Procrastination in Preparing for Retirement

Ted O'Donoghue
Department of Economics
Cornell University

and

Matthew Rabin
Department of Economics
University of California, Berkeley

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Abstract

Investing for retirement is one of the most important tasks of a person's life, and yet many people do a very poor job. This paper argues that a plausibly important source of poor performance is procrastination. We present a simple model and calibration exercises showing how a person who naively procrastinates due to a time-inconsistent taste for immediate gratification may put off investigating, or implementing, superior investment strategies. Even when the person knows that the benefits of finding a superior investment enormously outweigh the short-term effort costs, she may significantly procrastinate because she repeatedly plans to put in the effort soon. We conclude by discussing some policies that might be used to influence the savings behavior of procrastinators, with an emphasis on policies aimed at default options and short-term incentives that do not significantly alter long-term incentives.

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Mail: Ted O'Donoghue / Department of Economics / Cornell University / 414 Uris Hall / Ithaca, NY 14853-7601. Matthew Rabin / Department of Economics / 549 Evans Hall #3880 / University of California, Berkeley / Berkeley, CA 94720-3880. E-mail: edo1@cornell.edu and rabin@econ.berkeley.edu. CB handles: "Puck Boy" and "Game Boy". Rabin's web page (with related papers by O'Donoghue and Rabin): http://emlab.berkeley.edu/users/rabin/index.html.

1. Introduction

There has long been an interest in undersaving due to self-control problems (since Strotz (1955)), which has been given recent re-birth by Laibson (1994, 1995, 1997). This literature examines how a taste for immediate gratification can lead a person to sacrifice too much future consumption for the sake of current consumption, causing the person to end up with too little retirement savings. In this paper, we explore a second avenue through which self-control problems can lead to too little retirement saving: Instead of asking *how much* a person saves, we examine *how wisely* a person invests her savings. In particular, we illustrate how self-control problems combined with a lack of awareness of these self-control problems can lead a person to procrastinate in finding and implementing profitable investment strategies, even when she recognizes it as enormously important that she should do so.[1]

O'Donoghue and Rabin (forthcoming *a*) illustrate how even mild self-control problems can cause severe procrastination, and O'Donoghue and Rabin (1998) show in an abstract model how procrastination is likely to be especially severe in a class of situations similar to personal investment decisions. In this paper, we provide a series of calibration exercises attempting to show that for plausible degrees of self-control problems, people can severely hurt themselves by procrastinating on personal investment decisions.

Investing for retirement is among the most important tasks people undertake – or *should* undertake – in their lives, and so positing procrastination as a major source of suboptimal retirement planning may strike the reader as very odd. Given its immense importance, will people *really* harmfully procrastinate in preparing for retirement? Personal and anecdotal evidence certainly suggests severe problems along the lines of the examples we develop below. For instance, one of the authors has kept an average of over $20,000 in his checking account over the last 10 years, despite earning an average of less than 1% interest on this account and having easy access to very liquid alternative investments earning much more. While he (Rabin) may be an unusually bad procrastinator, non-trivial procrastination seems prevalent. When explaining our research to colleagues, we've been told numerous anecdotes of people leaving pots of money in low-interest accounts – pots of money that they realize they should re-invest, and had always *meant* to get around to re-investing. These anecdotes come from what is surely an unusually non-procrastinatory and financially savvy subset

[1] While we believe that people procrastinate in preparing for other aspects of retirement as well, we shall throughout this paper maintain this narrow focus on delay in investing wisely.

of people – successful academic economists.

Systematic evidence from a variety of researchers shows that people spend relatively little time thinking productively about their retirement. Benartzi and Thaler (forthcoming) find that recently hired (non-faculty) employees at the University of Southern California seem to spend very little time thinking about their retirement investments. In hypothetical investment decisions, Gneezy and Potters (1997) and Thaler, Tversky, Kahneman, and Schwarz (1997) induce people to behave more sensibly by making explicit the mathematical implications of their decisions. These results indicate a lack of attentiveness to retirement investments, since otherwise virtually all people over the age of thirty *should* already be familiar with the mathematical implications of investment decisions. Loewenstein, Prelec, and Weber (1998) find that significant numbers of retirees regret their lack of attentiveness to retirement planning. Laibson, Repetto, and Tobacman (1998) review substantial evidence suggestive of underattentiveness to retirement planning, and Lusardi (1998) also finds evidence highly suggestive of lack of thought.

Of course, research that identifies seemingly major sub-optimalities in investment behavior (e.g., Benartzi and Thaler (1995)) indicates even more directly that significant numbers of people invest unwisely. While we are skeptical that all or even most of the problem with poor investments is caused by procrastination as we have conceptualized it, the fact that people do not bother to adequately deal with this immensely important decision invites serious investigation of plausible alternatives to the rational-choice model. Indeed, our final reason for investigating the procrastination hypothesis is that procrastination follows as a natural consequence of "present-biased preferences" (e.g., hyperbolic discounting), in which people discount delays in gratification more severely in the short term than in the long term. Because such time inconsistency is among the most robust and extensively documented facts about human nature (confirmed by hundreds of experiments and millennia of folk wisdom), and because in this domain and elsewhere its predictions often seem more realistic than the predictions of the rational-choice model, it is sensible and natural to investigate its implications.

In Section 2 we introduce a simple model of present-biased preferences: Relative to time-consistent preferences, a person always gives extra weight to well-being *now* over well-being at any future moment.[2] These preferences imply that in any period a person may pursue immediate gratification more than she would have preferred if asked in any prior period. That is, the person has a self-control problem. We also discuss in Section 2 an important issue for people with self-control problems: Are they *sophisticated*, and foresee that they will have self-control problems in the future, or are they *naive*, and not foresee these self-control problems? O'Donoghue and Rabin (forthcoming *a*, 1998) show that mild self-control problems cannot cause severe procrastination if a person is fully sophisticated, and in this paper we investigate the implications of the (more realistic) assumption that people are not fully sophisticated. While most of our calibrations in this paper assume that a person is fully naive, we demonstrate in Section 3 that our procrastination examples really only rely on a person being a little naive.[3]

In Section 3 we present our first set of calibration exercises. We suppose a person has her retirement savings in Account A, but she knows it would be more beneficial to have the money in Account B. Does the person switch accounts? The person *should* transfer her money if the resultant increase in her retirement savings is large enough to offset the immediate cost of making the transfer. For example, suppose a person has a $10,000 principal which she is saving for retirement 30 years from now, and suppose further that this principal is currently in a 0%-interest account but the person has the opportunity to transfer the principal to a 5%-interest account. Making this transfer immediately will increase the person's retirement savings by nearly $35,000 (relative to never making the transfer). Hence, the person should transfer her money if the additional $35,000 in retirement savings 30 years from now is worth the immediate effort required to make the transfer.

For any reasonable discounting and transfer costs, a fully rational person would make this transfer immediately. But since the retirement benefits are delayed and the transfer costs are immediate, a person with self-control problems may want to incur the transfer costs in the future rather than today. Even so, if the person is fully sophisticated, and therefore correctly predicts her own future behavior, she will not tolerate a significant delay unless her taste for immediate gratification is enormous.

If the person is naive about her self-control problem, however, she perceives a very different

[2] The formal model of discounting we employ was originally proposed by Phelps and Pollak (1968) to model intergenerational altruism, and later adopted by Laibson (1994) to study self-control problems. It has since been used by Laibson (1995, 1997), Laibson, Repetto, and Tobacman (1998), O'Donoghue and Rabin (forthcoming *a*, forthcoming *b*, 1997*a*, 1997*b*, 1998), Fischer (1997), and others.

[3] O'Donoghue and Rabin (1998) show more generally that any degree of naivete can be sufficient to cause severe and costly procrastination. To our knowledge, these two papers are the only ones that provide a formal analysis of partial naivete.

problem. On any given day, she *thinks* she will make the transfer tomorrow if she does not do so today. Since the lost retirement savings from a one-day delay are minimal, even a small taste for immediate gratification can spark a desire to put off exerting the unpleasant effort required to transfer the funds until tomorrow. As a result, a naive person may procrastinate forever, because each day she decides to transfer the money tomorrow.[4] Our calibrations in Section 3 show that for plausible investment decisions a person ought to transfer the funds unless the transfer cost is enormous, and yet a naive person might never make the transfer even when the transfer cost is very small. For the previous example of switching $10,000 from a 0% account to a 5% account, for instance, a naive person might never make the transfer even when the immediate effort cost of doing so is as little as $7.

In Section 4, we introduce the idea that a person can find better investments by putting in more effort, and therefore must choose how much effort to exert towards finding a good investment. In an abstract model, O'Donoghue and Rabin (1998) show that for such situations the relevant effort level that determines whether the person procrastinates is the effort level that the person *should* exert. Our calibrations in Section 4 illustrate two implications of this point. First, even when there is a good investment which requires no effort (and therefore would not on its own spark the urge to procrastinate), the person may still procrastinate if she ought to exert some effort towards finding a better investment. For example, even if it is *costless* to transfer a $10,000 principal from a 0% account to a 5% account, the person may severely procrastinate if the optimal thing to do is to exert some effort towards finding a 6% account.[5] Because the person believes she is merely deciding when to transfer her funds to the 6% account, she views other alternatives as irrelevant.

The second implication is that as a person's retirement planning becomes more important, and therefore the person ought to exert even more effort towards finding a good investment, the person can in fact become more likely to procrastinate. For example, it could be that with a $10,000 principal a person would immediately exert the effort required to find a 6% account (and transfer the money), but with a $20,000 principal the person would severely procrastinate. The intuition here is that with a $20,000 principal the person plans to find something better than the 6% account

[4] For previous papers exploring this theme, see Akerlof (1991) and O'Donoghue and Rabin (forthcoming *a*, forthcoming *b*, 1997*a*, 1998). For other papers discussing procrastination as related to present-biased preferences, see Prelec (1989), who discusses delay of unpleasant tasks in a one-shot context (where naivete is irrelevant), and Fischer (1997), who develops a formal model of procrastination on big projects assuming complete sophistication.

[5] Of course, this conclusion requires that there be some cost associated with transferring funds first to the 5% account and later to the 6% account.

(e.g., a $6\frac{1}{2}$% account), and since finding this better investment requires more effort, the person has an increased desire to incur this effort tomorrow rather than today. Similarly, for any fixed principal, the more a person values her retirement consumption, the more effort she ought to exert towards finding a good investment, and as a result she may become more likely to procrastinate. This second implication reflects a theme laid out in more detail in O'Donoghue and Rabin (1998): In contrast to many other types of suboptimal behavior, procrastination may often be *worse* for important decisions than for unimportant ones. Hence, returning to the question of whether people are really likely to procrastinate on this most important of life decisions, our somewhat provocative answer is that people may procrastinate on investing for retirement exactly *because* it is one of the most important life decisions.

We conclude in Section 5 by stepping outside our specific model and calibration exercises to discuss the more general relationship between procrastination and retirement planning, and to speculate on policy prescriptions following from our analysis. As our analysis describes a type of major error that people may make in preparing for retirement, and our policy prescriptions provide ways to help people overcome this error, our policy prescriptions will be inherently paternalistic. However, our discussion will focus on policy prescriptions that satisfy a notion of "cautious paternalism": They can be extremely valuable if people are making errors, but they have relatively small costs if people are fully rational. This approach allows us to take seriously the idea that people might make errors, without dismissing the idea that for many decisions people might behave as is fully rational. Our policy prescriptions revolve around two principles that arise from our analysis: (1) People tend not to transfer their savings out of their default investment plans, and (2) people are highly sensitive to short-term incentives. The specific policies we shall discuss include the manipulation of default options, the use of tax incentives for saving (e.g., 401k plans or IRAs), the provision of work-place seminars on retirement planning, and the use of deadlines.

2. Present-Biased Preferences and Procrastination

The standard economics model assumes that intertemporal preferences are *time-consistent*: A person's relative preference for well-being at an earlier date over a later date is the same no matter when she is asked. But there is evidence that preferences are *time-inconsistent*: People tend to pursue immediate gratification in a way that their "long-run selves" do not appreciate.[6] To illustrate, suppose a person must choose between doing 7 hours of an unpleasant task on April 1 versus 8 hours of the same task on April 15. Time consistency requires a person make the same choice if asked on February 1 or if asked on April 1 (assuming no new information becomes available). We suspect, however, that if asked on February 1 most people would prefer the 7 hours on April 1 (i.e., to do less work next month), whereas if asked on April 1 many people would prefer the 8 hours on April 15 (i.e., to not work today).

The example above reflects a specific form of time-inconsistent preferences, which we call present-biased preferences: When considering trade-offs between two future moments, people give stronger relative weight to their well-being at the earlier moment as it gets closer. That is, people have a self-control problem whereby they pursue short-run immediate gratification in ways that they would not have approved from an earlier perspective. Phelps and Pollak (1968) developed an elegant model of intertemporal preferences for the context of intergenerational altruism which Laibson (1994) later employed to capture the taste for immediate gratification within an individual. Let u_t be the instantaneous utility a person gets in period t. Then her intertemporal preferences at time t, U^t, can be represented by the following utility function:

$$\text{For all } t, \; U^t(u_t, u_{t+1}, ..., u_T) \equiv u_t \; + \; \beta \sum_{\tau=t+1}^{T} \delta^{\tau-t} u_\tau .$$

The parameter $\delta \leq 1$ represents "time-consistent" impatience, whereas the parameter $\beta \leq 1$ represents a "bias for the present". For $\beta = 1$, these preferences are simply (the discrete version of) exponential discounting and are therefore time-consistent. We shall refer to people with time-consistent preferences as *TCs*. But for $\beta < 1$, these preferences parsimoniously capture the time-inconsistent preference for immediate gratification.[7]

A number of economists have formally modeled intertemporal choice given time-inconsistent

[6] See, for instance, Ainslie (1975, 1991, 1992), Ainslie and Haslam (1992*a*, 1992*b*), Loewenstein and Prelec (1992), and Thaler (1991).

[7] Consider again the above example. Assume that the instantaneous disutility from doing work is simply the number of hours of work, so that $u_t(7) = -7$ and $u_t(8) = -8$ for all t, and that there is no time-consistent discounting, so $\delta = 1$. Suppose also that $\beta = .8$: The person is willing to forego a given loss in utility *in the future* for a gain in utility *now* that is only 80% as large. Consider the person's decision on February 1. Because on February 1 she discounts both dates by β, the person will choose to work 7 hours on April 1 rather than 8 hours on April 15. Contrast this with the person's decision on April 1. She can experience a utility of -7 by working today, or experience a discounted utility of $.8(-8) = -6.4$ by delaying the work until 2 weeks from now. She will, therefore, delay work. Hence, for the exact same problem, the person's choice on April 1 is different from her choice on February 1.

preferences.[8] The standard approach used in this literature is to model a person at each point in time as a separate "agent" who chooses her current behavior to maximize her current preferences, predicting how her future selves will behave. Two extreme assumptions have appeared in the literature concerning a person's beliefs about future behavior. *Sophisticated* people are fully aware of their future self-control problems and therefore correctly predict how their future selves will behave. That is, sophisticates have "rational expectations" about their future behavior. *Naive* people are fully *un*aware of their future self-control problems and therefore believe their future selves will behave exactly as they currently would like them to behave. With the simple preferences described above, naive people believe that they will behave like TCs in the future.[9]

O'Donoghue and Rabin (forthcoming *a*, 1998) emphasize that severe procrastination does not arise from present-biased preferences per se, but rather from present-biased preferences combined with naivete. Since a sophisticated person correctly predicts her future behavior, she always knows exactly how long she would procrastinate if she does not complete some task now. In contrast, a naive person can repeatedly incorrectly believe that she will complete some task tomorrow if she does not do so now. The examples of investment behavior in the next two sections will therefore focus on naifs, discussing the behavior of TCs and sophisticates to emphasize this point. But we shall also illustrate in Section 3 that our examples do not rely on complete naivete by modeling and analyzing the behavior of less-than-complete sophistication.

3. Procrastination in Making a Known Investment

Akerlof (1991) and O'Donoghue and Rabin (forthcoming *a*, forthcoming *b*) discuss procrastination of an unpleasant task that a person should complete immediately.[10] In this section, we explore a simple investment decision that is analogous to such simple procrastination examples: A person *should* transfer her retirement savings from her current account to some fixed alternative that yields

8 See, in particular, Strotz (1955), Pollak (1968), Phelps and Pollak (1968), Peleg and Yaari (1973), Goldman (1979, 1980), Laibson (1994) and O'Donoghue and Rabin (forthcoming *a*).

9 Strotz (1955) and Pollak (1968) carefully lay out the two extreme assumptions. Most research on time-inconsistent preferences has assumed sophistication (e.g., Peleg and Yaari (1973), Goldman (1979, 1980), Laibson (1994, 1995, 1997) and Fischer (1997)). O'Donoghue and Rabin (forthcoming *a*, forthcoming *b*, 1997*a*, 1997*b*, 1998) consider both sophistication and naivete. Akerlof's (1991) model of procrastination is not explicitly framed as a model of time-inconsistent preferences, but is formally equivalent to a model with time-inconsistent preferences combined with naivete (and indeed Akerlof emphasizes the role that mispredicting future behavior plays in procrastination).

10 While these papers (and the current one) assume that the task at hand can be done instantly, Fischer (1997) discusses procrastination when a person must put in a fixed number of hours before some deadline.

higher interest, but since this transfer requires some effort, the person may procrastinate.

Our examples take the following form: Suppose a person has a $10,000 principal which she is saving for retirement 30 years from now. It is sitting in a 0% real-interest account. For a small opportunity cost on the day she does it, the person can transfer the money to a 5% real-interest account. Will she transfer the money, or let it sit in the 0% interest account? Making this transfer immediately will increase the person's retirement savings by nearly $35,000 (relative to never making the transfer). Hence, the person *should* make this transfer immediately unless the cost of transferring the funds is immense or the person heavily discounts the future.

For any reasonable discounting and transfer costs, a fully rational person would make this transfer immediately. Similarly, a person with self-control problems who is completely sophisticated about them will make the transfer without too much delay unless she has an extreme self-control problem. A person with self-control problems who is naive, in contrast, always believes that in the future she will behave optimally. For a small transfer cost and reasonable discounting, she repeatedly believes that if she waits today she will transfer the money tomorrow. Hence, a naive person with self-control problems will transfer the money only if doing so today is preferred to doing so tomorrow despite her taste for immediate gratification; therefore, even a small transfer cost can lead to the money never being transferred.

More generally, suppose a person's retirement savings are currently in some account, Plan A, that has yearly real rate of return r_A. The person has the option of transferring these savings into Plan B, which has yearly real rate of return r_B. We assume that Plan B has a higher rate of return than Plan A ($r_B > r_A$), but that making the transfer requires cost $C > 0$. The transfer cost incorporates any transactions costs, as well as the opportunity cost of the effort required to carry out the transfer. Importantly, we assume that all costs incorporated in C are *immediate* – hence, these costs do not include things such as opportunity costs of other investment opportunities that yield benefits only in the long term, but do include opportunity costs such as an afternoon nap, a rerun of *21 Jump Street,* or any other attractive alternative.

Consider in this environment how a person's retirement savings are affected by delay in transferring the funds. Throughout we assume interest is compounded daily.[11] Suppose the principal is P and the investment horizon is T days (e.g., a 30-year investment horizon implies $T = 10,950$ days).

[11] Technically, r_A and r_B are the "stated" yearly rates of return, where the effective yearly rates of return will be larger due to daily compounding.

If the person transfers the funds immediately, her retirement savings will be $P\left(1+\frac{r_B}{365}\right)^T$. If the person delays τ days before transferring the funds, her retirement savings will be $P\left(1+\frac{r_A}{365}\right)^\tau\left(1+\frac{r_B}{365}\right)^{T-\tau}$. Hence, the loss in savings at retirement from a τ-day delay, $L(\tau)$, will be

$$L(\tau) \equiv P\left[\left(1+\frac{r_B}{365}\right)^T - \left(1+\frac{r_A}{365}\right)^\tau\left(1+\frac{r_B}{365}\right)^{T-\tau}\right].$$

Two types of delay will play a prominent role in our analysis: a one-day delay and a T-day delay (i.e., never making the transfer). Assuming a principal of $10,000 and a 30-year investment horizon, Table 1 provides some examples of the cost of a one-day delay and the cost of never making the transfer for various values of r_A and r_B:

Table 1: Lost Retirement Savings from Delay
(Principal = $10,000, Horizon = 30 years)

r_A	r_B	Lost Retirement Savings from One-Day Delay ($L(1)$)	Lost Retirement Savings if Never Transfer ($L(T)$)
0%	1%	$0.37	$3,499
5%	6%	$1.66	$15,675
10%	11%	$7	$70,219
0%	5%	$6	$34,812
5%	10%	$28	$155,961
10%	15%	$123	$698,567
0%	10%	$55	$190,773
5%	15%	$246	$854,527
10%	20%	$1,103	$3,826,891

It is not surprising that the cost of never transferring the funds is quite large whereas the cost of a one-day delay is quite small. But as we shall demonstrate, these are precisely the conditions that can generate costly procrastination.

To complete our model, we describe an investor's preferences. We assume the utility of retirement savings is approximately linear – that is, if a person retires on day $T+1$ with retirement savings S, then she receives utility S on day $T+1$.[12] We also assume the transfer cost C is mea-

[12] Our model also assumes that people discount retirement savings as if they will consume all of them on the first day of retirement. This is not innocuous for two reasons. First, because consumption will be continued during retirement, the value of retiring with a fixed amount depends on the discount factor and the interest rate, which are parameters we vary. Second, when a person must choose her consumption allocation after retirement, her perceived value of savings entering retirement may depend on her sophistication, making our comparisons below between sophistication and naivete potentially misleading. We nonetheless believe that the basic insights of our model, and even the calibration exercises, would not be immensely altered by the more realistic and complicated model.

sured in terms of the utility equivalent of dollars of retirement savings, and that this cost is incurred immediately. Finally, we assume that the investor has present-biased preferences, with parameters β and δ as described in Section 2. Hence, if in period t the person expects to incur transfer cost C in period $\tau \geq t$ and expects to retire in period $T+1 \geq \tau$ with retirement savings S, then her period-t intertemporal utility is given by

$$U^t = \begin{cases} -C & + \quad \beta\delta^{T+1-t}S \qquad \text{if } \tau = t \\ -\beta\delta^{\tau-t}C & + \quad \beta\delta^{T+1-t}S \qquad \text{if } \tau > t. \end{cases}$$

With this formulation, on day t the person values a dollar invested in Plan B at $\left[\delta\left(1+\frac{r_B}{365}\right)\right]^{T+1-t}$ (from a long-run perspective). If $\delta\left(1+\frac{r_B}{365}\right) < 1$, then Plan B is more attractive to the person the *closer* she is to retirement. In this case, both TCs and naifs will initially delay but eventually transfer the money when Plan B becomes attractive enough. If $\delta\left(1+\frac{r_B}{365}\right) > 1$, meaning that the interest rate, r_B, is high relative to the person's discount rate, $1-\delta$, then Plan B is more attractive to the person the *further* she is from retirement. In this case, both TCs and naifs will either transfer the funds immediately or never transfer the funds (though naifs may, of course, be planning to save at some future date). Both because we consider it more realistic and to keep our analysis simple, we shall restrict attention to cases where $\delta\left(1+\frac{r_B}{365}\right) > 1$.

We now analyze behavior assuming that the person can make the transfer on any given day. A time-consistent person will choose on day 1 the best day to make the transfer (and will stick to this plan), and, as discussed above, when $\delta\left(1+\frac{r_B}{365}\right) > 1$ the best day will either be the first day or never. Given that the lost retirement savings from never transferring the funds is $L(T)$ and that the transfer cost is C, TCs will behave as follows:

Transfer funds immediately	if and only if	$C \leq \delta^T L(T)$
Never transfer funds	if and only if	$C > \delta^T L(T)$.

That is, TCs will transfer the money if and only if the present discounted value of the extra interest earned over T years (i.e., $\delta^T L(T)$) is larger than the immediate cost of transferring the funds (i.e., C).

Unlike TCs, naifs do not directly compare transferring the funds immediately to never transferring the funds. Rather, if TCs will make the transfer immediately, naifs repeatedly *believe* they will make the transfer tomorrow if they do not do so today. As a result, naifs make the transfer immediately if and only if doing so is preferred to a one-day delay; otherwise, they procrastinate forever – persistently planning to make the same transfer tomorrow. Given that the lost retirement savings from a one-day delay is $L(1)$ and that the transfer cost is C, naifs will prefer delaying one day if $C > \beta\delta C + \beta\delta^T L(1)$, and hence will behave as follows:[13]

Transfer funds immediately	if and only if	$C \leq \frac{\beta}{1-\beta\delta}\delta^T L(1)$
Never transfer funds	if and only if	$C > \frac{\beta}{1-\beta\delta}\delta^T L(1)$.

Table 2 presents our main calibration results: For various values of r_A, r_B, δ, and β, Table 2 provides the transfer costs above which TCs and naifs would never transfer the funds.

Table 2: When Naifs Procrastinate: Single Alternative, Daily Decisions
(Principal = \$10,000, Horizon = 30 years)

r_A	r_B	δ^{365}	TCs never transfer funds if	Naifs never transfer funds if $\beta = .99$	$\beta = .98$	$\beta = .95$	$\beta = .90$	$\beta = .80$
0%	1%	.99	$C >$2,588	$C >$27	$C >$13	$C >$5	$C >$2	$C >$1
5%	6%	.99	$C >$11,595	$C >$121	$C >$60	$C >$23	$C >$11	$C >$5
		.96	$C >$4,606	$C >$48	$C >$24	$C >$9	$C >$4	$C >$2
10%	11%	.99	$C >$51,941	$C >$542	$C >$269	$C >$104	$C >$49	$C >$22
		.96	$C >$20,634	$C >$214	$C >$106	$C >$41	$C >$20	$C >$9
		.91	$C >$4,147	$C >$42	$C >$21	$C >$8	$C >$4	$C >$2
0%	5%	.99	$C >$25,751	$C >$448	$C >$222	$C >$86	$C >$41	$C >$18
		.96	$C >$10,230	$C >$177	$C >$88	$C >$34	$C >$16	$C >$7
5%	10%	.99	$C >$115,364	$C >$2,008	$C >$995	$C >$386	$C >$183	$C >$81
		.96	$C >$45,830	$C >$791	$C >$394	$C >$153	$C >$73	$C >$32
		.91	$C >$9,210	$C >$157	$C >$79	$C >$31	$C >$15	$C >$6
10%	15%	.99	$C >$516,730	$C >$8,994	$C >$4,457	$C >$1,730	$C >$820	$C >$364
		.96	$C >$205,279	$C >$3,543	$C >$1,764	$C >$686	$C >$325	$C >$145
		.91	$C >$41,252	$C >$702	$C >$352	$C >$137	$C >$65	$C >$29
0%	10%	.99	$C >$141,115	$C >$4,016	$C >$1,990	$C >$772	$C >$366	$C >$163
		.96	$C >$56,060	$C >$1,582	$C >$788	$C >$306	$C >$145	$C >$65
		.91	$C >$11,266	$C >$313	$C >$157	$C >$61	$C >$29	$C >$13
5%	15%	.99	$C >$632,094	$C >$17,987	$C >$8,915	$C >$3,460	$C >$1,639	$C >$729
		.96	$C >$251,109	$C >$7,087	$C >$3,527	$C >$1,372	$C >$651	$C >$289
		.91	$C >$50,462	$C >$1,404	$C >$704	$C >$275	$C >$131	$C >$58
10%	20%	.99	$C >$2,830,753	$C >$80,544	$C >$39,920	$C >$15,492	$C >$7,340	$C >$3,263
		.96	$C >$1,124,561	$C >$31,733	$C >$15,794	$C >$6,145	$C >$2,914	$C >$1,296
		.91	$C >$225,989	$C >$6,287	$C >$3,151	$C >$1,231	$C >$585	$C >$260

[13] Technically, this condition merely guarantees that naifs prefer a one-day delay on day 1. This condition is necessary and sufficient, however, for indefinite delay by naifs, since a one-day delay becomes less costly in terms of lost retirement savings as the investment horizon becomes shorter.

Table 2 reveals striking differences between when TCs and when naifs transfer the funds. For all parameter values, TCs will transfer funds immediately unless the cost of doing so is immense. In contrast, naifs may never transfer funds even for a relatively small transfer cost. Moreover, Table 2 illustrates not only the differences between naifs and TCs, but also the scale of the problem for naifs. Consider our earlier example: Does a person switch $\$10,000$ from a 0% interest account to a 5% interest account? Doing so increases retirement savings thirty years from now by $\$34,812$. A naif with yearly discount factor $\delta^{365} = .96$ and $\beta = .9$ values the benefits of this transfer at $(.9)(.96)^{30}\$34,812 = \$9,207$. And yet this person will never make the transfer if the salient cost of doing so is merely $\$16$. This seemingly lunatic behavior is made more comprehensible (but no less harmful) by understanding the mind-set of the naif: She knows that it would be insane not to make the transfer, and so she very much plans to make the transfer. But she repeatedly plans to do so *tomorrow*.[14]

Table 2 illustrates our basic point: Whether a person *ought* to transfer the funds – and whether TCs do transfer the funds – depends on whether the present discounted value of making the transfer of funds exceeds the immediate cost; but a naive person with self-control problems will transfer the funds only if the lost interest from a short delay is sufficient to overcome the desire to delay incurring the transfer cost.

There are a number of caveats to our analysis, however, and we urge the reader not to infer too much from our basic calibration exercises in Table 2. An important assumption in our analysis is how frequently a person has the option of transferring funds. Table 2 assumes that the person can transfer the funds each day. Table 3 below is identical to Table 2 except for assuming that the person can transfer the funds only once a week. Notice that while this change does not affect whether TCs transfer the funds, naifs become more likely to make the transfer. When they can make the transfer on any given day, naifs believe they'll do it tomorrow if they wait now, whereas if they know they can make the transfer only once a week, they believe they'll do it next week if they wait now. Since a seven-day delay is more costly than a one-day delay, naifs become less likely to procrastinate when they can make the transfer only once a week. More generally, the less frequently a naif has the option of transferring the funds, the less likely she is to procrastinate.[15]

[14] Note that the entries in Table 2 are homogenous of degree one in the principal (e.g., if we multiplied the principal by 10 then all entries would be multiplied by 10). For example, a naif with $\beta = .9$ and a yearly discount factor of .96 will not transfer $\$100,000$ from a 5% to a 6% interest account if it takes merely $\$40$ worth of effort.

[15] On the other hand, a "seven-day β" is likely to be smaller than a "one-day β", which would partially counteract the effects of less frequent transfer opportunities.

Table 3: When Naifs Procrastinate: Single Alternative, Weekly Decisions
(Principal = \$10,000, Horizon = 30 years)

			TCs never	Naifs	never	transfer	funds	if
r_A	r_B	δ^{365}	transfer funds if	$\beta = .99$	$\beta = .98$	$\beta = .95$	$\beta = .90$	$\beta = .80$
0%	1%	.99	$C >$2,588	$C >$186	$C >$93	$C >$36	$C >$17	$C >$8
5%	6%	.99	$C >$11,595	$C >$833	$C >$416	$C >$162	$C >$77	$C >$34
		.96	$C >$4,606	$C >$313	$C >$161	$C >$64	$C >$30	$C >$14
		.99	$C >$51,941	$C >$3,733	$C >$1,865	$C >$727	$C >$345	$C >$154
10%	11%	.96	$C >$20,634	$C >$1,403	$C >$720	$C >$286	$C >$136	$C >$61
		.91	$C >$4,147	$C >$258	$C >$138	$C >$56	$C >$27	$C >$12
0%	5%	.99	$C >$25,751	$C >$3,086	$C >$1,542	$C >$601	$C >$285	$C >$127
		.96	$C >$10,230	$C >$1,160	$C >$596	$C >$236	$C >$113	$C >$50
		.99	$C >$115,364	$C >$13,825	$C >$6,908	$C >$2,694	$C >$1,279	$C >$569
5%	10%	.96	$C >$45,830	$C >$5,195	$C >$2,668	$C >$1,058	$C >$505	$C >$225
		.91	$C >$9,210	$C >$954	$C >$511	$C >$209	$C >$101	$C >$45
		.99	$C >$516,730	$C >$61,919	$C >$30,939	$C >$12,066	$C >$5,726	$C >$2,548
10%	15%	.96	$C >$205,279	$C >$23,265	$C >$11,949	$C >$4,740	$C >$2,263	$C >$1,010
		.91	$C >$41,252	$C >$4,273	$C >$2,291	$C >$935	$C >$451	$C >$202
		.99	$C >$141,115	$C >$27,639	$C >$13,810	$C >$5,386	$C >$2,556	$C >$1,137
0%	10%	.96	$C >$56,060	$C >$10,385	$C >$5,334	$C >$2,116	$C >$1,010	$C >$451
		.91	$C >$11,266	$C >$1,907	$C >$1,022	$C >$417	$C >$201	$C >$90
		.99	$C >$632,094	$C >$123,787	$C >$61,853	$C >$24,122	$C >$11,448	$C >$5,093
5%	15%	.96	$C >$251,109	$C >$46,511	$C >$23,888	$C >$9,477	$C >$4,524	$C >$2,019
		.91	$C >$50,462	$C >$8,543	$C >$4,579	$C >$1,869	$C >$901	$C >$404
		.99	$C >$2,830,753	$C >$554,302	$C >$276,971	$C >$108,015	$C >$51,264	$C >$22,806
10%	20%	.96	$C >$1,124,561	$C >$208,271	$C >$106,968	$C >$42,437	$C >$20,258	$C >$9,039
		.91	$C >$225,989	$C >$38,253	$C >$20,505	$C >$8,368	$C >$4,034	$C >$1,809

Of course, it is more realistic to suppose that transfer opportunities may arrive at irregular intervals; for example, a person may be able to make the transfer on weekdays but not weekends. On every Friday, naifs will face a three-day delay if they do not make the transfer then, and therefore naifs will never make the transfer only if they prefer a three-day delay to making the transfer immediately. The general principle is that the delay that determines whether naifs procrastinate indefinitely is the longest delay they might face. Similarly, in more realistic models the transfer cost might vary from day to day; e.g., the opportunity cost of time varies from day to day. In such a situation, a person will never make the transfer only if the *lowest* cost is sufficient to induce procrastination.

These considerations would likely diminish the scale of procrastination from that in our calibrations. On the other hand, we feel such factors would have to diminish predicted procrastination substantially – perhaps by a couple orders of magnitude – before procrastination could be dismissed as an important factor in investment behavior. This is especially true in our more dramatic calibration exercises in Section 4.

We now turn to the importance of the naivete assumption itself. Because our calibrations assume the investor is completely unaware of her propensity to procrastinate, here too the reader may suspect we are making an extreme assumption that leads us to exaggerate procrastination. At the start of this section we observed that sophisticates, who are fully aware of their self-control problems, are unlikely to severely procrastinate in this environment. Since a sophisticate correctly predicts future behavior, she will never make the transfer if and only if on day 1 she prefers never making the transfer to making it immediately – that is, if and only if $C > \beta\delta^T L(T)$. Table 4 below illustrates that sophisticates, like TCs and unlike naifs, will almost surely make the transfer; in fact, all entries are simply the critical transfer cost for TCs multiplied by β.

Table 4: When Sophisticates Procrastinate Forever: Single Alternative, Daily Decisions
(Principal = \$10,000, Horizon = 30 years)

r_A	r_B	δ^{365}	TCs never transfer if	Sophisticates never transfer funds if $\beta = .98$	$\beta = .95$	$\beta = .9$	$\beta = .8$
0%	1%	.99	C >2,588	C >2,536	C >2,458	C >2,329	C >2,070
5%	6%	.99	C >11,595	C >11,363	C >11,015	C >10,435	C >9,276
		.96	C >4,606	C >4,514	C >4,376	C >4,146	C >3,685
		.99	C >51,941	C >50,902	C >49,344	C >46,747	C >41,553
10%	11%	.96	C >20,634	C >20,222	C >19,603	C >18,571	C >16,507
		.91	C >4,147	C >4,064	C >3,939	C >3,732	C >3,317
0%	5%	.99	C >25,751	C >25,236	C >24,463	C >23,176	C >20,601
		.96	C >10,230	C >10,025	C >9,718	C >9,207	C >8,184
		.99	C >115,364	C >113,057	C >109,596	C >103,828	C >92,291
5%	10%	.96	C >45,830	C >44,914	C >43,539	C >41,247	C >36,664
		.91	C >9,210	C >9,026	C >8,749	C >8,289	C >7,368
		.99	C >516,730	C >506,395	C >490,894	C >465,057	C >413,384
10%	15%	.96	C >205,279	C >201,174	C >195,015	C >184,751	C >164,223
		.91	C >41,252	C >40,427	C >39,190	C >37,127	C >33,002
		.99	C >141,115	C >138,292	C >134,059	C >127,003	C >112,892
0%	10%	.96	C >56,060	C >54,939	C >53,257	C >50,454	C >44,848
		.91	C >11,266	C >11,040	C >10,702	C >10,139	C >9,013
		.99	C >632,094	C >619,452	C >600,489	C >568,885	C >505,675
5%	15%	.96	C >251,109	C >246,087	C >238,554	C >225,998	C >200,888
		.91	C >50,462	C >49,453	C >47,939	C >45,416	C >40,370
		.99	C >2,830,753	C >2,774,138	C >2,689,215	C >2,547,678	C >2,264,602
10%	20%	.96	C >1,124,561	C >1,102,070	C >1,068,333	C >1,012,105	C >899,649
		.91	C >225,989	C >221,470	C >214,690	C >203,390	C >180,791

Unlike naifs and TCs, who in the environment studied in this section either make the transfer immediately or never make the transfer, sophisticates might delay for some duration and then make the transfer. Intuitively, if a sophisticate (correctly) perceives that she would make the transfer two weeks hence, then given her self-control problem she might prefer not to make the transfer now. But Table 5 shows that such delays will be small:

Table 5: Maximum Delay for Sophisticates
(Principal = \$10,000, Horizon = 30 years, $\delta^{365} = .96$)

			Maximum Delay For Sophisticates				
r_A	r_B	C	$\beta = .99$	$\beta = .98$	$\beta = .95$	$\beta = .9$	$\beta = .8$
0%	5%	100	0 days	1 day	2 days	6 days	13 days
		300	1 day	3 days	8 days	18 days	42 days
		500	2 days	5 days	15 days	31 days	71 days
5%	10%	200	0 days	0 days	1 day	2 days	6 days
		800	1 day	2 days	5 days	11 days	25 days
		1400	1 day	3 days	9 days	19 days	44 days
10%	15%	1000	0 days	0 days	1 day	3 days	6 days
		3000	0 days	1 day	4 days	9 days	20 days
		5000	1 day	2 days	7 days	15 days	35 days

Hence, it is indeed the case that a person will not severely procrastinate in implementing more profitable investments if she is completely sophisticated about her self-control problems. But it turns out that even a small degree of naivete may be sufficient to induce a person to never make the transfer. That is, even if a person knows she will have future self-control problems, she can still severely procrastinate if she slightly underestimates their magnitude. We now turn to some calibration exercises showing the *degree* of naivete required to induce procrastination in some of the examples above.

As β captures the magnitude of a person's self-control problem, we let $\hat{\beta}$ capture a person's beliefs concerning future self-control problems. Then sophisticates have $\hat{\beta} = \beta$ and naifs have $\hat{\beta} = 1$. A person aware that she will have future self-control problems, but who underestimates their magnitude, will have $\hat{\beta} \in (\beta, 1)$.

To understand the behavior of a person with $\hat{\beta} \in (\beta, 1)$, it is helpful to better understand the behavior of sophisticates. For any self-control problem β, there is some maximum delay that a person is willing to tolerate, and in any given period the person will transfer the funds if and only if she perceives that waiting now would lead to an intolerably long delay. Since a sophisticate correctly predicts her own future behavior, her "strategy" will involve periodically planning to make the transfer. Suppose, for instance, that a person with $\beta = .9$ is willing to tolerate at most an 11-day delay. Then if this person is sophisticated, she might, for instance, plan to make the transfer on Day 1, anticipating that if she doesn't make the transfer on Day 1 she will do so on Day 13 (and if not then, on Day 25, etc.).[16] The important point is that sophisticates complete the task when they do because they perceive future behavior to be *just bad enough* to make delay too costly.

Now consider a partially naive person who has self-control problem $\beta = .9$, but who naively thinks that in the future she will have self-control problem $\hat{\beta} = .95$. Suppose that the situation is such that a person with $\beta = .95$ would tolerate at most a ten-day delay. Then on any given day the partially naive person must believe that waiting today will lead to a delay of at most 11 days – because she incorrectly thinks that beginning tomorrow she would tolerate a delay of at most 10 days. But since our hypothetical example assumes that for $\beta = .9$ the person will wait whenever she perceives that she would make the transfer within 11 days, a person with self control problem $\beta = .9$ and perceptions $\hat{\beta} = .95$ will never make the transfer. This hypothetical example illustrates why complete naivete is not required to induce a person to never make this manifestly desirable transfer. All that is required is that the person be merely naive enough to believe her future tolerance for delay will be at least one day smaller than her true tolerance for delay.

Table 6 reports the degree of naivete required to induce a person to never make the transfer for various r_A, r_B, and C. Table 6 assumes a principal of \$10,000, a 30-year investment horizon, and a yearly discount factor of $\delta^{365} = .96$. Importantly, the conditions in the table are sufficient to guarantee severe procrastination, but they are not necessary. See the Appendix for a derivation of these conditions. Table 6 reveals that in general $\hat{\beta}$ need not be that much larger than β to induce severe procrastination.[17]

[16] Note that a sophisticate might follow any plan that completes the task within 12 days and has 12-day cycles. E.g., make the transfer on days $(2, 14, 26, ...)$, or on days $(3, 15, 27, ...)$.

[17] The two blank cells are cases where a naif will make the transfer immediately, and hence a person with any degree of sophistication will do so as well.

Table 6: Degree of Naivete Required for Procrastination
(Principal = \$10,000, Horizon = 30 years, $\delta^{365} = .96$)

			Never	transfer	funds	if
r_A	r_B	C	$\beta = .98$	$\beta = .95$	$\beta = .9$	$\beta = .8$
		100	$\hat{\beta} > .9975$	$\hat{\beta} > .9665$	$\hat{\beta} > .9148$	$\hat{\beta} > .8116$
0%	5%	300	$\hat{\beta} > .9857$	$\hat{\beta} > .9554$	$\hat{\beta} > .9048$	$\hat{\beta} > .8038$
		500	$\hat{\beta} > .9834$	$\hat{\beta} > .9532$	$\hat{\beta} > .9028$	$\hat{\beta} > .8022$
		200	–	$\hat{\beta} > .9878$	$\hat{\beta} > .9339$	$\hat{\beta} > .8266$
5%	10%	800	$\hat{\beta} > .9897$	$\hat{\beta} > .9591$	$\hat{\beta} > .9082$	$\hat{\beta} > .8064$
		1400	$\hat{\beta} > .9855$	$\hat{\beta} > .9551$	$\hat{\beta} > .9046$	$\hat{\beta} > .8036$
		1000	–	$\hat{\beta} > .9837$	$\hat{\beta} > .9302$	$\hat{\beta} > .8238$
10%	15%	3000	$\hat{\beta} > .9916$	$\hat{\beta} > .9609$	$\hat{\beta} > .9098$	$\hat{\beta} > .8077$
		5000	$\hat{\beta} > .9869$	$\hat{\beta} > .9565$	$\hat{\beta} > .9058$	$\hat{\beta} > .8046$

To summarize, all that is required for severe procrastination is that a person always believe that she will be a little better behaved in the future than she would believe if she were sophisticated.[18] This same intuition applies to the calibrations in the next section, although we shall not formally demonstrate it.

We conclude this section by observing some straightforward comparative statics on the determinants of procrastination in transferring money to a known, better account. The larger is the long-run discount factor δ (i.e., the more patient is the person), the principal P, and the investment horizon T, the larger must be the transfer cost C for a person not to make the transfer. These comparative statics seem obvious: Increased patience, a larger principal, and more years for the benefits to accrue, all imply that making the transfer is more important to the person. We emphasize these comparative statics here, however, because it turns out that they do not necessarily hold in the (more realistic) calibrations of the next section.

4. Procrastinating in Choosing Among Investments

The previous section shows that a person might not invest sensibly for retirement because she repeatedly decides to incur the cost of transferring her funds to a better investment tomorrow rather than today, even when this cost is very small relative to the benefits. Nonetheless, if one interprets the transfer costs of Tables 2 and 3 to be merely the cost of moving the funds, then the critical costs

[18] In an analysis that parallels that above, O'Donoghue and Rabin (1998) show formally, in a more abstract environment, that any degree of naivete is sufficient to induce severe and costly procrastination.

for naifs may seem sufficiently large that procrastination should not be a problem. In this section, however, we shall demonstrate that the transfer cost should not be interpreted as merely the cost of moving the funds, but rather should be interpreted as the amount of effort the person would like to put in to determine *where* to transfer her money. Our calibrations in this section build upon a more general intuition identified in O'Donoghue and Rabin (1998): When a person must choose how much effort to put into some task, the relevant effort level that determines whether a person procrastinates is the effort level that the person *should* exert. Because the optimal effort level for important decisions like investing for retirement may be quite high, severe procrastination is likely to be a problem.

We begin with examples of the following form: Suppose again that a person has a $10,000 principal which she is saving for retirement 30 years from now. It is initially sitting in a 0% interest account, and she can *costlessly* transfer this money to an account that yields an interest rate of 5%. If this were the person's only option, she would immediately make the transfer, no matter how severe her self-control problem, since doing so is costless. But now suppose the person can also put in some costly effort that would guarantee finding a better investment, yielding an interest rate of 6%.

This example, and the more general formulation below, is a stylization of the more realistic situation that we wish to capture: There is a large array of accounts out there that the person expects to be better than her current account, but costly investigation is required to discover which of these are best. The "known" alternative is choosing one at random, and the "guaranteed" better alternative that can be found at a cost is the probabilistic improvement that comes with additional search effort.

What does a person do in such environments? As we saw in the previous section, even small differences in interest rates will have huge effects on retirement savings, and therefore the person *ought* to put in the effort to find the better investment (unless the cost of doing so is prohibitively large). A time-consistent person will do so immediately. A person with self-control problems who is sophisticated will do so with at most short delay. A person with self-control problems who is naive *plans* to do so with at most short delay, and therefore considers the costless investment to be irrelevant to her decision. But if the effort required is large enough, a naif will procrastinate just as in the previous section.

Formally, we again suppose that a person's retirement savings are currently in some default plan, Plan A, that has yearly rate of return r_A. Each period, the person can costlessly keep her money in

Plan A; can costlessly transfer her money to an alternative investment, "Plan B", yielding return $r_B > r_A$; or can exert some effort $C > 0$ to put her money in a second alternative, "Plan C", yielding return $r_C > r_B$. Importantly, we assume that the person cannot invest in Plan B now and later transfer to Plan C.[19] Our analysis shall again assume that $\delta\left(1+\frac{r_B}{365}\right) > 1$, so that a dollar invested in Plan B or Plan C is more valuable to the person the further off is her retirement.

In this environment, the person clearly should not leave her money in Plan A forever, since Plan B strictly dominates Plan A. A time-consistent person will either choose Plan B or Plan C immediately. Since Plan B yields intertemporal utility $\delta^T P\left(1+\frac{r_B}{365}\right)^T - 0$ and Plan C yields intertemporal utility $\delta^T P\left(1+\frac{r_C}{365}\right)^T - C$, TCs will behave as follows:

$$\text{Transfer to Plan C at } \tau = 1 \qquad \text{if and only if} \quad \delta^T P\left[\left(1+\frac{r_C}{365}\right)^T - \left(1+\frac{r_B}{365}\right)^T\right] \geq C$$

$$\text{Transfer to Plan B at } \tau = 1 \qquad \text{if and only if} \quad \delta^T P\left[\left(1+\frac{r_C}{365}\right)^T - \left(1+\frac{r_B}{365}\right)^T\right] < C.$$

Now consider a naive person with self-control problems. On any given day, a naif perceives that if she waits she will choose either Plan B or Plan C tomorrow (i.e., a TC would do something the next day). In addition, Plan B today is clearly better than Plan B tomorrow. Hence, on day τ a naif considers three options: choose Plan B today, choose Plan C today, and (plan to) choose Plan C tomorrow. These options yield the following period-τ intertemporal utilities:

$$\text{Plan B today:} \qquad \beta\delta^{T+1-\tau} P\left(1+\frac{r_A}{365}\right)^{\tau-1}\left(1+\frac{r_B}{365}\right)^{T+1-\tau} - 0$$

$$\text{Plan C today:} \qquad \beta\delta^{T+1-\tau} P\left(1+\frac{r_A}{365}\right)^{\tau-1}\left(1+\frac{r_C}{365}\right)^{T+1-\tau} - C$$

$$\text{Plan C tomorrow:} \qquad \beta\delta^{T+1-\tau} P\left(1+\frac{r_A}{365}\right)^{\tau}\left(1+\frac{r_C}{365}\right)^{T-\tau} - \beta\delta C.$$

How do naifs behave? There are two main cases.[20] First, it could be that TCs prefer to choose Plan B immediately. In this case, naifs will also choose Plan B immediately. Intuitively, when TCs find Plan C to require too much effort, so will naifs, and since Plan B is costless, when naifs plan to choose Plan B they will clearly do so immediately.

The more interesting and more relevant case is when TCs choose Plan C immediately. When Plan C is by far the right thing to do (which as discussed above and illustrated below will tend to

[19] But we note that we need only assume there is a small transactions fee for such a transfer. For example, if $r_B = 10\%$ and $P = \$10,000$, then the first day's interest is \$2.74. Then for any transactions fee larger than \$2.74 the person would not choose Plan B today while planning to transfer to Plan C tomorrow.

[20] For simplicity, we are ignoring the knife-edge case where TCs "barely" prefer Plan C to Plan B in period 1.

be the case), a naif will prefer Plan C today to Plan B today (unless she has a very large self-control problem). As a result, Plan B will be irrelevant to a naif's decision, and the relevant question becomes whether to do Plan C today or tomorrow. In other words, an analysis of whether naifs procrastinate here is essentially the same analysis as in the previous section where we proceed *as if the best action were the unique action.* Our first point in this section, then, is that introducing a costless option does not overturn procrastination of a costly option when the costly option is the right thing to do.

Before proceeding with calibrations to illustrate this point, however, we note a caveat of sorts to our claim that the analysis here is essentially identical to our analysis in the previous section. Recall that in the previous section, if on day 1 a naif prefers to complete Plan B tomorrow rather than today, then she will feel this way on all future days, and therefore she will never make the transfer. In this section we can similarly conclude that if on day 1 a naif prefers to complete Plan C tomorrow rather than today, then she will feel this way on all future days. But here this condition is not sufficient for the person to never make a transfer, because the person will eventually prefer Plan B today to Plan C tomorrow, and therefore will eventually make a transfer, albeit to Plan B. Since the benefit of Plan C relative to Plan B decreases as the investment horizon becomes shorter, eventually it will not be worth putting in the extra effort.

Hence, our calibrations below will illustrate two components of naive behavior. The first component is whether the person's self-control problem is large enough to induce procrastination in carrying out Plan C. That is, there will be a critical self-control problem β^c such that for smaller self-control problems $\beta > \beta^c$ naifs do not procrastinate (and thus choose Plan C on day 1) and for larger self-control problems $\beta < \beta^c$ naifs procrastinate. When naifs procrastinate, the second component arises: For how long does the person procrastinate? The answer to this question depends on how much time must pass before Plan B becomes as attractive as Plan C.

Table 7 describes the behavior of TCs and naifs for various values of r_A, r_B, r_C, C, and δ^{365}. The table assumes a principal of $10,000 and a 30-year investment horizon. In each case, β^c represents the critical self-control problem required to induce procrastination by naifs. The last column states how long a naif waits before giving up on Plan C and switching her money to Plan B.

Table 7: When People Transfer Funds: Choice of Alternatives
(Principal = \$10,000, Horizon = 30 years)

r_A	r_B	r_C	C	δ^{365}	TCs	β^c	Naifs If $\beta > \beta^c$	If $\beta < \beta^c$
			500	.99	Plan C on day 1	.986	Plan C on day 1	Plan B at 25.8 yrs
0%	5%	6%	500	.96	Plan C on day 1	.994	Plan C on day 1	Plan B at 25.3 yrs
			2000	.96	Plan C on day 1	.999	Plan C on day 1	Plan B at 14.0 yrs
			500	.99	Plan C on day 1	.966	Plan C on day 1	Plan B at 26.1 yrs
0%	7%	8%	500	.96	Plan C on day 1	.986	Plan C on day 1	Plan B at 25.7 yrs
			2000	.96	Plan C on day 1	.997	Plan C on day 1	Plan B at 17.1 yrs
			500	.99	Plan C on day 1	.892	Plan C on day 1	Plan B at 26.4 yrs
0%	10%	11%	500	.96	Plan C on day 1	.954	Plan C on day 1	Plan B at 26.1 yrs
			500	.91	Plan C on day 1	.991	Plan C on day 1	Plan B at 25.2 yrs
			2000	.96	Plan C on day 1	.988	Plan C on day 1	Plan B at 19.7 yrs

Table 7 illustrates striking procrastination by naifs. In general, the magnitude of self-control problems required to induce procrastination are consistent with the simple example of Section 3. And when a person procrastinates, she procrastinates for a very long time (e.g., almost 26 years in the first entry) and then does what she could have done for free at the start. So, for instance, when a person can transfer from 0% to 5% for free, but can spend an extra \$500 to find a 6% investment opportunity, then even for a very small self-control problem ($\beta = .99$) the naif may do nothing for 25 years, and then go ahead and transfer to the 5% account.

O'Donoghue and Rabin (1998) show that when a person must choose from among a set of alternatives, the relevant cost which determines whether a person procrastinates is the cost of the best option. Our calibrations in Table 7 illustrate one implication of this finding: The mere availability of a costless option does not undo procrastination of a costly option, unless the costless option is in fact the better option. We now turn to a more disturbing implication of this finding: As it becomes more important that a person prepare carefully for her retirement, the "right" thing to do is to put more effort into that preparation, but that is exactly what makes it more likely that the person procrastinates. Hence, it is possible that the more important it is for a person to invest wisely, the less likely it is that a person does so. O'Donoghue and Rabin (1998) play out this theme in detail in a somewhat different (and more abstract) model; but investing for retirement is perhaps both the prototypical and the most important example of the general principles attained. To illustrate these principles, we now further generalize our model here to incorporate the case where putting more and more effort into retirement preparation can yield a larger and larger return.

Suppose that a person's retirement savings are in some default plan, Plan A, that has yearly rate of return r_A. As before, suppose that each period the person can costlessly keep her money in Plan A, or can costlessly transfer her money to Plan B which yields return $r_B > r_A$. But now the person can also choose from among several costly options: Plan C yields interest rate $r_C > r_B$ at a cost $C_C > 0$, Plan D yields interest rate $r_D > r_C$ at a cost $C_D > C_C$, and Plan E yields interest rate $r_E > r_D$ at a cost $C_E > C_D$.

We observed in Section 3 that having a larger principal or being more patient – two factors that make retirement preparation more important – will make it *less likely* that a person procrastinates in transferring her money to a known alternative. Table 8 presents some calibrations which illustrate that when a person must choose from among alternatives, exactly the opposite can occur: Having a larger principal or being more patient can in fact make a person *more likely* to procrastinate. Table 8 assumes that a person's principal starts in a 0% interest account, and that there is a 30-year investment horizon. In addition, we assume that r_B is sufficiently smaller than r_C to be irrelevant (as it was in Table 7). For each case, the table presents which of the three costly plans TCs will choose immediately, and how large a self-control problem is required for naifs to procrastinate.[21]

[21] Unlike Table 7, Table 8 does not show how long naifs procrastinate because this characterization is more complicated here. For example, a person might initially plan to choose Plan D but procrastinate, and eventually complete Plan C when it becomes optimal; or the person might initially plan to choose Plan D but procrastinate, later decide that Plan C is optimal but still procrastinate, and eventually complete Plan B when it becomes optimal; etc.

Table 8: When People Transfer Funds: Increased Importance
(Horizon = 30 years, Plan A yields $r_A = 0\%$)

	r_C	C_C	r_D	C_D	r_E	C_E	P	δ^{365}	TCs	When Naifs Procrastinate:
(1)	6%	300	6.5%	3,500	6.75%	8,000	10,000	.96	Plan C	$\beta < .990$
							20,000	.96	Plan D	$\beta < .998$
							30,000	.96	Plan E	$\beta < .999$
(2)	8%	300	8.25%	3,500	8.35%	9,000	10,000	.96	Plan C	$\beta < .977$
							30,000	.96	Plan D	$\beta < .993$
							60,000	.96	Plan E	$\beta < .995$
(3)	10%	300	10.1%	3,500	10.15%	10,000	10,000	.96	Plan C	$\beta < .949$
							50,000	.96	Plan D	$\beta < .977$
							100,000	.96	Plan E	$\beta < .983$
(4)	10%	100	10.5%	2,500	10.75%	9,000	10,000	.91	Plan C	$\beta < .969$
							10,000	.96	Plan D	$\beta < .992$
							10,000	.99	Plan E	$\beta < .994$
(5)	12%	100	12.25%	2,500	12.35%	9,000	10,000	.91	Plan C	$\beta < .934$
							10,000	.96	Plan D	$\beta < .985$
							10,000	.99	Plan E	$\beta < .989$
(6)	15%	100	15.1%	2,500	15.15%	9,000	10,000	.91	Plan C	$\beta < .821$
							10,000	.96	Plan D	$\beta < .957$
							10,000	.99	Plan E	$\beta < .969$

Parts (1), (2), and (3) of Table 8 illustrate how having a larger principal can increase the likelihood of procrastination. To understand these results, consider again the mind-set of a naif. In part (3), for instance, with a principal of $10,000, the best thing to choose is Plan C (i.e., TCs choose Plan C). While for any $\beta < .949$ a naif would procrastinate in switching to Plan C, for $\beta > .949$ she would in fact transfer her $10,000 immediately. Now suppose her principal increases to $50,000. If the person still planned to choose Plan C, she would be less likely to procrastinate, since an increased principal makes the person less likely to procrastinate any specific choice. But Table 8 reveals that Plan D is now the best choice (i.e., TCs now choose Plan D), and that the person will procrastinate Plan D for any $\beta < .977$. Hence, even though the principal is larger, the person is more likely to procrastinate (i.e., the critical β increases) because Plan D is more costly than Plan C. A similar logic applies when the principal increases to $100,000 – the person would be less likely to procrastinate if she stuck to Plan D, but the more costly Plan E becomes the best choice and as a result the person is more likely to procrastinate despite the larger principal.

Parts (4), (5), and (6) of Table 8 illustrate how becoming more patient (i.e., having a larger δ^{365}) can increase the likelihood of procrastination. The intuition is almost identical to that for an increased principal. Although becoming more patient implies it is less likely that a person will procrastinate any given plan, becoming more patient also implies that the best plan is more costly, and as a result the person can become more likely to procrastinate.

Table 8 clearly required some "crafting" to produce our results. The primary reason for this, however, is that these calibrations are a discrete representation of more continuous real-life choice sets, where there are decreasing returns to the effort exerted towards finding a better investment but no upper bound on the amount of effort. Indeed, O'Donoghue and Rabin (1998) show (in a more abstract setting) that the results illustrated in Table 8 hold more generally when the choice set is continuous. The reader may have noticed that the calibrations in Table 8 involve large increases in the effort cost yielding only small increments to the rate of return. But these are precisely the types of margins a person is likely to confront in finding investments with high returns.[22]

We conclude our discussion of the calibrations in Table 8 by returning to the rhetorical question from the introduction: "Given its immense importance, will people really harmfully procrastinate in preparing for retirement?" Economists often make the reasonable conjecture that while people may make errors, they will be less prone to do so the more important is the decision. But our calibrations in Table 8 illustrate that this conjecture may very much be incorrect when the error is irrational procrastination. Indeed, our answer to the rhetorical question above is that it is exactly *because* retirement preparation is so important that people are likely to procrastinate such preparation.

5. Policy Implications

The premise of this paper is that people may make substantial errors of one particular form in preparing for retirement: They plan to invest wisely, but then procrastinate in carrying out these plans. While our formal model and calibrations illustrate this point for the simple decision to transfer funds from a low-interest account to a high-interest account, we feel the intuitions hold more generally. There are a variety of situations where a person ought to exert some effort towards retirement preparation, such as periodic adjustments to changing life circumstances or changing risk profile. And such situations would seem to have the same characteristics as our formal model – that is, given the immense importance of the decision, the person would like to put in significant effort,

[22] At the same time, we suspect that procrastination might be mitigated by another type of error: People do not realize how much effort they ought to be willing to expend to find a slightly higher return. We conjecture that many people don't realize that earning 10.6% rather than 10.5% for 30 years will cause their retirement savings to be 70% larger.

but since the cost of a short delay is small the person would rather put in this effort in the near future rather than today. We now conclude the paper by discussing some highly tentative policy prescriptions suggested by our procrastination theory of retirement preparation.

Because our policy prescriptions suggest ways to help people overcome errors, they are inherently paternalistic, and we realize this may bother some readers. We would like to emphasize, however, that we focus on policy prescriptions satisfying a notion of "cautious paternalism": They can be extremely valuable if people are making errors, but they have relatively small costs if people are fully rational. We believe that most people are most of the time better judges of what is good for them than are government officials, economic theorists, and other social scientists. But we also believe that people often make errors, that there is some discernible pattern to these errors, and that people can sometimes cause significant harm to themselves by making these errors.[23] Hence, it seems to us a worthwhile topic of research to explore the expected costs and benefits of different policies when we believe in the coexistence of rational behavior and specific errors.[24]

Our discussion in this section will also serve a second purpose that should be of interest even for those not interested in our prescriptive speculations. For many of the policies we consider (some of which already exist in some form or another), we discuss what our model and calibrations would *predict* about how people should react to these policies. These predictions can serve as proposed tests of the descriptive validity of our model.

Perhaps our core finding is that people will exhibit a strong status-quo bias: People will tend to keep their retirement savings in their existing investment plan even when it is not optimal because they never get around to switching. This suggests an obvious act of cautious paternalism: The government, or perhaps firms, could choose the default investment of individuals, while allowing them to override this status quo at minimal costs. For example, we might require that by default a portion of every worker's paycheck goes automatically into some reasonable investment-for-retirement plan. As long as the costs of opting out of this default investment are minor, there should be absolutely minimal costs of such manipulations if people are fully rational. In contrast,

[23] Another realm where people would seem to be making costly errors is the realm of addiction. See for instance Schelling (1992) and O'Donoghue and Rabin (1997*b*).

[24] Indeed, we believe that developing a *formal* approach to exploring cautiously paternalistic policies, where one carefully lays out exactly under what conditions a proposed policy would improve social welfare, would be a useful alternative to the rigidly anti-paternalistic approach the field of economics has adopted. Moreover, we feel that such a disciplined approach would also impose useful constraints on those who openly advocate paternalistic policies by forcing them to carefully examine the costs and benefits of proposed policies.

our model suggests that such manipulations can have huge benefits for procrastinators.[25]

In addition to the status-quo bias, our model also suggests that people will be highly sensitive to "short-term" incentives. According to our model, a person will procrastinate in preparing for retirement unless the cost of a short delay is sufficient to overcome the desire to put in the effort sometime in the future rather than now. Hence, two types of policies can make procrastination less likely: 1) policies that make the cost of a short delay loom larger, and 2) policies that reduce the effort required to take action and thereby reduce the desire to delay. As long as such manipulations of short-term incentives do not significantly affect long-term incentives, they can be relatively innocuous to fully rational people while immensely benefitting procrastinators.

One such intervention that already exists is the use of tax incentives to encourage people to invest in retirement plans (e.g., 401k plans and IRAs). Such tax incentives can help overcome procrastination in preparing for retirement because they may increase the perceived cost of delay. If a person's default plan is taxable, and her likely best alternative is tax-exempt, then the perceived cost of delay will include in addition to the lost interest the lost tax savings. We should emphasize that our model sheds no light on the ongoing debate concerning whether tax incentives for 401k plans and IRAs increase or decrease a person's tendency to save. Our model does suggest, however, that such tax incentives could get people to *invest* these savings more wisely, because the tax incentives make it more worthwhile to transfer one's savings from a low-interest checking or savings account at the local bank to the higher-interest funds available through 401k plans and IRAs.

Our model also suggests a second way to make a person perceive larger costs of delay: Impose "deadlines" on financial decisions. A particularly simple way to impose deadlines is to allow less frequent "transactions dates". For example, if transactions can occur on only the first day of any given month, then the first day of each month will loom as a deadline – that is, the person will be forced to recognize that if she does not decide to transfer her money before April 1, for instance, then she will not be able to make the transfer for at least 30 days. Such deadlines will for all intents and purposes not change the behavior of fully rational people, and will impose at most very small costs (i.e., the lost interest from having to wait until the first transaction date). But our analysis implies that such deadlines can have a large impact in helping a person overcome procrastination.

A practical way in which the government can impose deadlines on financial decisions is through specific rules concerning tax incentives. Indeed, there already exists a real-world deadline of this

[25] Of course, the value of this intervention depends on whether the default option is chosen wisely.

sort. American tax law encourages many workers to invest up to about $10,000 per year in tax-exempt IRAs. But the law requires that they make any given year's investment before April 15 of the following year (the annual tax deadline). As a result, April 15 looms as a deadline by which a person must transfer her money to an IRA if she wishes to receive the tax benefits. Of course, unless IRAs are inferior investments, this deadline ought to be irrelevant, because people ought to invest in IRAs well in advance of the deadline so as to avoid paying taxes on the interest earned in the interim. But Summers (1986) reports that 45 percent of 1984 IRA contributions were made in 1985. To reconcile this behavior with fully rational behavior, Summers attributes this timing to reasons such as "the advertising blitz that financial institutions put on every March and April". In contrast, we feel that our model may provide a more plausible explanation. Moreover, our model suggests that having this deadline may be exactly the right policy, because if a person could retroactively invest her $10,000 per year in an IRA at anytime she wanted, she might in fact never get around to investing in an IRA at all.

Our final proposed intervention, aimed at reducing the effort required to invest wisely, is the provision of work-place seminars on retirement planning. These seminars can potentially reduce the required effort in two ways. First, these seminars might provide truly helpful information towards finding a good investment. Second, if these seminars are made part of a normal workday – e.g., attendance at an hour-long seminar substitutes for an hour of work – and if people actually focus on investing wisely during these seminars, then such seminars will further reduce the opportunity cost of focusing attention on investing wisely.[26] In addition to reducing the effort required to invest wisely, workplace seminars might further help overcome procrastination by creating deadlines of the sort discussed above. If these seminars significantly reduce the effort required to invest wisely, and these seminars are offered relatively infrequently, then a person may perceive that not going to today's seminar means having to wait until the next seminar. Bernheim (1994) has in fact argued that organized retirement seminars can have large effects on retirement savings.

Of course, the policy prescriptions discussed above are highly tentative, and more formal analysis is required to determine under what conditions their benefits outweigh their costs. But as our model suggests that people may make major errors in retirement planning, we feel a careful consideration of cautiously paternalistic policies such as those discussed above is certainly called for.

[26] Offering employees a cash subsidy for attending the seminar on their own time may not be sufficient since the extra take-home pay will likely be perceived as a delayed reward.

Appendix: Derivation of Tables

Derivation of Table 1: The table merely presents $L(1)$ and $L(T)$ as defined in the text.

Derivation of Table 2: As should be clear from the text, the critical cost for TCs is $\bar{C}^{tc} \equiv \delta^T L(T)$, and the critical cost for naifs is $\bar{C}^n \equiv \frac{\beta}{1-\beta\delta}\delta^T L(1)$.

Derivation of Table 3: We assume in Table 3 that the person can make the transfer on days $(1, 8, 15, ...)$. Just as for Table 2, on day 1 a TC directly compares making the transfer immediately to never making the transfer, and therefore the critical cost for TCs is unchanged. When TCs make the transfer immediately, naifs repeatedly *believe* they will make the transfer in seven days if they do not do so today. Given the lost retirement savings from a seven-day delay is $L(7)$ and the transfer cost is C, on day 1 a naif will prefer delaying seven days if and only if $C > \beta\delta^7 C + \beta\delta^T L(7)$, and hence the critical cost for naifs is $\bar{C}^n \equiv \frac{\beta}{1-\beta\delta^7}\delta^T L(7)$.

Derivation of Table 4: As should be clear from the text, the critical cost for sophisticates is given by $\bar{C}^s \equiv \beta\delta^T L(T)$.

Derivation of Table 5: If a sophisticate delays for τ days, then on day 1 she must prefer to delay for τ days rather than to make the transfer immediately, which holds if and only if $C > \beta\delta^\tau C + \beta\delta^T L(\tau)$. Hence, the maximum delay for sophisticates is

$$\bar{\tau} \equiv \max\left\{\tau \in \{0, 1, 2, ...\} \mid \beta\delta^T L(\tau) - (1 - \beta\delta^\tau)C < 0\right\}.$$

Derivation of Table 6: Let $\hat{\tau}_t(\hat{\beta})$ denote the delay *perceived* in period t by a person with perceptions $\hat{\beta}$. To formalize a solution concept for partial naivete, we assume that $\hat{\tau}_t(\hat{\beta})$ is equal to the delay perceived in period t by a completely sophisticated person with self-control problem $\hat{\beta}$ (which can be uniquely determined via backwards induction). If we then let $\bar{\tau}_t(\beta)$ denote the longest delay that a person with self-control problem β would tolerate in period t, we can conclude that a person with self-control problem β and perceptions $\hat{\beta}$ will never make the transfer if and only if $\hat{\tau}_t(\hat{\beta}) \leq \bar{\tau}_t(\beta)$ for all t.

Unfortunately, both $\hat{\tau}_t(\hat{\beta})$ and $\bar{\tau}_t(\beta)$ will vary across t, making it computationally difficult to fully characterize the set of $\hat{\beta}$ that will induce procrastination. We can, however, arrive at sufficient conditions without too much trouble. First note that the longest delay a sophisticate with self-control problem $\hat{\beta}$ could perceive in period t is $\bar{\tau}_t(\hat{\beta}) + 1$, and therefore a sufficient condition for a person to never make the transfer is $\bar{\tau}_t(\hat{\beta}) < \bar{\tau}_t(\beta)$ for all t.

Let $L_t(\tau)$ be the lost retirement savings from a τ-day delay starting in period t (and obviously conditional on not having made the transfer prior to period t). It is straightforward to derive

$$L_t(\tau) \equiv P\left(1+\frac{r_A}{365}\right)^{t-1}\left[\left(1+\frac{r_B}{365}\right)^{T-t+1} - \left(1+\frac{r_A}{365}\right)^{\tau}\left(1+\frac{r_B}{365}\right)^{T-t+1-\tau}\right].$$

It is convenient to define $A_t(\tau) \equiv \delta^{T+1-t} L_t(\tau) + \delta^{\tau} C$, and then

$$\begin{aligned} \bar{\tau}_t(\beta) &\equiv \max\left\{\tau \in \{0,1,2,...\} \mid C > \beta A_t(\tau)\right\} \\ \text{and} \quad \bar{\tau}_t(\hat{\beta}) &\equiv \max\left\{\tau \in \{0,1,2,...\} \mid C > \hat{\beta} A_t(\tau)\right\}. \end{aligned}$$

For any given t, $\bar{\tau}_t(\hat{\beta}) < \bar{\tau}_t(\beta)$ if and only if $\hat{\beta} A_t(\bar{\tau}_t(\beta)) \geq C$. By definition $\bar{\tau}_t(\beta)$ satisfies $A_t(\bar{\tau}_t(\beta)+1) \geq (C/\beta)$. It is straightforward to show that if $\delta\left(1+\frac{r_B}{365}\right)/\left(1+\frac{r_A}{365}\right) \geq 1$ (which holds for all examples considered), then we have $A_t(\tau+1) - A_t(\tau) \leq A_1(1) - A_1(0)$ for all $t \geq 1$ and $\tau \geq 1$, which implies

$$A_t(\bar{\tau}_t(\beta)) \geq A_t(\bar{\tau}_t(\beta)+1) - [A_1(1) - A_1(0)] \geq (C/\beta) - [A_1(1) - A_1(0)] \text{ for all } t.$$

A sufficient condition for $\bar{\tau}_t(\hat{\beta}) < \bar{\tau}_t(\beta)$ for all t is then $\hat{\beta}\left[(C/\beta) - [A_1(1) - A_1(0)]\right] \geq C$, and the condition used in Table 6 is

$$\hat{\beta} \geq \frac{C}{(C/\beta) - [A_1(1) - A_1(0)]}.$$

Derivation of Table 7: As discussed in the text, on any given day a naif will consider three options: choose Plan B today, choose Plan C today, and (plan to) choose Plan C tomorrow. First, consider the comparison of Plan C today vs. Plan C tomorrow. If we define

$$\tilde{L}(\tau) \equiv P\left[\left(1+\frac{r_C}{365}\right)^T - \left(1+\frac{r_A}{365}\right)^\tau \left(1+\frac{r_C}{365}\right)^{T-\tau}\right],$$

then a sufficient condition for a naive person to always prefer Plan C tomorrow to Plan C today is $C > \beta\delta^T\tilde{L}(1) + \beta\delta C$ or $\beta < \frac{C}{\delta^T\tilde{L}(1)+\delta C} \equiv \beta^c$.

Next consider the comparison of Plan B today vs. Plan C tomorrow. Define t^* to be the first day on which the person prefers Plan B today over Plan C tomorrow. Assuming $r_A = 0\%$,

$$t^* = \min\left\{t \in \{1,2,...\} \;\middle|\; \beta\delta^{T+1-t}P\left(1+\frac{r_C}{365}\right)^{T-t} - \beta\delta C < \beta\delta^{T+1-t}P\left(1+\frac{r_B}{365}\right)^{T+1-t}\right\}.$$

Note that t^* is independent of β.

Table 7 then uses the following logic. If $\beta > \beta^c$, the person will either choose Plan C on day 1 or Plan B on day 1. In fact, for all examples we consider, she will choose Plan C on day 1 (which follows from $t^* > 1$). If $\beta < \beta^c$, then the person will choose Plan B on day t^*.

Derivation of Table 8: TCs will clearly choose Plan $K \in \{C, D, E\}$ that maximizes

$$\delta^T P\left(1+\frac{r_K}{365}\right)^T - C_K.$$

For each $K \in \{C, D, E\}$, define

$$\tilde{L}^K(\tau) \equiv P\left[\left(1+\frac{r_K}{365}\right)^T - \left(1+\frac{r_A}{365}\right)^\tau \left(1+\frac{r_K}{365}\right)^{T-\tau}\right],$$

and then a sufficient condition for a naif to always prefer Plan K tomorrow to Plan K today is $C > \beta\delta^T\tilde{L}^K(1) + \beta\delta C$ or $\beta < \frac{C}{\delta^T\tilde{L}^K(1)+\delta C} \equiv \beta^K$.

Table 8 then reports the Plan $K^{tc} \in \{C, D, E\}$ chosen by TCs, and the critical self-control problem $\beta^{K^{tc}}$ that will induce naifs to procrastinate on Plan K^{tc}. To ensure procrastination for all $\beta < \beta^K$, we must confirm that for each $K' \in \{C, D, E\}$ the person does not prefer Plan K' today to Plan K tomorrow. For all examples we consider this condition holds.

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