p\bar{c})^2 + 2(1-p)p(2-\beta)\beta S\bar{c}}\right)}{(1-p)(2-\beta)^2\sqrt{(p\bar{c})^2 + 2(1-p)p(2-\beta)\beta S\bar{c}}},$$

are both positive for $0 < p < 1$, and $0 < \beta \leq 1$, we can confirm that if (9) is satisfied then both $\partial\tau/\partial\beta$ and $\partial\tau/\partial S$ are always negative ■

Proposition 2 *The lower the interest rate offered, r, and the lower β is (i.e, the more impatient an individual), the higher the probability that an individual will prefer a check now rather than in the next period.*

Proof. The probability that an individual prefers a check today is given by

$$\text{(13)} \qquad \Pi = \begin{cases} 0 & \text{if } \beta > \bar{\beta} \\ \dfrac{S - \beta\left(S + rS - L^*(S+rS)\right)}{\bar{c}} & \text{if } \underline{\beta} < \beta < \bar{\beta} \\ 1 & \text{if } \beta < \underline{\beta} \end{cases}$$

$$\text{(14)} \qquad \text{where} \quad \bar{\beta} = \frac{S}{S + rS - L^*(S+rS)}$$

$$\text{(15)} \qquad \text{and} \quad \underline{\beta} = \max\left(\frac{S}{S + rS - [L^*(S+rS) - L^*(S)]}, \frac{S - \bar{c}}{S + rS - L^*(S+rS)}\right).$$

We first show that the probability of taking the check today is decreasing in r and β for the case $\underline{\beta} < \beta < \bar{\beta}$. The derivative of $L^*(S)$ with respect to c^* is given by

$$\text{(16)} \qquad \frac{\partial L^*(S)}{\partial c^*} = \frac{\frac{1}{2}(1-p)c^{*2} - p\bar{c}(S - c^*)}{(c^* + p(\bar{c} - c^*))^2}.$$

Using (2) and solving for c^* indicates that (16) is negative if

$$\text{(17)} \qquad c^* \leq \frac{\sqrt{(p\bar{c})^2 + 2(1-p)pS\bar{c}} - p\bar{c}}{(1-p)},$$

which holds as long as $\beta \leq 1$. Combining this with the positive sign of (11) and (12) ensures that $\partial\Pi/\partial r < 0$. Moreover, since it always the case that $S + rS > L^*(S+rS)$, it follows that $\partial\Pi/\partial\beta < 0$.

Next, we look at how r affects the threshold values $\bar{\beta}$ and $\underline{\beta}$. Note that, since (11) is positive and (16) is negative, $\bar{\beta}$ is decreasing in r. In other words, a low r makes it more likely that the individual always delays taking the check irrespective of the value of c_0. Similarly, given the signs of (11) and (16), it follows that $\underline{\beta}$ is also decreasing in r. Correspondingly, a low r makes it less likely that the individual always takes the check irrespective of the value of c_0.

Lastly, we look at how changes in β change the threshold values $\bar{\beta}$ and $\underline{\beta}$. In the case of $\bar{\beta}$, the fact that (12) is positive and (16) is negative immediately implies that $\partial\bar{\beta}/\partial\beta < 0$, and therefore an increase (decrease) in β makes it more (less) likely that the individual always delays taking the check irrespective of the value of c_0. In the case of $\underline{\beta}$, we have to look separately at each possible maximum value. If the maximum value happens to be the right value in equation (15), then it is easy to see that, given the signs of (11) and (16), $\partial\underline{\beta}/\partial\beta < 0$. In other words, once again, an increase (decrease) in β makes it less (more) likely that the individual always takes the check irrespective of the value of c_0. The relative effect of β on $\underline{\beta}$ is not as straightforward if its maximum value is the left value in equation (15). In this case, β has the desired effect on the threshold if $\partial\underline{\beta}/\partial\beta < 1$. Unfortunately, it is not possible to find a manageable analytical solution for this inequality. Therefore, to show that this holds in this study we calculated $\partial\underline{\beta}/\partial\beta$ for cases in which the value of β is close to $\underline{\beta}$. Specifically, we calculated $\partial\underline{\beta}/\partial\beta$ for the following parameter values: $p \in [0.01, 0.99]$, $S \in [1, 300]$, $\bar{c} \in [1, 300]$, and $r \in [0, 0.15]$, when $\beta = \underline{\beta}$.[20] We find a maximum value for $\partial\underline{\beta}/\partial\beta$ of 0.126, which is less than 1. Consequently, if β is close to $\underline{\beta}$, we obtain once again that an increase (decrease) in β makes it less (more) likely that the individual always takes the check ■

Corollary 1 *For high interest rates r there is a negative relationship between the amount of the check S and the probability of accepting a check right away. For low interest rates, this relationship is positive.*

Proof. From (13) one can see that, as long as $\underline{\beta} < \beta < \bar{\beta}$, the relationship between S and the probability of taking the check today is given by

$$\frac{\partial \Pi}{\partial S} = \frac{1}{\bar{c}}\left(1 - \beta\frac{\partial(S + rS - L^*(S + rS))}{\partial S}\right) \tag{18}$$

To facilitate notation, we denote $\partial(S + rS - L^*(S + rS))/\partial S$ as λ^*. If $\lambda^* < 1$ the relationship between Π and S is positive, otherwise it is negative. Writing $c^*(\beta, p, S + rS, \bar{c})$ as c^*, we get

$$\lambda^* = \frac{1 + r - \frac{1}{2}c^*_S}{c^* + p(\bar{c} - c^*)}c^* + \frac{(1 + r)S - \frac{1}{2}c^*}{(c^* + p(\bar{c} - c^*))^2}p\bar{c}c^*_S \tag{19}$$

$$\text{where } c^*_S = \frac{p\beta(1 + r)\bar{c}}{\sqrt{(p\bar{c})^2 + 2(1 - p)p(2 - \beta)\beta(1 + r)S\bar{c}}} \tag{20}$$

[20] Calculations were done in steps of 0.01 for p and r, and steps of 1 for S and $\bar{c}$. They are available upon request.

which is clearly positive as $\frac{1}{2}c_S^* < (1+r)$ and $\frac{1}{2}c^* < (1+r)S$. The derivative of λ^* with respect to r is

$$\frac{\partial \lambda^*}{\partial r} = \frac{2S(1-p)(c^*-Sc_S^*)+\left(2-\frac{1}{1+r}c_S^*\right)pS\bar{c}}{(c^*+p(\bar{c}-c^*))^3}p\bar{c}c_S^* + \frac{(1+r)S-\frac{1}{2}c^*}{(c^*+p(\bar{c}-c^*))^2}p\bar{c}c_{Sr}^* + \frac{1-\frac{1}{2}c_{Sr}^*}{c^*+p(\bar{c}-c^*)}c^* \tag{21}$$

$$\text{where } c_{Sr}^* = \frac{p\bar{c}+(1-p)(2-\beta)\beta(1+r)S}{\sqrt[3]{(p\bar{c})^2+2(1-p)p(2-\beta)\beta(1+r)S\bar{c}}}\beta(p\bar{c})^2 \tag{22}$$

which again is positive as $0 < c_{Sr}^* < 1$, as well as $S > c^* > Sc_S^*$ and $2(1+r) > c_S^*$. In other words, $\partial\Pi/\partial S$ switches from being (weakly) positive to (weakly) negative as r increases if for a low r it holds that $\beta\lambda^* < 1$. In this case, there is an r^* such that for $r > r^*$ it holds that $\partial\Pi/\partial S \leq 0$ and for $r < r^*$ it holds that $\partial\Pi/\partial S \geq 0$.[21] The precise value of r^* is given by the r that solves $\partial\Pi/\partial S = 0$. Although it is not possible to find an explicit expression for r^*, it is easy to calculate it for various parameter values. For example, if $S = \$80$, $\bar{c} = \$20$, $p = 0.03$, and $\beta = 1$, then $\underline{\beta} = 0.969$, $\bar{\beta} = 1.061$, and $r^* = 0.033$. Similarly, if $S = \$135$, $\bar{c} = \$35$, $p = 0.1$, and $\beta = 0.9$, then $\underline{\beta} = 0.889$, $\bar{\beta} = 1.002$, and $r^* = 0.127$ ■

Corollary 2 *Even if offered a positive interest rate r, an individual with $\beta = 1$ will not necessarily delay receiving the check.*

Proof. As can be seen from (13), an individual with $\beta = 1$ has a positive probability of taking the check today as long as $rS < L^*(S + rS)$,[22] which is the true for all r that satisfy

$$r < \frac{c^*}{2S} + p\frac{\bar{c}-c^*}{c^*}. \tag{23}$$

It is not hard to find parameter values for which (23) holds. For example, if $S = \$100$, $\bar{c} = \$50$, and $p = 0.01$, an individual with $\beta = 1$ has a positive probability of taking the check today as long as $r < 0.090$ ■

Proposition 3 *In the study, for $\beta < 1$, the probability that a naïve individual prefers a check right away is less than the probability of a sophisticated individual with the same characteristics. All the other comparative static is the same as for sophisticated individuals.*

[21] Note that for very low and very high values of r, there might not be a relationship between Π and S as β can fall outside the thresholds $\underline{\beta}$ and $\bar{\beta}$. Thus, this corollary applies strictly only when comparing intermediate values of r.

[22] For individuals with $\beta = 1$ it is always the case that $rS - (L^*(S + rS) - L^*(S)) > 0$, which implies that their only motivation to take a check today is due to a low value of c_0.

Proof. Let's define $\Pi_e(\beta_e)$ as the probability that an individual take the immediate delivery of the check given her belief β_e or her present-bias. Similarly, we denote $\bar{\beta}_e(\beta_e)$ and $\underline{\beta}_e(\beta_e)$ as the threshold values of β below/above which an individual with belief β_e strictly prefers to take/not take the check today. The probability of cashing today is given by

$$\Pi(\beta_e) = \begin{cases} 0 & \text{if } \beta > \bar{\beta}_e(\beta_e) \\ \dfrac{S - \beta\,(S + rS - L_e^*(S + rS, \beta_e))}{\bar{c}} & \text{if } \underline{\beta}_e(\beta_e) < \beta < \bar{\beta}_e(\beta_e) \\ 1 & \text{if } \beta < \underline{\beta}_e(\beta_e) \end{cases} \tag{24}$$

$$\text{where} \quad \bar{\beta}(\beta_e) = \frac{S}{S + rS - L_e^*(S + rS, \beta_e)} \tag{25}$$

$$\text{and} \quad \underline{\beta}_e(\beta_e) = \max\left(\frac{S}{S + rS - [L_e^*(S + rS, \beta_e) - L_e^*(S, \beta_e)]}, \frac{S - \bar{c}}{S + rS - L_e^*(S + rS, \beta_e)}\right). \tag{26}$$

Moreover, note that $\partial L_e^*/\partial \beta_e < 0$ as (12) is positive and (16) is negative for $0 < p < 1$ and $0 < \beta \leq 1$.

From (24), it is easy to see that for intermediate values of $\beta < 1$, an individual has a lower probability of choosing the check today if she is naïve since

$$\frac{S - \beta(S + rS - L_e^*(S + rS, \beta))}{\bar{c}} > \frac{S - \beta(S + rS - L_e^*(S + rS, 1))}{\bar{c}}. \tag{27}$$

In addition, for high values of β, one can see from (25) that $\bar{\beta}_e(\beta) > \bar{\beta}_e(1)$ and therefore, a naïve individual has a higher likelihood of choosing the delayed payment with probability 1 than a sophisticated individual. Similarly, for low values of β, if the maximum value of (26) is given by the rightmost expression, then $\underline{\beta}_e(\beta) > \underline{\beta}_e(1)$, which implies that naïve individuals are less likely to choose the immediate payment with probability 1 than sophisticated individuals.

This leaves us with the situation with low values of β where the maximum value of (26) is given by the leftmost expression. In this case, either $\underline{\beta}_e(\beta) > \beta > \underline{\beta}_e(1)$ and the probability of taking the immediate delivery for a sophisticated individual equals 1 and for a naïve individual it is strictly less than 1, or $\underline{\beta}_e(1) > \beta > \underline{\beta}_e(\beta)$ and the opposite is true. Thus, the latter case is the only scenario in which a sophisticated individual is more likely cash the check than a naïve one. In order to assess the likelihood that it occurs we checked for various values of S, $\bar{c}$, p, and r, whether this scenario's conditions hold. We used the following parameter values: $p \in [0.01, 0.99]$, $S \in [1, 300]$, $\bar{c} \in [1, 300]$, and $r \in [0, 0.15]$.[20] We did not find that the inequalities $\underline{\beta}_e(1) > \beta > \underline{\beta}_e(\beta)$ ever hold in these range of values. Therefore, we conclude that a naïve individual has a lower probability of choosing the check today compared to a sophisticate individual with the same characteristics.

It is easy to see that the other comparative statics hold for naïve individuals. Proposition 1 holds as cashing the check is independent of the level of naïvité. Proposition 2 holds in an even more straightforward manner as $L_e(S, 1)$ and $L_e(S + rS, 1)$ are independent of the value of β. Lastly, corollaries 1 and 2 depend only on β and not on β_e and hence also hold for naïve individuals ■

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