Procrastination and Impatience*

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Abstract

There is a large body of literature documenting both a preference for immediacy and a tendency to procrastinate. O'Donoghue and Rabin (1999a,b, 2001) and Carroll et al. (2007) model these behaviors as two facets of the same phenomenon. In this paper, we use a combination of lab and field evidence to study whether these two types of behavior are indeed linked. To measure immediacy we had subjects choose between a series of smaller-sooner and larger-later rewards. Both rewards were paid by check to control for transaction costs. To measure procrastination we record how fast subjects cash their checks and complete other tasks. Our results lend support to the hypothesis that subjects who have a preference for immediacy are more likely to procrastinate. We also find evidence that subjects differ in the degree with which they anticipate their own procrastination, that is, in their degree of "sophistication" in the O'Donoghue and Rabin (1999a) terminology.

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A large body of experimental literature documents the tendency for people to exhibit strong preferences for immediacy (Thaler, 1981; Benzion et al., 1989; Kirby, 1997; Coller and Williams, 1999; Shui and Ausubel, 2005; Ashraf et al., 2006).[1] At the same time, there is a small but growing number of studies that show that people tend to procrastinate (Ariely and Wertenbroch, 2002; DellaVigna and Malmendier, 2006; Choi et al., 2006). O'Donoghue and Rabin (1999a,b, 2001) and Carroll et al. (2007) model these behaviors as two facets of the same phenomenon. Highly impatient individuals overweigh immediate costs vis-á-vis delayed benefits and thus procrastinate in activities where costs are upfront and overindulge in activities where costs are delayed. Procrastination is not necessarily due to impatience. For example, Akerlof (1991) derives procrastination from the saliency of current costs, not from a discounting problem.

While the link between these two phenomena is at the heart of this literature, we are not aware of any paper that tests this connection with an incentivized experiment. Psychologists have documented the positive association between procrastination and impulsivity with the use of several surveys (Steel, 2007), but no money was at stake. In this paper we designed an experiment to achieve this goal. We asked a large sample of MBA students who earned between \$0 and \$300 whether they wanted to receive their earnings now 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.

Since access to credit disassociates money from consumption, the use of monetary rewards to elicit discount rates has been criticized (Besharov and Coffey, 2003; Cubitt and Read, 2007). However, recent studies suggest money can indeed be used to observe time preferences. For example, there is neurological evidence showing activation of the same limbic areas of the brain when an intertemporal choice includes an immediate monetary reward (McClure et al., 2004) and an immediate consumption good (McClure et al., 2007). This evidence suggests that subjects experience a "utility jolt" both when they receive a carrier of a reward (i.e., money) and when they receive a good they can consume (Knutson et al., 2001). Therefore, as the carrier has an equivalent effect as a good—regardless of the time of the actual consumption—it can be used, in our opinion, to infer

[1]See Frederick et al. (2002) for a recent review.

an individual's degree of impatience. Furthermore, in a similar experiment, Reuben et al. (2008b) find a positive and statistically significant correlation between the discount rate for a monetary reward and the discount rate for a primary reward (chocolate). However, this effect is not present for subjects 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).

Thinking of the check as a carrier of reward, however, introduces an additional problem. After the immediate gratification of receiving a check, subjects 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). The only benefit is long term: the check is not lost and the funds will be there in case the subject needs them. This tension between short-term cost and long-term benefits, similar to the 401(k) enrollment decision analyzed by Carroll et al. (2007), makes this task suitable for identifying a subject's tendency to procrastinate. Applying the model of Carroll et al. (2007) to our context, we derive the equilibrium cashing policy as a function of the amount of the prize and individual characteristics. Consistent with O'Donoghue and Rabin (1999a), the model predicts that subjects 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 of when to accept the check, and consequently, the observed degree of impatience. On average, subjects with a strong present bias value more the psychological benefit of receiving the check immediately. Nevertheless, an extremely low realization of the transaction cost (e.g., a subject already planned to go to the bank for another reason) can induce even a patient subject to ask for an immediate delivery of the check, which would result in her being falsely classified as an impatient individual. This misclassification can cause an attenuation bias in the estimated relationship between impatience and check-cashing behavior.

The model is also able to differentiate between the behavior of "naïve" and "sophisticated" procrastinators (O'Donoghue and Rabin, 1999a). Not anticipating their future procrastination, naïve subjects 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.

When we test the relationship between impatience and procrastination using the check-cashing behavior we find a positive, but not significant, correlation. One possible reason for the lack of significance is that procrastination and impatience are indeed not linked. Alternately, heterogeneity in other individual characteristics may cloud the relationship of interest—as with a standard attenuation bias. In particular, the model suggests that heterogeneity in the risk of losing the check or in the cost of going to the next ATM to cash it can induce a negative correlation between impatience and cash-checking behavior, which could affect the experimental results.

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 subject 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 relationship with impatience. However, in this case the coefficient is not statistically significant. Most importantly, when we instrument the check-cashing measure of procrastination with the other two, 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. Applying this idea to our context we derived the counterintuitive implication that present-biased sophisticated subjects should exhibit a *higher degree of impatience* toward receiving the check than present-biased naïve subjects.

To test this prediction, we develop a proxy of sophistication by comparing the subjects' behavior when delay is costly and when it is not. As part of their class duties, subjects had to answer a survey. As long as this survey was completed on time, there was no penalty. By contrast, in the online game, delaying their response was costly. Thus, subjects 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 subjects do exhibit a higher degree of short-term bias as predicted by our model.

All these results are remarkable given that they were found with University of Chicago MBAs—one of the most economically-minded and profit-motivated populations we can imagine. That two thirds of these individuals exhibit present-bias preferences and at the same time delay for weeks the cashing of their checks (even when the money at stake is relatively large, up to $260) suggests that procrastination and impatience are pervasive phenomena.

The rest of the paper proceeds as follows: Section I describes the experiment and the data used; Section II models the decision to accept the money today or tomorrow when there are costs involved in cashing the check; Section III tests the predictions of the model by using our experimental data; Section IV concludes.

I Experimental Design

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 entire 2008 MBA cohort at the University of Chicago Graduate School of Business (see Reuben et al., 2008a).

As part of a required class, all the students were asked to complete a survey and participate in a few experiments. Although participation in these two tasks was mandatory, the Institutional Review Board at the University of Chicago required that subjects have the opportunity to opt out of the study by not consenting to the use of their data for research purposes. In this paper, we use data from these two sources plus admission data obtained from the University (also with the students' consent). Out of 550 MBA students, 543 completed the survey and participated in the experiment. Of these, 475 (87.48%) consented to the use of their survey, experiment, and admissions data. Each of these data sources as well as the subject pool is briefly described below.

The survey was designed to acquire demographic data and measure various personality traits (the questions used are available in Reuben et al., 2008a). In this paper we concentrate only on two variables: trust and cognitive ability. 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?"[2] Table I shows sample statistics for this variable: 54.40% of the students responded that most people can be trusted. We also tried to capture mistrust of the experimenters by asking the following question: "Suppose that a new and very desirable dorm/apartment has become available. The University of Chicago organizes a lottery to assign it among the many applicants. How confident are you that the allocation will be fair?" The possible answers are: "Not at all," "Not much," "Quite a lot," and "A great deal." Less than 1.00% of the students do not have any trust at all in the fairness of the University, 8.89% "not much;" 42.79% "quite a lot;" and 47.60% "a great deal."

Frederik (2005) and Benjamin et al. (2006) show that cognitive reflection is related to discount rates. Consequently, in our analysis, we also control for cognitive reflection. Following Frederik (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 Frederik (2005). These four questions were then administered to the entire study sample.[3] Sample statistics for the CRT scores are in Table I: the average student answered 2.49 out of 4 questions correctly.

< Table I around here >

A Experiment

The main data come from a laboratory experiment, which 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.

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

[3]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?"

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, we paid them according to their performance. We randomly drew one of the games and paid them according to their earnings in that game.

At the end of the session, a message appeared on the screen that announced the subject's final earnings and offered her the choice between receiving her payment the day of the experiment or receiving a larger amount two weeks later. 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 the task designed to measure impatience: the rate of return at which a subject switches from asking for an immediate delivery of the check to accepting a delayed one. 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. (2008a).

A.1 Impatience over money

To measure impatience, we use the subjects' short-term discount rate. We elicit discount rates by giving subjects a series of simple choices of the following type: receive x dollars today or receive $(1 + r)x$ dollars in two weeks, where x equals their earnings in the experiment. Each subject 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 to be paid. Only the 495 subjects 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 observation in our sample is 432. Additional constraints to the sample will be explained as necessary.

If, for a given r and x, a subject prefers x dollars today, we can infer that she is willing to sacrifice $r\%$ of earnings in order to receive the payment today instead of in two weeks. Thus, by varying r and observing the point where subjects switch from payment today to payment in two weeks, we get a precise measure of each subject'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 subjects' 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). We tried to obviate this problem 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.

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. (2008b), 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 the same activation pattern in their brain irrespective of whether the choice involves monetary (McClure et al., 2004) or primary rewards (McClure et al., 2007). This evidence suggests that, regardless of the time of the actual consumption, subjects 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 IA 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 I 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 $r = 12\%$).

< Figure I around here >

Since students confronted this task with varying amounts of money at stake, we needed to parcel out the effect of their different earnings in order to isolate their degree of impatience. The amount of money at stake can affect the discount rate in various ways. First, as we show in the next section, the size of the check can affect the subjects' cashing behavior (smaller checks are more likely to be lost), which in turn will affect their choice between money today and money in two weeks. Second, as suggested by Camerer and Hogarth (1999), when the monetary stakes are high, subjects are more likely to think carefully about the problem. In this case, if more deliberation leads to more money-maximization we should see a shift to later delivery options. Third, if subjects perceive the delayed delivery as more risky, then a higher than expected reward can induce subjects to "gamble" (Arkes et al., 1995; Cherry, 2001), which in our context means choosing the delayed delivery.

Indeed, when we run a regression (not reported) of the discount rate on the level of money, the switching point is heavily influenced by the amount of money at stake: the larger the amount, the lower the discount rate. Figure IB and Figure IC show that this relationship is non-linear: the best fit is obtained using the logarithm of the amount of money at stake. Hence, in the remaining part of the paper, whenever we use the switching point as a measure of impatience, we control for the logarithm of the amount of money at stake.

Interestingly, while the amount of money at stake changes the rate at which subjects switch between today and two weeks from now, it does not change the proportion of people switching at the 1% rate (i.e., supposedly rational exponential discounters). In other words, it looks as if a fraction of the population (roughly a third) behaves as rational exponential discounters regardless of how much money is at stake. The remaining two thirds have a present bias but are sensitive to incentives.

A.2 Time to cash a check

In order to keep the transaction costs constant over both delivery times we paid subjects by putting a check in their mailfolders. 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 subjects attend class and thus have to be present on campus. Mailfolders are easily accessed and are usually checked on a daily basis. Utilizing a check not only homogenizes transaction costs, it also gives us a measure of procrastination: the number of days a subject takes to cash the check.

The values for this variable are reported in Figure IIA. 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 subjects. When we do so, we set their cashing date at 30 weeks.

< Figure II around here >

As we will discuss in the model in the next section, the time taken to cash a check is not a pure measure of procrastination. First of all, the economic incentive to cash the check in the presence of check-cashing costs will be affected by the amount of money at stake. Second, check-cashing costs might vary as people differ on how busy they are and how costly it is to go to the bank.

Figure IIB and IIC plot the check-cashing time on the money at stake and the logarithm of the money at stake, respectively. Not surprisingly, people with a larger check cash it sooner. As Figure IIC shows, a better fit is obtained using the logarithm of the level of money at stake. This impression is confirmed by a formal regression test (not reported).

A.3 The Online Game

After a year and a half, we launched an online game with the same cohort of students. Participants had to guess, by looking at old facebook pictures, who were the most successful alumni of the University of Chicago MBA program. The student with the highest number of correct answers received a $1500 prize. Students had four weeks to participate in 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) was randomly awarded to one of the students who had participated up to that date (each participant had an equal chance of winning and winners were not excluded from future draws). Thus, students who took part in the game in the first week participated in three draws, those who took part in the second week participated in two draws, and those who took part in the third week in one. This declining benefit of participation was designed to separate subjects who procrastinate and subjects who do not.

In total 284 students participated in the online game. As we can see from Figure III, a disproportionate number of them (86.27%) participated 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 subject 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.

< Figure III around here >

B 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.

As Figure IV shows, 30.32% of the applicants adhere to the first deadline, 57.64% to the second, and 12.04% adhere to the last.

< Figure IV around here >

II 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 subjects. However, these are highly intelligent MBAs 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 subjects who won more than $100. For this reason, we model this behavior as a manifestation of present-biased preferences a la O'Donoghue and Rabin (1999a).

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, subjects experience a "utility jolt", as measured by increased brain activity, in anticipation of a monetary reward. Thus, independent of the utility from consuming this reward, subjects also enjoy receiving the reward itself. Consistent with these findings we assume that the carrier of reward is the check itself.

Once subjects have received their reward (and enjoyed the associated utility), they are confronted with the decision of when to cash the check. Given the near-zero return on checking accounts, cashing the check has no immediate reward. It has, however, an immediate *cost*: subjects 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.

This structure of short-term cost and long-term benefit is similar to the Carroll et al. (2007) model of 401(k) enrollment. For this reason, we adapt this model to our problem and analyze the subjects' decision to cash their check. The novel aspect of our problem is that the check-cashing equilibrium policy 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.

A Cashing the check

Solving the model by backward induction, we first analyze the decision to cash the check. As in Carroll et al. (2007), 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.

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. Not only is this cost very realistic (6.25% of the checks were never cashed), but it also captures, in a continuous fashion, the fact that checks become invalid after six months.

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 some variability in the cost of cashing the check. The day a subject 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.

By assuming that c_t is known at time t the model also captures the possibility that an individual wants to receive the check today because she is afraid to forget about it in the future (this would correspond to a very low c_0).

After receiving the check, in each period t a subject has to decide whether to cash the check that period or to delay the decision to the next period. In other words, after receiving the check for an amount $S > 0$, a subject minimizes the following current discounted loss function V:

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

where L is the individual's expected future costs if she does not cash the check and p the probability of losing it.

As we show in Appendix B, the solution to this problem takes the form of 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 $c^* < \bar{c}$ we can calculate the expected number of future periods that an individual takes to cash the check τ, considering that only checks that are not lost are cashed

$$\tau = \frac{(1-p)(\bar{c} - c^*)c^*}{(c^* + p(\bar{c} - c^*))^2}, \tag{3}$$

and the expected value to the individual of receiving a check for an amount S (including the expected cost of cashing it), which we denote as $\sigma(S)$[4]

$$\sigma(S) = \frac{c^*}{c^* + p(\bar{c} - c^*)}\left(S - \frac{c^*}{2}\right). \tag{4}$$

The following proposition follows:

Proposition 1 *If the check is not negligibly small, 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. (2007). When choosing between cashing today and cashing tomorrow, an impatient individual will discount

[4]For $c^* \geq \bar{c}$, the check is always cashed in the first period, and therefore, $\tau = 0$ and $\sigma(S) = S - \frac{\bar{c}}{2}$

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 a subject to cash the check earlier.

The reason why the result is not true for all values of S, but only for non-trivial values is that for very small values of S very impatient individuals will postpone the cashing for so long that most of them will lose the check. Therefore, their expected cashing time conditional on cashing might be smaller than the expected cashing time conditional on cashing for more patient individuals.

In Appendix B, we argue that the condition for Proposition 1 is satisfied in our sample, otherwise at least 51% of the people would have lost the check, while the actual amount is at most 6.25%.

B Getting the check

Having derived the optimal check-cashing behavior, we now analyze how subjects choose the timing of the reward as a function of their present bias. At the end of the experiment, subjects 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. We start by analyzing the choice of a sophisticated individual—that is, an individual who is aware that she will postpone the cashing decision in the future.

B.1 Sophisticated subjects

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

$$\beta < \frac{S - c_0}{\sigma(S + rS)} \text{ or } \beta < \frac{(1-p)\sigma(S)}{\sigma(S + rS)}. \tag{5}$$

Conditions (5) illustrate that there are two reasons to prefer a check today. The first one is that today's realization of the cost c_0 is so low that a subject 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 subject 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 subjects with a present bias, but it is common to rational exponential discounters. So we have

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

This result is not unique to our setting, but it applies to all the situations in which subjects have to incur a cost to receive the reward (e.g., as in the gift certificate experiment in McClure et al., 2004). The time series variability in this cost may generate the appearance of impatience, even among patient individuals.

The second reason a subject might choose to receive her check right away is that she has a very high bias toward the present (i.e., a very low β). Indeed, combining (5) with (2), and (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 a player), 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 will switch is a function of her β. The intuition is straightforward. A higher β makes the delayed delivery more valuable as does a higher interest rate r.

In contrast, the relationship between the delivery timing and the amount of the check is not so straightforward. In fact, we have

Corollary 2 *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. 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.

B.2 Naïve subjects

All the above results are derived under the assumption that subjects are aware of their degree of present bias (i.e., they were 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 $\beta = 1$.

We denote $\sigma_e(S, \beta_e)$ as the expected value of the check given a belief β_e a subject has about her own future level of impatience. Consequently, we have that a naïve individual will choose immediate delivery over a delayed delivery if and only if

$$\beta < \frac{S - c_0}{\sigma_e(S + rS, 1)} \text{ or } \beta < \frac{(1-p)\sigma_e(S, 1)}{\sigma_e(S + rS, 1)}. \tag{6}$$

Comparing (6) with (5) leads to the following proposition.

Proposition 3 *Generally 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 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 a higher degree of impatience 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 c 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 reward that requires subjects to incur a cost (like gift certificates or checks).

III 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 II tests this hypothesis with the data from our experiment. Since each value of the impatience 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 parentheses (White, 1980).

< Table II around here >

In column A, we regress each student's subjective two-week discount rate on a measure of procrastination. As proxy for procrastination, in this specification we use the number of weeks it took a subject to cash her check—excluding the 27 students who never cashed it (and consented to the study). 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 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 and achieve higher grades. Consistent with Frederik (2005), we find that students with higher cognitive ability have lower discount rates.[5]

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 subjects have lower discount rates. This result is not specific to the WVS measure of trust. When we use the measure of trust towards the University of Chicago, we find similar results (not reported). 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

[5] Frederik (2005) suggests an alternative interpretation of this correlation between patience and cognitive abilities: CRT problems generate an incorrect "intuitive" answer. Impatient individuals are more likely to respond impulsively and make mistakes. We tested for this effect by isolating the answer to the one question without any intuitive wrong answer (the one with two cars crashing). The result is the same.

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 almost doubles, but it is still economically small and statistically insignificant.

A Alternative measures of procrastination

Table II 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, subjects are likely to differ on both these dimensions. If we introduce this heterogeneity, with people differing in the cost of cashing the check and/or in their absent-mindedness (i.e., in the probability of losing the check), the theoretical model exhibits a negative correlation between the discount rate and the time to cash the check. In other words, unobserved heterogeneity can induce an attenuation bias in our estimated correlation between impatience and procrastination.

To address this issue, we use some measures of procrastination that do not suffer from these problems. As we will explain, 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 subjects participated in the online game. 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.

$<$ Table III around here $>$

In column A of Table III, we report the interval regression of two-week subjective discount rates on the week in which subjects participated in the online game, plus the other control variables used in Table II, columns B and C. Subjects 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 II, restricting it to the sample of students who participated in the online game. The estimates are similar to those in Table II, 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. In this case, we have information for a larger number of students. The disadvantage with this variable is that we have a lot less control. 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 second and the third (and final) deadline. For this reason, we inserted two dummy variables, one for students who adhered to the second deadline and another 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, but still not statistically significant: these students exhibit a discount rate that is 0.85 percentage points higher (about 16% higher) than the other students.

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 regression is exactly what we do in column D. We re-estimate the basic specification of Table II, using these two instruments.[6] 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 delay in cashing 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, hy-

[6]For the regression with endogenous regressors we use Tobit estimates. Note that, running the regressions in Tables II and III with Tobit estimates gives almost identical results.

pothesized in O'Donoghue and Rabin (1999a,b, 2001).

B 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 subjects 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.

Our context enables us to 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 subjects performing different tasks makes it easier to develop a proxy for sophistication. In particular, we use the difference in response behavior between the survey subjects answered at the beginning of their MBA program and the online game they played eighteen months later. The survey was a requirement for a course and, therefore, there was no penalty to wait until the last minute to complete it. By contrast, we designed the online game so that there is a cost to procrastination. Every week of delay, the value of participating dropped by roughly one-fourth.

A sophisticated individual with present-biased preferences will delay responding to the survey until the last minute. At the same time, she is more likely to anticipate her participation in the online game. To capture this behavior, we created a dummy variable equal to one for all subjects 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 subjects who completed the survey in the last two days.

< Table IV around here >

Table IV reports the result of inserting these measures of sophistication in the IV specification of column D of Table III. 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%.

IV 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 psychologists classify 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, however, had not been tested using actual behavior. In this paper, we design a combination of laboratory and field experiments to address this gap in the literature. We find strong 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 has not been tested. 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, we show that two thirds of the University of Chicago MBAs, perhaps one of the most economically-minded and profit-motivated populations, exhibit present-bias preferences and at the same time delay for weeks the cashing of their checks—even when the money at stake is relatively large (up to $260).

Together, these results suggest that impatience and procrastination are pervasive phenomena, and that O'Donoghue and Rabin (1999a) and Carroll et al. (2007) provide a very useful analytical framework to capture them.

A Instructions and Experimental Procedures

A Experimental procedures

The experiment was run during Tuesday, October 3$^{\text{rd}}$ and Thursday, October 5$^{\text{th}}$, 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 subject. 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 subjects 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.

B 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

C 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*

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

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

$$c^* = \beta[pS + (1-p)L(c^*)]. \tag{7}$$

Since the probability that an individual cashes the check in a given period is $\frac{c^*}{\bar{c}}$, and if she does, she pays an average cost of $\frac{c^*}{2}$, we can write $L(c^*)$ as[7]

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

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

Note that β does not appear in L as the individual is evaluating trade-offs between future periods only. Substituting (8) into (7) and solving for c^* gives (2).[8] ■

Proposition 1 *If the check is not negligibly small, 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, if this condition is met, the partial derivatives of $c^*(.)$ with respect to S and β equal

$$\frac{\partial c^*}{\partial S} = \frac{p\beta\bar{c}}{\sqrt{(p\bar{c})^2 + 2(1-p)p(2-\beta)\beta S\bar{c}}} \tag{10}$$

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

which are both positive for $0 < p < 1$, and $0 < \beta \leq 1$. The partial derivative of τ with respect to c^* is

$$\frac{\partial \tau}{\partial c^*} = \frac{(1-p)\left((\bar{c}-2c^*)(c^* + p(\bar{c}-c^*)) - 2(1-p)(\bar{c}-c^*)c^*\right)}{(c^* + p(\bar{c}-c^*))^3} \tag{12}$$

which is positive if $c^* < \frac{p}{1+p}\bar{c}$. Using (2) and given that $\partial c^*/\partial\beta > 0$ and $\partial c^*/\partial S > 0$, it follows that:

$$\text{if } S > \frac{4p - p(1-p)\beta}{2(1+p)^2\beta}\bar{c} \text{ then } \frac{\partial \tau}{\partial \beta} < 0 \text{ and } \frac{\partial \tau}{\partial S} < 0. \tag{13}$$

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

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

Note that, for reasonable parameter values, (13) is easily satisfied even by a small S relative to $\bar{c}$. For example if $\beta \geq 0.5$ and $p \leq 0.2$ then (13) holds if $S > \frac{1}{2}\bar{c}$. However, the clearest evidence that this inequality is satisfied in our sample is that if it is not, it implies that a large percentage of subjects never cash the check. To see this, note that the probability that a subject never cashes the check, $P(c^*)$, is given by

$$P(c^*) = \frac{1 - \left(2 - p\right)\left(1 - \frac{c^*}{\bar{c}}\right)}{1 - \left(1 - p\right)\left(1 - \frac{c^*}{\bar{c}}\right)} \frac{c^*}{\bar{c}}. \tag{14}$$

Given that $P(c^*)$ is decreasing in c^* if (13) is not satisfied, it is easy to verify that the minimum value of $P(c^*)$ in this range is $P\left(\frac{p}{1+p}\bar{c}\right) \approx 51\%$. This is much higher than the actual 7% who did not cash the check ■

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

Proof. An individual with $\beta = 1$ will chose the check today if $c_0 < S - \sigma(S + rS)$.[9] Thus, there is a positive probability that the individual will take the check today as long as the righthand side of this inequality is positive. This is the true for all r that satisfy

$$r < \frac{c^*}{2S} + \frac{p\bar{c}}{c^*} - p \tag{15}$$

It is not hard to find parameter values for which (15) 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 2 *The lower the interest rate offered, r, and the lower β is (i.e, the more impatient a player), 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

$$\Pi = \begin{cases} 0 & \text{if } \beta > \bar{\beta} \\ \dfrac{S - \beta\sigma(S + rS)}{\bar{c}} & \text{if } \underline{\beta} < \beta < \bar{\beta} \\ 1 & \text{if } \beta < \underline{\beta} \end{cases} \tag{16}$$

[9] When $\beta = 1$, the second inequality in (5) is never satisfied.

$$\text{where } \underline{\beta} = \max\left(\frac{(1-p)\sigma(S)}{\sigma(S+rS)}, \frac{S-\bar{c}}{\sigma(S+rS)}\right) \text{ and } \bar{\beta} = \frac{S}{\sigma(S+rS)}$$

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 $\sigma(S)$ with respect to c^* is given by

$$\frac{\partial \sigma(S)}{\partial c^*} = \frac{p\bar{c}(S-c^*) - \frac{1}{2}(1-p)c^{*2}}{(c^* + p(\bar{c}-c^*))^2} \tag{17}$$

Using (2) and solving for c^* indicates that (17) is positive if

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

which holds as long as $\beta \leq 1$. Combining this with the positive sign of (10) and (11) ensures that $\partial\Pi/\partial r < 0$ and $\partial\Pi/\partial\beta < 0$.

Note that, since (10) and (17) are positive, it must be the case that $(\bar{\beta} - \beta)$ and $(\underline{\beta} - \beta)$ are decreasing in r. In other words, a high r or β makes it more likely that the individual never takes the check today and less likely that she always takes the check today.

Finally we show that if β is close to $\bar{\beta}$ then $(\bar{\beta} - \beta)$ is decreasing in β, and if β is close to $\underline{\beta}$ then the same is true for $(\underline{\beta} - \beta)$. In the case of $(\bar{\beta} - \beta)$ and $(\underline{\beta} - \beta)$ when $S - \bar{c} > (1-p)\sigma(S)$, this follows immediately from the fact that (11) and (17) are both positive. For $(\underline{\beta} - \beta)$ when $S - \bar{c} < (1-p)\sigma(S)$, this is true as long as $\partial\underline{\beta}/\partial\beta < 1$. Unfortunately we are unable to solve this inequality for a manageable analytical solution. Therefore, to show that this holds in the experiment we calculated $\partial\underline{\beta}/\partial\beta$ for the following parameter values: $p \in [0.005, 0.995]$, $S \in [1, 300]$, $\bar{c} \in [1, 300]$, and $r \in [0, 0.15]$, when $\beta = \underline{\beta}$.[10] We find a maximum value for $\partial\underline{\beta}/\partial\beta$ of 0.0235 which is less than 1. In other words, if β is close to any of the two threshold values, a high β lowers the $\bar{\beta}$ threshold making it more likely that the individual never takes the check today and increases the $\underline{\beta}$ threshold making less likely that she always takes the check today ■

Corollary 2 *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 (16) 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

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

[10] Calculations where done in steps of 0.005 for p and r, and steps of 1 for S and $\bar{c}$. They are available upon request.

Thus, if $\beta(\partial\sigma(S+rS)/\partial S) < 1$ the relationship between Π and S is positive, otherwise it is negative. Writing $c^*(\beta, p, S+rS, \bar{c})$ as c^*, the partial derivative of $\sigma(S+rS)$ with respect to S is

$$\frac{\partial\sigma(S+rS)}{\partial S} = \frac{1+r-\frac{1}{2}c_S^*}{c^*+p(\bar{c}-c^*)}c^* + \frac{(1+r)S-\frac{1}{2}c^*}{(c^*+p(\bar{c}-c^*))^2}p\bar{c}c_S^* \tag{19}$$

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

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

$$\begin{aligned}\frac{\partial^2\sigma(S+rS)}{\partial S\partial r} = {} & \frac{2S(1-p)(c^*-Sc_S^*)+\left(2-\frac{1}{1+r}c_S^*\right)pS\bar{c}}{(c^*+p(\bar{c}-c^*))^3}p\bar{c}c_S^* + \frac{(1+r)S-\frac{1}{2}c^*}{(c^*+p(\bar{c}-c^*))^2}p\bar{c}c_{Sr}^* + \\ & \frac{1-\frac{1}{2}c_{Sr}^*}{c^*+p(\bar{c}-c^*)}c^*\end{aligned} \tag{20}$$

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

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 $\beta(\partial\sigma(S+rS)/\partial S) < 1$. 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 $\partial\Pi/\partial S \geq 0$.[11] The precise value of r^* is given by the r that solves $\partial\Pi/\partial S = 0$. Although we did not find a meaningful 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 $\underline{\beta} = 0.937$, $\bar{\beta} = 1.061$, and $r^* = 0.033$. Similarly, if $S = \$135$, $\bar{c} = \$35$, $p = 0.1$, and $\beta = 0.9$, then $\underline{\beta} = 0.787$, $\bar{\beta} = 1.002$, and $r^* = 0.127$ ■

Proposition 3 *Generally 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.*

Proof. Lets define $\underline{\beta}_e(\sigma_e(S, \beta_e))$ as the threshold value of β below which an individual with belief β_e strictly prefers to cash the check today:

$$\underline{\beta}_e(\sigma_e(S,\beta_e)) = \max\left(\frac{(1-p)\sigma_e(S,\beta_e)}{\sigma_e(S+rS,\beta_e)}, \frac{S-\bar{c}}{\sigma_e(S+rS,\beta_e)}\right). \tag{21}$$

[11] 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.

Furthermore, note that since (17) and (11) are both positive for $0 < p < 1$ and $0 < \beta \leq 1$, it follows that $\partial\sigma/\partial\beta > 0$.

If $S - \bar{c} > (1-p)\sigma_e(S, 1)$, it is clear that an individual for whom $\beta < 1$ has a lower probability of choosing the check today if she is naïve since

$$\frac{S - \beta\sigma_e(S + rS, \beta)}{\bar{c}} > \frac{S - \beta\sigma_e(S + rS, 1)}{\bar{c}}. \tag{22}$$

If $(S - \bar{c}) < (1-p)\sigma_e(S, 1)$ then the same can be said as long as $\beta > \underline{\beta}_e\left(\sigma_e(S, 1)\right)$. In this case, either $\beta > \underline{\beta}_e\left(\sigma_e(S, \beta)\right)$ and (22) holds, or $\underline{\beta}_e\left(\sigma_e(S, \beta)\right) > \beta$ and the probability of cashing the check today for a sophisticated individual equals 1 and for a naïve individual it is strictly less than 1.

If $(S - \bar{c}) < (1-p)\sigma_e(S, 1)$, $\beta < \underline{\beta}_e\left(\sigma_e(S, 1)\right)$, and $\beta < \underline{\beta}_e\left(\sigma_e(S, \beta)\right)$ then the individual cashes the check today with probability 1 irrespective of whether she is sophisticated or naïve.

Finally, if $(S - \bar{c}) < (1-p)\sigma_e(S, 1)$, $\beta < \underline{\beta}_e\left(\sigma_e(S, 1)\right)$, and $\beta > \underline{\beta}_e\left(\sigma_e(S, \beta)\right)$ then the individual cashes the check today with probability 1 if she is naïve and with probability less than 1 if she is sophisticated. Thus, this 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 calculated for various values of S, $\bar{c}$, p, and r, the range of βs for which this scenario's conditions hold. We used the following parameter values: $p \in [0.005, 0.995]$, $S \in [1, 300]$, $\bar{c} \in [1, 300]$, and $r \in [0, 0.15]$.[10] We find that the largest range occurs for $p = 0.585$, $K = 201$, $S = 240$, and $r = 0.15$, where this scenario occurs for $\beta \in [0.327, 0.332]$. If we further restrict the search to cases where $\beta \geq 0.5$, we find the largest range is $\beta \in [0.500, 0.504]$ for $p = 0.375$, $K = 125$, $S = 84$, and $r = 0.15$.

Given the very small range of values for which a sophisticate individual has a higher probability of choosing the check today compared to a naïve individual with the same characteristics, we conclude that generally, naïve individuals are less likely to accept the check right away.

It is easy to see that the other comparative statics hold for naïve individuals. Proposition 1 holds as check cashing is independent of the level of naïvité. Proposition 2 holds in an even more straightforward manner as $\sigma_e(S, 1)$ and $\sigma_e(S + rS, 1)$ 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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Table I: Summary statistics

This table reports the summary statistics for all variables used in the paper. The two-week discount rate is inferred from the subjects' choice between $\$x$ today and $\$x(1+r)$ in two weeks ($r \in [0, 0.12]$). The variable used is the r at which a subject switches from money today to money in two weeks. The two-week discount rate ≤ 1 is a dummy equal to one if a subject behaves as an exponential discounter: i.e. switches at $r = 0$ or $r = 1$. Weeks to cash check equals the number of weeks a subject took to cash the check. Days before application deadline equals the number of days between the last deadline to apply to the MBA program and the day the subject applied. Application deadline equals the deadline to apply to the MBA program to which the subject adhered to. Days before online game deadline equals the number of days between the last deadline to participate in the online game and the day the subject participated. Week of online game participation indicates the week the subject completed the online game. Days before survey deadline equals the number of days between the deadline to complete the survey and the day the subject completed it. Money at stake equals the amount $\$x$ used to measure the subjects' discount rate. Female is a dummy equal to one if the subject is female. CRT score is the number of correct answers to 4 questions that measure cognitive reasoning skills. Trust is a dummy equal to one if a subject answers "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?" Trust in University of Chicago is the answer to the question "Suppose that a new and very desirable dorm/apartment has become available. The University of Chicago organizes a lottery to assign it among the many applicants. How confident are you that the allocation will be fair?" answers range from 1-"Not at all" to 4-"A great deal".

	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
Trust in University of Chicago	3.37	3.00	0.68	1.00	4.00	416

Table II: Impatience and procrastination

The dependent variable is the subjects' two-week discount rate, which is inferred from their choice between $\$x$ today and $\$x(1+r)$ in two weeks ($r \in [0, 0.12]$). The variable used is the r at which a subject switches from money today to money in two weeks. Weeks to cash check equals the number of weeks a subject took to cash the check. Money at stake equals the logarithm of the amount $\$x$ used to calculate a subject's discount rate. Female is a dummy equal to one if the subject is female. CRT score is the number of correct answers to 4 questions that measure cognitive reasoning skills. Trust is a dummy equal to one if a subject answers "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?" The table presents interval regressions 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.

Two-week discount rate as the dependent variable			
	A	**B**	**C**
Weeks to cash the check	0.014	0.034	0.052
	(0.078)	(0.077)	(0.049)
Money at stake	-2.434***	-2.404***	-2.484***
	(0.493)	(0.488)	(0.459)
Female		-1.368*	-1.531**
		(0.760)	(0.756)
CRT Score		-0.954***	-0.960***
		(0.261)	(0.263)
Trust		-1.520**	-1.385**
		(0.720)	(0.705)
Constant	13.298***	16.713***	16.960***
	(2.190)	(2.393)	(2.282)
χ^2	24.466***	40.190***	47.595***
Log likelihood	-854.627	-846.777	-903.091
Obs.	405	405	432

Table III: Impatience and alternative measures of procrastination

The dependent variable is the subjects' two-week discount rate, which is inferred from their choice between $\$x$ today and $\$x(1+r)$ in two weeks ($r \in [0, 0.12]$). The variable used is the r at which a subject switches from money today to money in two weeks. Week of online game participation indicates the week the subject completed the online game. Weeks to cash check equals the number of weeks a subject took to cash the check. Application on 2^{nd} (3^{rd}) deadline is a dummy variable indicating the deadline the subject adhered to when applying to the MBA program. Money at stake equals the logarithm of the money $\$x$ used to calculate a subject's discount rate. Female is a dummy equal to one if the subject is female. CRT score is the number of correct answers to 4 questions that measure cognitive reasoning skills. Trust is a dummy equal to one if a subject answers "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?" 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.

Two-week discount rate as the dependent variable				
	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 2^{nd} deadline			0.031	
			(0.766)	
Application on 3^{rd} 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)
χ^2	37.153***	31.489***	44.504***	12.537**
Log likelihood	-599.615	-601.994	-903.422	-1364.626
Obs.	284	284	432	269

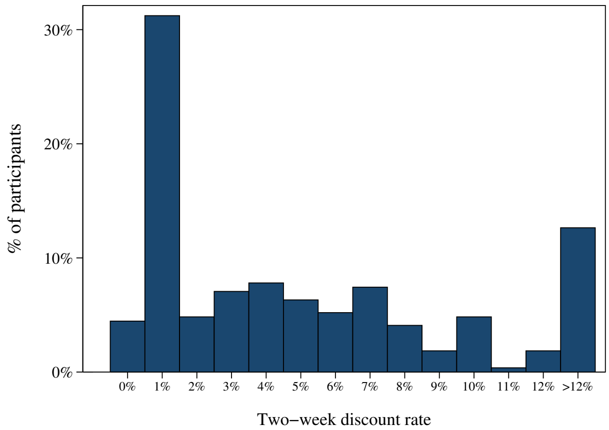
Table IV: Impatience and sophistication

The dependent variable is the subjects' two-week discount rate, which is inferred from their choice between $\$x$ today and $\$x(1+r)$ in two weeks ($r \in [0, 0.12]$). The variable used is the level of r at which a subject switches from money today to money in two weeks. Weeks to cash check equals the number of weeks a subject took to cash the check. Sophisticate I or II are dummy variables equal to one if the subject participated in the online game in the first week and answered the survey in the last day (I) or last two days (II). Money at stake equals the logarithm of the amount $\$x$ used to measure the subjects' discount rate. Female is a dummy equal to one if the subject is female. CRT score is the number of correct answers to 4 questions that measure cognitive reasoning skills. Trust is a dummy equal to one if a subject answers "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?" 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.

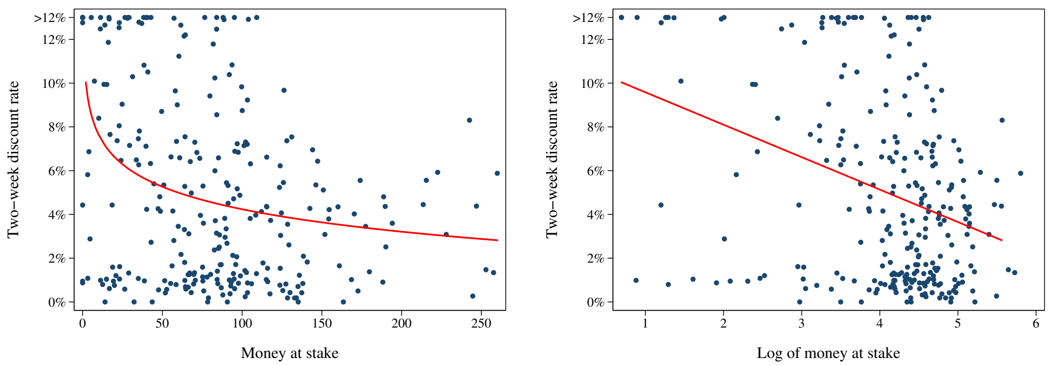
Two-week discount rate as the dependent variable		
	A	**B**
Weeks to cash the check	2.165*	2.197*
	(1.152)	(1.194)
Sophistication I	7.237**	
	(3.377)	
Sophistication II		3.616
		(2.594)
Money at stake	-1.005	-0.992
	(1.211)	(1.253)
Female	-1.038	-0.931
	(1.742)	(1.769)
CRT Score	-0.453	-0.427
	(0.630)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

Figure I: Discount rates

Distribution of the the subjects' two-week discount rate, which is inferred from their choice between \$$x$ today and \$$x(1+r)$ in two weeks ($r \in [0, 0.12]$). The variable used is the r at which a subject switches from money today to money in two weeks. Money at stake equals the amount \$$x$ used to calculate a subject's discount rate. The red line indicates the best-fitting polynomial regression of degree 1.



(A) Histogram of two-week discount rates

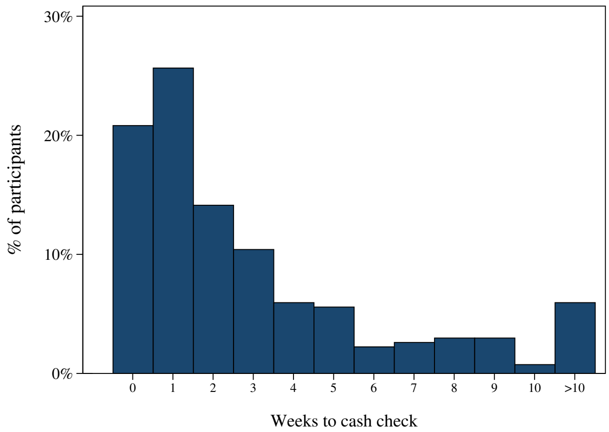


(B) Two-week discount rate and money at stake

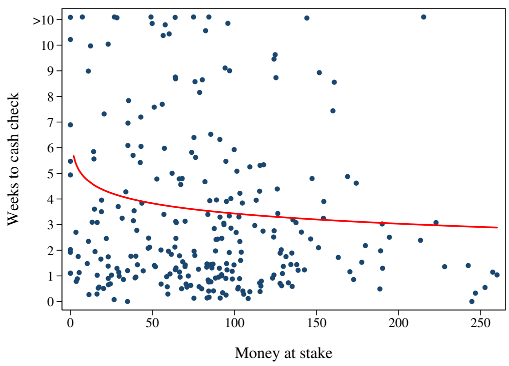
(C) Two-week discount rate and log of money at stake

Figure II: Check cashing

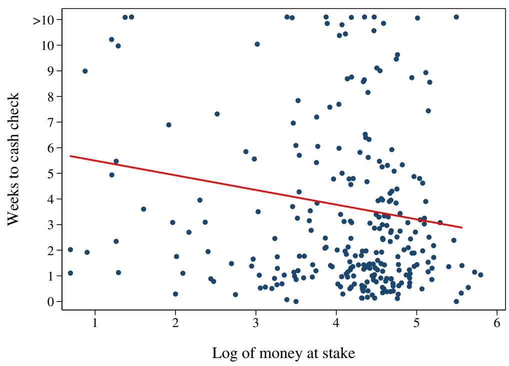
Distribution of the weeks taken to cash the check. We use the censored version of this variable in which subjects who did not cash the check are given a value equal to the highest number of weeks. Money at stake equals the amount $\$x$ used to calculate a subject's discount rate. The red line indicates the best-fitting polynomial regression of degree 1.



(A) Weeks to cash the check



(B) Weeks to cash the check and money at stake



(C) Weeks to cash the check and log of money at stake

Figure III: Online game participation

Distribution of the day in which subjects 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.

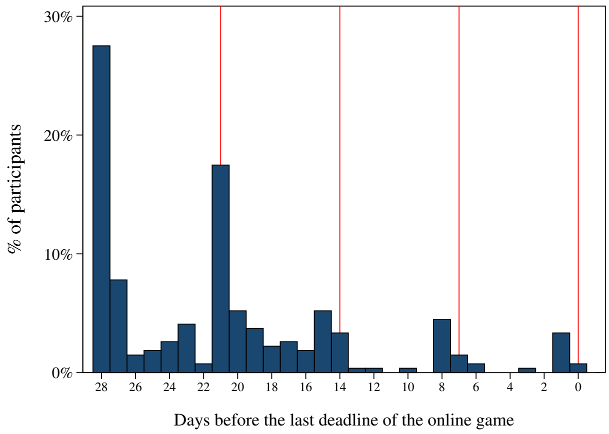


Figure IV: Applications to the MBA program

Distribution of the days in which subjects 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.