HOW TO MODEL PROCRASTINATION AND REDUCE RELATED WELFARE LOSS

Master’s Thesis
Henni Puhakka
Aalto University School of Business
Master’s Programme in Economics
Fall 2021
Author: Henni Puhakka

Title: How to model procrastination and reduce related welfare loss

Date: Fall 2021  
Language: English  
Number of pages: 4+87

Master of Science in Economics and Business Administration
Master’s Programme in Economics

Advisor: Daniel Hauser

A large body of empirical evidence shows that time-inconsistent preferences and procrastination are common. We all have proven that procrastination occurs often in mundane situations when studying, working, exercising, or saving money, for instance. As procrastination causes severe welfare losses both at individual and societal levels, new ways to battle the problem must be found. Therefore, this thesis studies how to model procrastination and reduce related welfare loss.

This paper strives to respond to these questions by providing a semi-systematic literature review gathering the essence of existing procrastination-related knowledge into one research paper and by developing a new theoretical model analyzing scheduling as a soft commitment device. The model suggests how the reference point framework can be applied to scheduling in a task-specific way and examines how different types of agents decide about their schedule and the completion date of a certain task. Furthermore, it analyzes whether and when scheduling decreases procrastination.

The literature review concludes that severe welfare losses may occur when naifs procrastinate or sophisticates preproperate repeatedly. Naifs are prone to procrastinate with tasks that have immediate costs and future benefits, whereas sophisticates tend to preproperate with tasks that include immediate benefits and future costs. Furthermore, the literature review discusses four welfare-improving devices, self-rewards, deadlines, cooperation, and promises, in greater detail.

The model concludes that scheduling can be used as a commitment device since it decreases procrastination and related welfare loss under certain conditions. In general, scheduling is effective when the agent’s present bias is mild or moderate and when the task in question has high stakes. Agents with severe present bias procrastinate anyway, so scheduling cannot help them. An important exception to this is an agent who underestimates their present bias significantly and schedules in the first period. In that case, the exponentially increasing reference-dependent welfare loss can incentivize the agent to complete the task regardless of their severe present bias. The model also shows that sophisticates always schedule such that they never procrastinate, whereas naifs schedule as they would have time-consistent preferences. Partial naifs schedule as sophisticates but based on their belief in their present bias. Therefore, only naifs and partial naifs can be harmed by scheduling.

Keywords: Time-inconsistent preferences, procrastination, preproperating, present-biased preferences, present bias, sophisticates, naifs, partial naifs, scheduling, deadlines, commitment devices, welfare loss.

Tässä tutkielmassa pyritään vastaamaan näihin kysymyksiin laatimalla semisysteematautinen kirjallisuuskatsaus, jossa kootaan olemassa oleva, viivyttelyyn liittyvä tieto olennaisilta osin yhteen tutkimukseen, ja kehitetään uusi teoreettinen malli, jossa analysoidaan aikataluttamista joustavana sitoutumisvälineenä. Mallissa ehdotetaan, miten referenssipiste-mallia voidaan soveltaa aikataluttamiseen tehtäväkohtaisesti, ja tarkastellaan, miten erityyppiset agentit päättävät aikatalustaan ja tietyyn tehtävän suoritusajankohdasta. Lisäksi siinä analysoidaan, vähentääkö aikatalutus viivyttelyä ja missä tilanteissa.

Kirjallisuuskatsauksen perusteella voidaan todeta, että vakavia hyvinvointitappioita voi aiheutua, kun naivit agentit viivyttelivät tai sivistyneet tekevät tehtävänä liian aikaisin toistuvasti. Naiivit agentit ovat alttiita viivyttelemään tehtävissä, joihin liittyvät välittömät kustannukset ja tulevia hyötyjä, kun taas sivistyneillä on tapaturma suoritaa liian aikaisin tehtäviä, joihin liittyvät välittömät hyötyjä ja tulevia kustannuksia. Lisäksi kirjallisuuskatsauksessa käsitellään tarkemmin neljää hyvinvointia parantava välineitä, itsepalpitseminen, määrääikoja, yhteistyötä ja lupauksia.


Avainsanat: Viivyttely, ajallisesti epäjohdonmukaiset preferenssit, sivistyneet agentit, naivit agentit, osittain naivit agentit, aikatalutus, deadline, määrääika, sitoutumisväline, hyvinvointitappio, nykyvainouma.
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1 Introduction

In classical economics, individuals are assumed to behave rationally. Consumers are often seen as rational utility maximizers who are fully aware of their preferences and completely able to make well-reasoned decisions to achieve the best possible outcomes. [Herrnstein, 1990; Dellavigna, 2009]. However, not all economists think that this is the best way to proceed. In the 1980s, behavioral economics was founded by a group of economists who argued that more realistic assumptions about human behavior were needed in economic models. [Barberis, 2018]. Behavioral economics combines psychology with economics to augment the economic modeling framework in order to accommodate observed behavior that is seemingly at odds with standard models. Time inconsistency in decision-making is one of the most common behaviors that behavioral models seek to capture. [Hepburn et al., 2010; Samson, 2014]. Temporally biased preferences cause irrational behavior and various self-control problems including procrastination [Akerlof, 1991]. Procrastination relates to various mundane activities regarding studying, working, saving, exercising, dieting, and stopping addictive behavior. As the consequences of these self-control problems accumulate, welfare losses may become severe at both individual and societal levels [O’Donoghue and Rabin, 1999]. Procrastination is a significant and common problem among students, for instance. As the development of human capital is crucial for economic growth and well-being, delayed graduation or dropping out caused by procrastination produce substantial societal welfare losses. [Himmler et al., 2019]. Several stakeholders, as policymakers, teachers, and employers would benefit from understanding the issue better and having concrete solution options. Therefore, it is necessary to find ways to decrease procrastination and reduce related welfare loss.

Both time-inconsistent preferences and procrastination are widely studied. Beyond theoretical work, there is rich experimental literature documenting time inconsistency in psychology and economics. These models are broadly applied in many diverse fields including finance, marketing, industrial organization, and macroeconomics. My thesis studies how to economically model procrastination, its welfare effects, and how to decrease related welfare loss. The research questions are:

- How to model procrastination?
- What are the welfare effects of procrastination?
- How can we decrease procrastination-related welfare loss?

To answer these questions, I study in which ways procrastination is modeled in the literature of economics and what the different models say about the welfare effects of procrastination. I also discuss whether there exists consensus between different studies
and researchers. Furthermore, I present possible solutions to decrease the welfare loss and discuss their advantages and shortcomings. Finally, I develop a new theoretical model analyzing whether scheduling can be used as a commitment device to decrease procrastination.

1.1 Research objectives

Empirical research shows that time inconsistency is an essential part of economic decision-making. Procrastination relates to many everyday self-control problems and causes significant welfare losses. It is important to understand it better and have ways to incorporate time inconsistency into economic models. Furthermore, it is necessary to find ways to reduce the welfare loss caused by procrastination. I aim to gather the essence of this information into one research paper, and thus provide a coherent and concise study about the phenomenon. In addition, I develop a new theoretical model analyzing scheduling as a commitment device. From the academic perspective, this research serves as a totality that combines various studies from different perspectives and uses this information to provide a new model.

1.2 Structure of the thesis

The thesis is structured as follows. The second section of this thesis is a literature review consisting of six chapters. The first one introduces the main concepts regarding procrastination. The second chapter discusses two basic models of procrastination by O’Donoghue and Rabin (1999, 2001). The third chapter presents two alternative modeling approaches; the dual-self model and rational addiction. The fourth chapter introduces leading applications of procrastination, and the fifth covers its welfare effects. The last chapter presents four ways to reduce procrastination-related welfare loss. The third section introduces a model that analyzes whether scheduling works as a commitment device and decreases procrastination. The fourth section covers research material and methods in greater detail. The fifth section sums up the findings of the thesis, and the sixth section is allocated for discussion. Finally, the seventh section concludes the thesis, after which appendices are presented.
2 Literature Review

2.1 Basic concepts concerning procrastination

This chapter introduces the main concepts concerning procrastination. The chapter begins with the introduction of time-inconsistent preferences, where present-biased preferences and hyperbolic discounting are covered. Then it discusses reference point shifts and deprivation as a way to explain time-inconsistent preferences. Lastly, different types of agents are presented.

2.1.1 Time-inconsistent preferences

Economists often assume people to have time-consistent preferences, meaning that an agent’s relative preference for future utility does not change as time passes. This means that an agent does not change their mind as a reward or cost approaches. Time-consistent preferences are often modeled by exponential discounting of utility which captures agents’ impatience. In this model, \( u_t \) is agent’s instantaneous utility in period \( t \). The agent gets utility from period \( t \)’s instantaneous utility \( (u_t) \) but also from upcoming periods’ instantaneous utilities \( (u_{t+1}, u_{t+2}, \ldots, u_T) \). Thus, agent’s intertemporal preferences are denoted by \( U^t(u_t, u_{t+1}, \ldots, u_T) \). A simple model for exponential discounting used commonly is:

\[
U^t(u_t, u_{t+1}, \ldots, u_T) = \sum_{\tau=t}^{T} \delta^\tau u_\tau
\]

for all \( t \) and with a discount factor \( \delta \in (0, 1] \). This way of modeling intertemporal preferences is technically convenient as the same consumption stream solves the equation at every point in time. It enables us to write the problem recursively, for instance.

O’Donoghue and Rabin (1999) study a simple decision problem where an agent chooses when to undertake a single task. If the agent does the task at time \( t \), they receive reward \( v_t \) and cost \( c_t \). In the model with exponential discounting an agent never violates two properties, dominance and independence of irrelevant alternatives. They define dominance being obeyed if the agent always chooses a period with positive rewards and no costs over a period with positive costs and no rewards. Formally:

DEFINITION 1: An agent obeys dominance if whenever there exists some period \( \tau \) with \( v_\tau > 0 \) and \( c_\tau = 0 \) the agent does not complete the task in any period \( \tau' \) with \( c_{\tau'} > 0 \) and \( v_{\tau'} = 0 \).

Definition 1 states that the agent always chooses the strategy that dominates other strategies. The independence of irrelevant alternatives means that deleting a non-dominant option from a choice set should not affect the agent’s decision in any way.
Formally:

**DEFINITION 2:** For any \( \mathbf{v} \equiv (v_1, v_2, \ldots, v_T) \) and \( \mathbf{c} \equiv (c_1, c_2, \ldots, c_T) \), define \( \mathbf{v}^{-t} \equiv (v_1, \ldots, v_{t-1}, v_{t+1}, \ldots, v_T) \) and \( \mathbf{c}^{-t} \equiv (c_1, \ldots, c_{t-1}, c_{t+1}, \ldots, c_T) \). An agent's behavior is independent of irrelevant alternatives if whenever they choose period \( \tau' \neq t \) when facing \( \mathbf{v} \) and \( \mathbf{c} \) they also choose \( \tau' \) when facing \( \mathbf{v}^{-t} \) and \( \mathbf{c}^{-t} \).

Agents with time-inconsistent preferences do not obey the dominance and independence of irrelevant alternatives the same way as agents with time-consistent preferences do.[O’Donoghue and Rabin, 1999]. There exists a large body of empirical research, both in the field of psychology and economics, showing that time-inconsistent preferences are common; people desire instant rewards but tend to avoid instant costs even when these actions may harm their long-run utility. This finding is strongly supported by casual observation as time-inconsistent decision-making is apparent in our everyday life. People tend to procrastinate, get addicted, and irrationally obey authorities, for instance. There does not exist consensus, whether decisions driven by time-inconsistent preferences can be thought of as reasonable and justified. Economists endeavor to answer this question by analyzing the welfare effects of decisions driven by time-inconsistent preferences, elaborated in chapter 2.3. For example, Hoch and Loewenstein (1991) argue that decisions driven by time-inconsistent preferences are not rational. Agents themselves report regretting these impulsive decisions when they could not resist the temptation. Furthermore, agents often engage in different kinds of activities that are supposed to help them control their behavior and be more patient. Thus, it seems that at least the agents themselves do not see decisions driven by time-inconsistent preferences as reasonable as those driven by time-consistent preferences.

**Present bias and hyperbolic discounting**

Consider a situation where an agent can choose between 150 euros today or 160 euros in 4 weeks and between 150 euros after 48 weeks or 160 euros after one year. If the agent has time-consistent preferences, they should answer these questions similarly since once 48 weeks have passed, the choice they face is exactly the same as the choice today. However, it has been shown that people often do not give the same answer for both questions. Present-biased preferences make one prefer the present moment relatively more compared to future periods, and thus many agents choose 150 euros now, but 160 in one year. However, when 48 weeks have passed, they would prefer to have 150 euros immediately. Many of us fail to foresee this, and when asked in advance, prefer to wait for the larger reward.
Present-biased preferences make the agent value well-being in the present moment more compared to any future moment. In other words, the agent tends to give greater relative weight to earlier moments. Present-biased preferences are commonly modeled by hyperbolic discounting, meaning that the agent discounts events in the near future more than those farther away. The discount rate between the two periods is different depending on whether those periods are in close proximity to the current period or not. A general version of the hyperbolic discount function can be represented as follows:

$$U_t = E_t[u(c_t) + \beta \sum_{\tau=1}^{T-t} \delta^{\tau} u(c_{t+\tau})].$$

The equation above gives dynamically inconsistent preferences, meaning that preferences at different dates are not consistent with each other. The agent changes their mind as time passes and does not want to follow plans made earlier. [Laibson, 1997]. Another equation used to represent present-biased preferences by using hyperbolic discounting is the following by O’Donoghue and Rabin (1999):

$$U_t^\delta(u_t, u_{t+1}, \ldots, u_T) \equiv \delta^t u_t + \beta \sum_{\tau=t+1}^{T} \delta^{\tau} u_\tau$$

(2)

for all $t$, $\beta > 0$ and $\delta \leq 1$. $\delta$ is interpreted as a long-run, time-consistent discount factor and $\beta$ as the bias for the present. If $\beta = 1$, there exist no present bias, and the equation becomes the simple exponential discounting model (equation 1) presented earlier. Whereas, if $\beta < 1$, there exists a bias for the present; the agent values period $\tau$ more relative to future periods in period $\tau$ than they did in previous periods. The preferences represented by this model are called $(\beta, \delta)$-preferences.[O’Donoghue and Rabin, 1999].

Reference points and deprivation

Discounting is not the only possible way to explain time-inconsistent preferences. Hoch and Loewenstein (1991) highlight that the discounting perspective does not explain why agents’ time-inconsistent preferences are only related to specific goods such as alcohol, drugs, desserts, etc., and why physical proximity is often required for agents to behave impulsively. They offer an alternative explanation that describes impulsive decisions as results of shifts in agents’ reference points. These shifts cause sudden changes in agents’ desire, make them behave irrationally, and cave into their impatience. Different factors, for example, physical proximity, can cause reference point to shift. If an agent’s reference point shifts, they develop a psychological need for the good and feel deprived if this need is not fulfilled, i.e., face negative utility from not consuming the good in question. [Hoch and Loewenstein, 1991].
The magnitude of a reference point shift is denoted by $r$. The agent’s utility $D$ can be modeled as follows:

$$D = \alpha(P - r) + \beta(r - 0),$$

where $\alpha$ stands for the slope of the value function in the positive region and $\beta$ for the slope in the negative region. Furthermore, $P$ is normalized such that $\alpha P$ matches the agent’s no-adaptation utility level for the good $D_1$. This equation shows that whenever the slope in the negative region is larger ($\beta > \alpha$), a rise in $r$ will increase $D$. In other words, a shift in the reference point raises the agent’s desire for the good. [Hoch and Loewenstein, 1991].

Figure 1 demonstrates how the reference point shift affects the agent’s value of consumption. In Figure 1, $r$ is the agent’s level of adaptation between purchase ($P$) and non-purchase ($0$). Lines in the graph represent the agent’s value functions relative to reference points, which are located in the intersection points of the value functions and x-axis. To capture loss aversion, it is assumed that the value function is steeper below the x-axis. The no adaptation line (lighter line) represents the state when the agent has not experienced a shift in the reference point. If they do not purchase the good, they get zero utility, and if they purchase the good, they receive utility denoted by $D_1$. The adaptation line (thicker line) represents the state when the agent has experienced a shift.

Figure 1: Adaptation and the value of consumption

in their reference point. This can be a consequence of physical proximity, for instance, which makes the agent partially adapt to owning the good in advance. This shifts the value function to the right. Now the reference point is situated in between purchase and no purchase, which means that choosing not to buy the good is not neutral anymore but causes a utility loss. Accordingly, the utility from buying the good is denoted by $D_2$, which is larger than $D_1$. [Hoch and Loewenstein, 1991].

Even though Figure 1 demonstrates a shift in the reference point, it is insufficient since

![Diagram](image)

Figure 2: Choice between immediate and delayed consumption


it is static and does not consider time. To complete this analysis, Hoch and Loewenstein introduce a dynamic figure that demonstrates how time affects the agent’s decision process, see Figure 2. Rectangles in the positive region present utility gains from consumption, and polygons in the negative region present utility losses from waiting. In Figure 2a, the agent dislikes the waiting as much the whole time, and thus the utility loss is represented by a rectangle. The figure shows that if the utility loss caused by waiting is big enough, the agent chooses to consume immediately. The size of the utility loss depends on the length of waiting and the agent’s personal level of dislike towards waiting. Figure 2b presents a case when the growth of waiting-related utility loss decreases as time passes, and thus the area is represented by a triangle. This is
common in cases where the agent focuses on other things and kind of forgets that they are waiting. The final case is represented in Figure 2c, in which the growth of the utility loss from waiting increases as time passes. Waiting becomes more unpleasant every day as the agent’s urge to consume increases. In this case, the area is represented by a triangle facing in the opposite direction compared to Figure 2b. [Hoch and Loewenstein, 1991].

Hoch and Loewenstein propose three different causes for reference point shifts. The first one is physical proximity. Experiments have shown that placing the reward in view increases the agent’s impatience and desire for the reward. Physical proximity causes agent’s reference point to shift as they adapt to having the reward in advance, and waiting becomes harder. The second cause for a reference point shift is temporal proximity. Agents are more impatient towards rewards that are available immediately. In other words, temporal proximity shifts the agent’s reference point, and hence agent’s desire towards the reward increases. The third cause for a reference point shift is social comparison. Studies show that people tend to compare themselves to lightly superior peers. The agent adapts to owning the reward the lightly superior peer already has and this causes the agent’s desire and impatience regarding the reward to increase. [Hoch and Loewenstein, 1991].

2.1.2 Different types of agents

In O’Donoghue and Rabin’s (1999) article, agents are divided into two different groups: sophisticates and naifs. Sophisticates are completely aware of their time-inconsistent preferences. They understand that they will face self-control problems later and are prone to procrastinate. Naifs, on the other hand, are completely unaware of their time-inconsistent preferences. They do not realize that they will have self-control problems in the future. This difference between the types causes significant differences in agents’ decision-making and utility outcomes. Both sophisticates and naifs are compared to a standard type with time-consistent preferences to find out the effect of time-inconsistent preferences. Sophisticates are also compared to naifs to find out the effect of sophistication. [O’Donoghue and Rabin, 1999].

Sophisticates capture the fact that people want to commit to smaller choice sets, as addiction clinics or gym memberships to overcome their self-control problems. However, only a sophisticated person would want to do this as they know they will face self-control problems in the future. At the same time, naifs never feel any need for commitment devices as they wrongly believe that they will have the willpower to perform tasks at hand. It is common for naifs to believe that one will stop smoking tomorrow, even though it should have already been done today.[O’Donoghue and Rabin, 1999]

Another possible type for an agent is partial naivete. A partially naive agent foresees that
they will have self-control problems in the future but underestimates the magnitude of those problems. To formally model this type’s preferences, agent’s belief in their future self-control problems are noted by \( \hat{\beta} \). As sophisticates are fully aware of their future self-control problems, for them \( \hat{\beta} = \beta \). Naïfs believe their preferences are time-consistent, thus for them \( \hat{\beta} = 1 \). Partial naïfs belong somewhere between sophisticates and naïfs. They are not fully aware of the magnitude of their future self-control problems, nor do they think they have time-consistent preferences. Formally noted, for them \( \hat{\beta} \in (\beta, 1) \). [O’Donoghue and Rabin, 2001].

2.2 Basic models of procrastination

This chapter represents two basic economic ways to model procrastination. The first one discusses how procrastination with a single item choice set can be modeled, whereas the second section covers models regarding procrastination with a choice set of several items.

2.2.1 Single item choice set

In O’Donoghue and Rabin’s (1999) model agents decide on the timing of an activity during a finite amount of periods, denoted by \( T \). In other words, agents have a single item choice set and the only decision they make is to choose when to complete the task. Agents are not able to commit to completing the activity in the future, meaning they can only choose whether to perform the activity in the current period or not. If an agent has not completed the activity by period \( T \), they have no choice but to perform it then since the activity must be completed precisely once. The agent faces a reward schedule \( v = (v_1, v_2, \ldots, v_T) \in \mathbb{R}_+^T \) and cost schedule \( c = (c_1, c_2, \ldots, c_T) \). The agent receives the cost and the reward corresponding to the period when they choose to perform the activity, but the reallocation of one or both of them might be delayed. O’Donoghue and Rabin introduce two cases of interest: costs are immediate and rewards delayed, and vice versa. With immediate costs the agent’s intertemporal utility in period \( t \leq \tau \) is presented as follows assuming they perform the activity in period \( \tau \):

\[
U^t(\tau) = \begin{cases} 
\beta v_\tau - c_\tau & \text{if } \tau = t, \\
\beta v_\tau - \beta c_\tau & \text{if } \tau > t.
\end{cases}
\]  

(3)

\( \beta v_\tau - c_\tau \) is the agent’s utility if they complete the activity today. In that case, the agent discounts only the rewards, because costs are immediate. \( \beta v_\tau - \beta c_\tau \) represents the agent’s utility from taking the action in the future. In those cases, both rewards and costs are discounted because they lie in the future. With immediate rewards agent’s intertemporal utility in period \( t \leq \tau \) is presented as follows assuming they perform the
activity in period \(\tau\):

\[
U^t(\tau) = \begin{cases} 
u_\tau - \beta c_\tau & \text{if } \tau = t, \\ \beta u_\tau - \beta c_\tau & \text{if } \tau > t. \end{cases}
\]  

(4)

Now we notice that discounting in the upper row is reversed compared to equation 3. The upper row represents the agent’s utility in the period they complete the activity. As rewards are now immediate, the agent discounts only the costs. The lower row is identical to equation 3. As already mentioned earlier, in this model agents are divided into two different groups, sophisticateds and naifs, who both have present-biased preferences \((\beta < 1)\). O’Donoghue and Rabin compare these two types to a standard type, which has time-consistent preferences \((\beta = 1)\), denoted by TC. [O’Donoghue and Rabin, 1999].

The agent’s behavior strategy is denoted by \(s = (s_1, s_2, \ldots, s_T)\), where \(s_\tau \in \{Y, N\}\) for all \(t \in \{1, 2, \ldots, T\}\). \(Y\) means that the agent decides to perform the activity in the current period and \(N\) stands for waiting. The solution concept is a perception-perfect strategy which is defined as a strategy where the agent chooses the best possible action in all periods taking into account their current preferences and their assumption about their future preferences. These perception-perfect strategies are defined for both types considered, sophisticateds and naifs, and for TCs as well. For TCs the perception-perfect strategy \(s^c = (s_1^c, s_2^c, \ldots, s_T^c)\) satisfies \(s_\tau^c = Y\) for all \(t < T\) if and only if \(U^t(t) \geq U^t(\tau)\) for all \(\tau > t\). They simply choose the period that gives them the highest utility. For naifs, the perception-perfect strategy \(s^n = (s_1^n, s_2^n, \ldots, s_T^n)\) satisfies \(s_\tau^n = Y\) for all \(t < T\) if and only if \(U^t(t) \geq U^t(\tau)\) for all \(\tau > t\). Naifs have the exact same decision process as TCs because they believe incorrectly that they have time-consistent preferences even though, in reality, they suffer from present bias. For sophisticateds, the perception-perfect strategy \(s^s = (s_1^s, s_2^s, \ldots, s_T^s)\) satisfies \(s_\tau^s = Y\) for all \(t < T\) if and only if \(U^t(t) \geq U^t(\tau')\) where \(\tau' = \min_{\tau > t}\{\tau : s_\tau^s = Y\}\). Sophisticateds suffer from present bias but, unlike naifs, they are aware of that and anticipate how their preferences evolve over time. Therefore, their decision process differs from that of naifs and TCs. [O’Donoghue and Rabin, 1999].

Present bias causes agents to procrastinate with immediate costs and preproperate with immediate rewards. Both sophisticateds and naifs delay the completion of the task too much when immediate costs occur and complete the action too early when rewards are immediate. It is very intuitive, as present bias means that the agent gives too much weight to the current period relative to future periods. When costs are immediate, the agent does not want to realize them even though they might face even higher costs in the future. With immediate rewards, the situation is reversed since the agent wants to receive the reward in the current period even though they would get a bigger reward.
in the future. O’Donoghue and Rabin argue that naifs are only influenced by the present bias effect. Naifs incorrectly believe that their preferences are time-consistent so sophistication effect cannot play a role in their decision-making. That is to say, naifs always procrastinate with immediate costs and preprooperate with immediate rewards compared to the standard type with time-consistent preferences. The sophistication effect captures the difference in behavior between the naifs and the sophisticates, i.e., how the awareness of one’s present bias affects decision-making. Since sophisticates are fully aware of their future self-control problems, their behavior is influenced by both the sophistication effect and the present bias effect. The sophistication effect causes sophisticates to complete the action at hand always before naifs as sophisticates anticipate that they will have self-control problems in the future. However, this has different welfare implications with immediate costs and with immediate rewards. These welfare implications are discussed in greater detail in chapter 2.3. [O’Donoghue and Rabin, 1999].

2.2.2 Several item choice set

O’Donoghue and Rabin (2001) present a model where in every period an agent chooses whether to complete a task or wait. If they choose to complete a task they also must choose which one from a static menu of tasks \( X \subset \mathbb{R}_+^2 \). \( X \) is assumed to be closed. Each task can be completed exactly once, and the agent can complete only one task in total. This model has an infinite number of periods. In each period, the agent has a set of actions available \( A \equiv X \cup \{\emptyset\} \), where \( \emptyset \) denotes that the agent does not complete any task in that period. The agent’s behavior is described by a strategy \( s \equiv (a_1, a_2, \ldots) \) where \( a_t \in A \) defines an action for each period \( t \). The period when the agent chooses to complete the task is denoted by \( \tau(s) \), whereas the task they choose to complete is denoted by \( x(s) \). In addition, every single task \( x \) in the menu \( (x \in X) \) includes a non-negative immediate cost \( c \) \((c \geq 0)\) and a delayed non-negative constant stream of benefits \( v \) \((v \geq 0)\), which starts from period \( \tau(s) + 1 \). Thus, \( x = (c, v) \). According to this model, the following equations hold when \( \tau(s) = \infty \):

\[
\tau(s) = \min\{t | a_t \neq \emptyset\} \quad \text{and} \quad x(s) = a_{\tau(s)}.
\]

Furthermore,

\[
x(s) = \emptyset \quad \text{if} \quad a_t = \emptyset \quad \text{for all} \quad t
\]

describes the following strategy profile \( s^\emptyset = (\emptyset, \emptyset, \ldots, \emptyset) \), which is an especially interesting case as it means that the agent never completes any task. [O’Donoghue and Rabin, 2001].
With this model, O’Donoghue and Rabin characterize which task the agent chooses to complete and when, if at all. The agent’s period-t beliefs in their future behavior are denoted by \( \hat{s}^t \equiv (\hat{a}^t_{t+1}, \hat{a}^t_{t+2}, \ldots) \), where \( \hat{a}^t_t \) indicates agent’s belief in period \( t \) in which action they would choose in period \( \tau \) if they have not completed the task by that time. Furthermore, \( V^t(a_t, \hat{s}^t, \beta, \delta) \) denotes the agent’s period-t preferences over actions in the current period \( (a_t) \), conditional on following the strategy \( \hat{s}^t \) beginning in period \( t + 1 \). Period-t preferences can be expressed as follows:

\[
V^t(a_t, \hat{s}^t, \beta, \delta) \equiv \begin{cases} 
-c + \frac{\beta \delta v}{1 - \delta} & \text{if } a_t = (c, v); \\
\beta \delta^\tau (-c + \frac{\delta v}{1 - \delta}) & \text{if } a_t = \emptyset, \\
\tau \equiv \min\{d > 0|\hat{a}^t_{t+d} \neq \emptyset\} & \text{exists,} \\
\text{and } \hat{a}^t_{t+\tau} = (c, v); \\
0 & \text{if } a_t = \emptyset \text{ and } \hat{a}^t_{t+d} = \emptyset \text{ for all } d > 0.
\end{cases}
\]

The three cases above describe different possibilities for the agent. In the first case, the action chosen in the current period \( (a_t) \) is a task with the following cost and benefit structure \( (c, v) \). Since the task is completed in the present moment, the cost is not discounted, whereas the delayed reward \( (\frac{\delta v}{1 - \delta}) \) is. In the second case, the action chosen in the current period is to do nothing, and the agent believes that they will complete a task \( (c, v) \) in \( \tau \) periods, thus both the cost and benefit are discounted by \( \beta \). In the last case, the action chosen in the current period is again to do nothing, but unlike in the previous case, now the agent believes that they will never complete any task in any future period, thus their payoff is 0. [O’Donoghue and Rabin, 2001].

Since the agent maximizes their utility in the current period \( V^t \) taking into account their beliefs \( \hat{s}^t \), it is required that the beliefs are dynamically consistent.

**DEFINITION 3:** With \( \hat{\beta} \leq 1 \) and given \( \delta \), a set of beliefs \( \{\hat{s}^1, \hat{s}^2, \ldots\} \) is dynamically consistent if

1. for all \( \hat{s}^\tau \), \( \hat{a}^\tau_t = \arg\max_{a \in A} V^\tau (a, \hat{s}^\tau, \hat{\beta}, \delta) \) for all \( \tau \) and
2. for all \( \hat{s}^t \) and \( \hat{s}^{t'} \) with \( t < t' \), \( \hat{a}^\tau_t = \hat{a}^{\tau'}_{t'} \) for all \( \tau > t' \).

Part (1) defines internal consistency, which means that the agent believes they will always choose the optimal action in each period, given that they will follow this path in the future. Part (2) defines external consistency, which for its part means that the agent’s belief in which action they will choose in future periods may not change as time passes. In other words, the action they believe they will choose in period \( \tau \) remains the same for all periods \( t < \tau \). This assumption excludes procrastination caused by irrational expectations so that one can merely focus on procrastination caused by
time-inconsistent preferences and inability to foresee future self-control problems. With the assumption of dynamic consistency, the agents’ equilibrium beliefs can be denoted simply by \( \hat{s}(\hat{\beta}, \delta) = (\hat{a}_2(\hat{\beta}, \delta), \hat{a}_3(\hat{\beta}, \delta), \ldots) \) since external consistency prevents agents from changing their mind as time passes. [O’Donoghue and Rabin, 2001].

O’Donoghue and Rabin (2001) use a solution concept called "perception-perfect strategies", which means that the agents have rational beliefs in their future behavior, and they choose a task that maximizes their current utility taking into account these beliefs. Formally the agent’s perception-perfect strategy is denoted by \( s^p(\beta, \hat{\beta}, \delta) \equiv (a_1(\beta, \hat{\beta}, \delta), a_2(\beta, \hat{\beta}, \delta), \ldots) \), where \( a_t(\beta, \hat{\beta}, \delta) = \arg \max_a V^t(a, \hat{s}(\hat{\beta}, \delta), \beta, \delta) \) for all \( t \). Furthermore, it is assumed that beliefs \( \hat{s}(\hat{\beta}, \delta) \) are dynamically consistent and exist.

Task \((c, v)\) is defined \(\beta\)-worthwhile if \( \frac{\beta v}{1-\delta} - c \geq 0 \) for given \( \beta \) and \( \delta \). It means that the task has a positive present value, and thus the agent prefers completing it now to never completing any task at all. The \(\beta\)-best task in \( X \) is:

\[
x^*(\beta, \delta, X) = \arg \max_{(c,v) \in X} \frac{\beta v}{1-\delta} - c \quad \text{for given} \ X.
\]

It is important to note, that if the agent never completes any task, the conclusion is not always that they procrastinate. If there does not exist a \(\beta\)-worthwhile task in \( X \), it is a completely rational choice to do nothing. Procrastination may only occur when there exists at least one \(\beta\)-worthwhile task in \( X \). In this model, there are two possibilities for behavior when \(\beta\)-worthwhile tasks exist, either agent completes the \(\beta\)-best task immediately or with a small delay, or they delay it infinitely. O’Donoghue and Rabin focus on extreme delays, defining procrastination as delaying completion of the \(\beta\)-best task infinitely. Formally procrastination occurs when the agent chooses strategy \( s^p \) even though there exists a \(\beta\)-worthwhile task in \( X \). When there are multiple tasks in \( X \), agent must choose between completing the \(\beta\)-best task in the current period and completing the \(\hat{\beta}\)-best task in the near future. Whether agent ends up procrastinating depends on their tolerance for delay. The maximum tolerable delay, denoted by \( d^* \), is the cutoff such that for any \( d \geq d^* + 1 \), the agent prefers to complete the task in the current period compared to completing it in \( d \) periods. Sophisticates are fully aware of their future self-control problems and their \( \hat{\beta} = \beta \), thus they always complete the task within tolerable delay and never procrastinate infinitely. However, for naïfs and partial naïfs, the situation is not similar. Set \( d(\beta|\hat{\beta}) \) denotes the maximum delay \( d \) so that the agent with given \( \beta \) prefers to complete the \(\hat{\beta}\)-best task in \( d \) periods rather than completing the \(\beta\)-best task in the current period.

\[
d(\beta|\hat{\beta}) = \max\{d \in \{0, 1, \ldots\} | -c^* + \frac{\beta \delta v^*}{1-\delta} < \beta \delta d(-\bar{c} + \frac{\delta \bar{v}}{1-\delta})\},
\]
assuming that \( x^*(\beta, \delta, X) = (c^*, v^*) \) and \( x^*(\hat\beta, \delta, X) = (\hat c, \hat v) \). Given this, an agent with beliefs \( \hat\beta \) procrastinates if \( d(\hat\beta|\hat\beta) + 1 \leq d(\beta|\hat\beta) \). [O’Donoghue and Rabin, 2001].

With dynamically consistent beliefs \( \hat s(\hat\beta, \delta) \), the only task the agent is willing to complete is the \( \hat\beta \)-best task. Furthermore, dynamically consistent beliefs are cyclical, and thus the agent plans to complete the \( \hat\beta \)-best task in every \( d(\hat\beta|\hat\beta) + 1 \) period. Finally, various dynamically consistent beliefs may exist if \( d(\hat\beta|\hat\beta) > 0 \) since the agent tolerates some amount of delay and the first day of completion can vary. As multiple dynamically consistent beliefs may exist, multiple perception-perfect strategies may exist. The entire set of perception-perfect strategies is denoted by \( S^{pp}(\beta, \hat\beta, \delta, X) \) and characterized as follows:

**Lemma 1:** For all \( \beta, \hat\beta, \delta, \) and \( X \), either \( S^{pp}(\beta, \hat\beta, \delta, X) = \{\emptyset\} \), or for every \( s \in S^{pp}(\beta, \hat\beta, \delta, X) \), \( x(s) = x^*(\beta, \delta, X) \), \( \tau(s) \geq d(\hat\beta|\hat\beta) + 1 \), and if \( \tau(s) > 1 \) then \( \tau(s) = \tau(\hat s) \), where \( \hat s \) is the corresponding set of dynamically consistent beliefs.

Lemma 1 establishes that the set of perception-perfect strategies has two possible outcomes under the assumption of dynamically consistent beliefs. The first option is that there exists a unique perception-perfect strategy with which the agent never completes any task. The second option is that there exist multiple perfection-perfect strategies, but the task chosen \( (x^*(\beta, \delta, X)) \) remains the same for all the strategies. That is to say, the task chosen only differs with respect to its timing. To conclude, the task completed is always the same and the task is always completed in some period. It is not possible with these multiple perception-perfect strategies that the agent procrastinates infinitely. The role of parameter \( \hat\beta \), i.e., the role of sophistication, can be specified more explicitly as follows:

**Proposition 1:** For all \( \beta, \delta, \) and \( X \):

1. if no \( x \in X \) is \( \beta \)-worthwhile, then \( S^{pp}(\beta, \hat\beta, \delta, X) = \{s^p\} \) for all \( \hat\beta \); and

2. if there exists \( x \in X \) that is \( \beta \)-worthwhile, then either
   
   (a) \( S^{pp}(\beta, \hat\beta, \delta, X) \neq \{s^p\} \) for all \( \hat\beta \), or
   
   (b) "generic"ly there exist \( \beta^* \) and \( \beta^{**} \) satisfying \( \beta < \beta^* \leq \beta^{**} < 1 \) such that \( S^{pp}(\beta, \hat\beta, \delta, X) \neq \{s^p\} \) for any \( \hat\beta < \beta^* \) and \( S^{pp}(\beta, \hat\beta, \delta, X) = c \) for any \( \hat\beta > \beta^{**} \).

Part (1) states that if there does not exist a \( \beta \)-worthwhile task, then the degree of sophistication plays no role as the agent never completes any task no matter their parameter \( \hat\beta \). Part (2) describes the more interesting case when at least one \( \beta \)-worthwhile task exists. If the agent is sophisticated or nearly sophisticated, i.e., their \( \hat\beta = \beta \) or \( \hat\beta \) is close to \( \beta \), then the agent does not delay infinitely and they do not procrastinate. In
other words, this finding is robust to small degrees of naivete meaning that being even nearly sophisticated prevents the agent from procrastinating in a given environment. If the agent is naive or partially naive, i.e., their \( \hat{\beta} \) is far enough from \( \beta \), they delay infinitely, and thus procrastinate. For all \( \beta, \delta, \) and \( \hat{\beta} > \beta \), there exists \( X \) such that the agent procrastinates. That is to say, an environment where the agent procrastinates can be found for all agents suffering from even remotest degree of naivete.[O’Donoghue and Rabin, 2001].

In this setting, individuals must not only choose when to perform an activity but also which activity to perform. Related to choosing which task to perform, it can be shown that increasing the number of possible options may induce procrastination. If the agent is provided with a new tempting option with a high net benefit, they will choose to perform that activity in place of the original choice. If this new option has a large immediate cost related to its immediate benefit, the agent will procrastinate and might do it even longer than they would have done with the original choice of activity. An example could be an investment decision. Let’s assume that the agent would make the decision immediately if they only have one option, but as they have multiple options, they procrastinate in the hope of figuring out the best one shortly.[O’Donoghue and Rabin, 2001].

### 2.3 Alternative modeling approaches

This chapter represents two alternative modeling approaches for procrastination. The first one concentrates on the dual-self model, and the second section discusses the model of rational addiction.

#### 2.3.1 Dual-self model

This section introduces the dual-self model developed by Fudenberg and Levine (2006). This model has been presented to challenge standard economic models with quasi-hyperbolic discounting. It is called the dual-self model because it is a stage game between a sequence of myopic short-run selves and a patient long-run self, called doers and planners accordingly. In the following pages, I describe how this model can be used to explain saving behavior and other self-control problems caused by time-inconsistent preferences.

Let’s consider a case where an infinitely-lived agent must choose how much to save. The agent has an amount of wealth denoted by \( y \in \mathbb{R}_+ \), and they need to decide how to divide this amount between consumption and savings. In this model, time is assumed to be discrete and periods are denoted by \( t = 1, 2, \ldots \). This model works with bounded time as well. In each period of the game, there are two players, the long-run self and a short-run self. The long-run self remains the same in each period, but each short-run
self plays only in one period. \( A \) is the set of actions available for the short-run selves, and \( R \) is set of actions available for the long-run self. In addition, the effects of history are indicated by \( Y \). All of these sets are closed subsets of Euclidean space, and \( R \) is also bounded. At the beginning of the period, the long-run self chooses their action \( r \), which is observable for the short-run self and interpreted as self-control. This action does not directly affect the future state but is intended to affect other player’s decisions. Then short-run self chooses how large portion of the wealth they want to save by choosing action \( a \in [0, 1] \). In this model agent cannot borrow money. The amount agent chooses to save is invested in an asset, and since the agent has no other source of income, their wealth evolves as follows:

\[
y_{t+1} = Ra_t y_t.
\]

If the long-run self chooses no self-control action \((r = 0)\), then the short-run self has the following logarithmic utility:

\[
u(y, 0, a) = \log((1 - a)y),
\]

where \( \log(0) = -\infty \). The equilibrium concept used in this model is called SR-perfection. It means that each short-run self chooses an optimal savings rate considering the history, and the long-run self foresees this and is able to plan their behavior consistently. [Drew Fudenberg and David K. Levine, 2006].

Intuitively, the myopic short-run self who only cares about the current period wants to use all wealth on consumption. As the self-control cost is \( u(y, r, a) - u(y, 0, a) \), it can be presented in this case linearly as follows:

\[
C(y, a) = \gamma(\log(y)) - \log(1 - a)y = -\gamma \log(1 - a).
\]

It is assumed that self-control is always costly, thus if \( r \neq 0 \) then \( u(y, r, a) < u(y, 0, a) \) and this cost affects both players similarly. Preferences of the long-run self can be represented in the following reduced form:

\[
U_{RF} = \sum_{t=1}^{\infty} \delta^{t-1} [(1 + \gamma) \log((1 - a_t)y_t) - \gamma \log(y_t)].
\]

The long-run self simply maximizes their utility subject to the budget constraint \( y_t = Ra_{t-1} y_{t-1} \). By calculating the first-order conditions, the following solution is obtained:

\[
a = \frac{\delta}{1 + \gamma - \delta \gamma}.
\]

It can be seen from the solution above that the cost of self-control rises as \( \gamma \) increases, which leads to a decrease in the savings rate. What’s more, when \( \delta \) increases (patience
of the long-run self increases), so does the effect of $\gamma$ since the cost of future self-control plays a more important role then. With fixed $\gamma$, the increase of $\delta$ raises the savings rate. Two cases are of special interest here, the first of which is the case when $\gamma = 0$. In this case, self-control costs vanish, and the optimal savings rate is $\alpha^* = \delta$. Another special case is when $\delta = 0$ and no matter the size of $\gamma$, the agent does not save at all. [Drew Fudenberg and David K. Levine, 2006].

Cognitive load

Shiv and Fedorikhin (1999) conducted an experiment about agents’ self-control while cognitively bothered. They asked agents to memorize a number and then go to a table and choose a dessert. Agents were divided into two groups which differed in the length of the number to be memorized. One of the groups was asked to memorize a two-digit number and the other a seven-digit number. There were two options for the dessert at the table: a chocolate cake and a fruit salad. Agents needed to pick a ticket for the dessert they desired and then continue to another room to report both their number and the dessert they chose. It was assumed that agents experienced a greater positive effect from eating a chocolate cake than a salad, whereas cognitions concerning cake were assumed to be less favorable compared to fruit salad. Therefore, agents were assumed to experience a self-control problem with the cake. [Shiv and Fedorikhin, 1999].

Two different treatments were conducted. In one of them, real desserts were on the table, and in the other only pictures of desserts were provided. Researches expected that real desserts would exacerbate the self-control problem faced by agents. Results of the experiment were as assumed. With real desserts on the table, 63% of the agents who needed to remember a seven-digit number chose cake compared to only 41% of agents who needed to remember a two-digit number. Furthermore, with only pictures provided, 45% of the seven-digit agents and 42% of two-digit agents chose cake. In the case of real desserts, the difference in the results between two groups of agents is statistically significant, while in the case of pictures, it is not. Based on these results, it seems that cognitive load makes agents more vulnerable to temptation. [Shiv and Fedorikhin, 1999].

The dual-self model can be used to explain the behavioral effect of cognitive load. It is assumed that the marginal cost of self-control rises as the agent’s cognitive load increases. It can be explained in two ways. First, let’s assume that the long-run self has a fixed capacity for cognitive processing denoted by $D$. The cognitive load caused by other tasks than self-control is $d$. Then, the cognitive resources left for self-control are $D - d$, and applying greater self-control is impossible unless the agent drops some of the cognitive tasks and decreases the amount of $d$. Alternatively, it can be assumed
that there exists no fixed capacity for cognitive processing, but the marginal cost of
cognitive center increases as cognitive load rises. Let’s denote actions so that \( h \) stands
for chocolate cake and \( f \) for fruit salad and their short-term utilities by \( u^h \) and \( u^f \),
\( u^h > u^f \). However, the long-term utility related to a fruit salad is greater than that of
chocolate cake. With this notation, the self-control cost of choosing fruit salad with
cognitive load \( d \) is as follows:

\[
C(d, f) = g(d + u^h - u^f) - g(d)
\]

where \( g \) is an increasing convex function with \( g' > 0 \) and \( g'' > 0 \). In other words, the
cognitive load uses the same resources which are needed for self-control. The quasi-
hyperbolic model could explain this same situation by assuming that the cognitive load
decreases parameter \( \beta \). [Drew Fudenberg and David K. Levine, 2006].

### 2.3.2 Rational addiction

Addictions are challenging the view that individuals behave rationally, and in economic
models, maximize their long-run utility. If addictions cannot be explained as rational, it
is a significant flaw of the theory of rational behavior. How can we assume individuals
to behave rationally when we constantly see not only substance abuse-related addictions
but also addictions to pleasant activities such as jogging, working, and religion. Within
this chapter, I describe Becker and Murphy’s model of rational addiction and discuss
the criticism it has received.

Becker and Murphy (1988) present a theory of rational addiction where agents have
time-consistent preferences and are forward-looking. In their model, the agents are
assumed to derive utility from the consumption of two goods, \( c \) and \( y \). The difference
between these two goods is that the current utility derived from consuming \( c \) depends
on past consumption of it. With \( y \), this is not the case. Hence, the agent’s utility is
denoted as follows:

\[
\begin{align*}
  u(t) &= u[y(t), c(t), S(t)],
\end{align*}
\]

where \( S(t) \) stands for the stock of “consumption capital” of good \( c \). This is the parameter
through which past consumption of \( c \) affects the agent’s utility. The stock of consumption
capital evolves according to:

\[
\dot{S}(t) = c(t) - \delta S(t) - h[D(t)],
\]

where \( \dot{S} \) is the rate of change in \( S \), \( \delta \) is the depreciation rate, and \( D(t) \) stands for
expenditures on endogenous depreciation or appreciation. The agent’s lifetime equals \( T \)
and their rate of time preference (\( \sigma \)) is constant. The utility function can be denoted
as follows:

$$U(0) = \int_0^T e^{-\sigma t} u[y(t), c(t), S(t)] \, dt.$$  \hfill (6)

The utility is separable in $y$, $c$, and $S$. The agent maximizes utility subject to a budget constraint, which is denoted as follows:

$$\int_0^T e^{-rt} [y(t) + p_e(t)c(t) + p_d(t)D(t)] \, dt \leq A_0 + \int_0^T e^{-rt} w[S(t)] \, dt,$$  \hfill (7)

where $r$ is a constant rate of interest, $p$ stands for prices, and $y$ has a constant price over time. In addition, the initial level of assets is denoted by $A_0$ and earnings by $w$. Finally, capital markets are assumed to be perfect. The agent maximizes their utility (6) subject to their budget constraint (7) and investment equation (5). The first-order conditions of this problem determine the optimal choices for $y(t)$ and $c(t)$. [Becker and Murphy, 1988].

Becker and Murphy define addiction the way that an increase of current consumption of a certain good must raise the agent’s future consumption of this particular good. In their model, the addictive good is denoted by $c$. Addiction is only possible in the presence of adjacent complementarity, which means that earlier consumption of the addictive good raises the marginal utility of present consumption. Past and present consumption are complements, and thus present consumption also raises future consumption. In addition, the degree of complementarity is related to the strength of addiction. Adjacent complementarity is needed for addiction to develop, but it does not cause addiction by itself. [Becker and Murphy, 1988].

Unstable steady-states are used to explain rational addictions when the agent’s consumption of addictive goods increases over time, even though other model parameters do not explain the continuing growth. Another case when unstable steady-states are needed to explain rational addiction is when an agent’s consumption of addictive goods increases rapidly but only for a limited period. Furthermore, rational addiction can be explained by multiple steady-states. Consumption of highly addictive goods can be explained by the existence of two steady-states, from which one is stable, and another is unstable. Then consumption is mostly distributed between very low or zero level and very high level. [Becker and Murphy, 1988].

Not all people get addicted, and one individual can get addicted to one good but not to another. This can be explained in various ways. First, agents differ from each other in their time orientation. Present-orientated agents discount future more strongly and develop an addiction to harmful goods with a greater probability than future-orientated agents. On the other hand, future-orientated agents are more likely to develop an addiction to beneficial activities. Agents’ time orientation can be thought to be related to their life expectancy. That is to say, elders are perfectly rational by being present-
orientated as they do not have many years left to live. Nevertheless, even though teenagers have their lives ahead of them, they are known to be most impatient and thus susceptible to addictions. This is explained by the finding that stressful and shocking events may turn individuals more vulnerable to addictions temporarily. In other words, divorce, unemployment, death of a next of kin, or insecurity and anxiety produced by adolescence can stimulate the consumption of addictive goods, especially harmful ones. [Becker and Murphy, 1988].

The theory of rational addiction has also received criticism. For example, Gruber and Köszegi (2001) argue that one of the main assumptions, namely agent’s time-consistent preferences, made in Becker and Murphy’s paper is incorrect. They claim that addiction cannot be seen as rational since in reality agents have time-inconsistent preferences. Even though there does not exist non-experimental evidence for time-inconsistent preferences in decision-making, there exists a lot of psychological and experimental evidence. As already explained in previous chapters, in experimental settings, a major part of participants reveals to have present-biased preferences. In addition, harmful addictions match perfectly with the description of the decision-making context in which time inconsistency prevails. That is to say, with addictive goods, agents get immediate rewards, and the costs are significantly delayed. What additionally supports time inconsistency is that addicts often express their wish to stop and try to engage in different commitment devices and self-control techniques to get rid of their addiction. There exists data indicating that a large part of smokers tries to quit, fails, and then tries again. This is an anomaly not captured by rational addiction. All of this gives an impression that a large part of addicts continues to consume these addictive goods against their long-run preferences. Finally, even though there is no clear evidence for addiction-related time inconsistency, there is neither evidence that supports time consistency instead. [Gruber and Köszegi, 2001].

2.4 Leading applications

This chapter introduces three leading applications of procrastination. First, I discuss procrastination of pleasant activities. Then, I present a model for saving decisions. Finally, I present experiments studying procrastination related to gym membership and attendance.

2.4.1 Procrastination of pleasant activities

Procrastination is most often explained by present-biased preferences that cause agents to put too much weight on immediate costs compared to future benefits. These models predict that agents end up procrastinating with activities such as studying, saving, starting a diet, or stopping smoking. However, Shu and Gneezy (2010) argue that agents
procrastinate with pleasant activities as well. Many studies have shown that people discount future effort and time investment more than future monetary compensation. This is often attributed to peoples’ biased belief that they will have more free time in the future compared to the current moment. The same biased belief does not include money, at least not as strongly as free time. In other words, people discount future costs, time and effort, more strongly than future monetary rewards, and thus activities seem more appealing in the future compared to the current moment. Such discounting can lead to procrastination since as an activity approaches, an agent wants to delay it again and again because it always seems more appealing in the future. Shu and Gneezy (2010) conducted two experiments that provide support for stronger discounting of future time and effort compared to future benefits. In the first experiment, they asked participants how likely they would use a gift certificate for a 45-minute massage. They had two different versions of the survey. In the first one, the gift certificate was going to expire in one week’s notice, whereas, in the second one, the participant was told that they would remember about the certificate in one month and then they would have only one week left to use it. The participants were also asked about their willingness to pay to extend the expiration date of the certificate and to estimate of how busy they would be in a month. Participants’ estimates of the likelihood of use were significantly lower when the certificate expired within a week from the current moment. In addition, participants were more willing to pay to extend the expiration date now than in one month, and they estimated that they would be less busy in a month. [Shu and Gneezy, 2010].

In a second experiment, participants were provided with gift certificates to a local French pastry café. There were two different types of certificates: the first type expired in three weeks and the second type in two months. After all the certificates had expired, Shu and Gneezy conducted a follow-up survey to find out how many of the participants redeemed the certificate and if they did not, did they regret it, and what was the reason to not use the certificate. Before the experiment started, the researchers measured predicted redemption rates from a control group. Participants of the control group estimated that they would more likely use the certificate with a longer expiration period. In reality, the reserve held up for the participants who actually received the gift certificates. Shu and Gneezy found that those participants who received gift certificates with longer expiration periods were significantly less likely to redeem them. In addition, in the follow-up survey, participants admitted that they regretted not using the certificate and blamed haste. They also admitted that they thought they would use it later. These findings explain in their part why people procrastinate with pleasant activities as well and the role of deadlines in procrastination. Furthermore, it seems like participants suffer from some degree of naivety as they predict their future behavior and preferences incorrectly.[Shu and Gneezy, 2010].
The main difference between procrastination of unpleasant activities and pleasant activities is the reward and cost structure of the activities to be completed. As already explained in previous chapters, the prevailing view of procrastination explains this behavior through present-biased preferences. The activities that are delayed often have immediate costs and future rewards. However, with pleasant activities, both the costs and the rewards concerning the activity are temporally close to each other. Shu and Gneezy completed an experiment to explain further the role of the cost structure in procrastination. They provided participants with different kinds of gift certificates for movie tickets to study how changes in cost structure affected participants' behavior. They had low-benefit gift certificates, which entitled the owner to one free movie ticket, and high-benefit gift cards, which entitled the owner to two free movie tickets. The gift certificates were for two different movie theaters; one was a low-cost option situated near participants, and the other was a high-cost option significantly further away. Finally, they also had a share of certificates reframed into financial terms. Normal certificates entitled the owner for one or two movie tickets but this reframed certificate entitled the owner to a specific dollar amount of discount. To summarize, Shu and Gneezy had four pairs of conditions: baseline (a low-cost and low-benefit pair), increased benefit (a low-cost and high-benefit pair), increased cost (a high-cost and low-benefit pair), and money frame benefit (a low-cost and low-benefit pair reframed into financial terms). The researchers were provided with actual redemption data from the movie theaters, and they also conducted a follow-up survey for the participants after all certificates had expired.

<table>
<thead>
<tr>
<th></th>
<th>Baseline</th>
<th>Increased benefit</th>
<th>Money frame benefit</th>
<th>Increased cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>Short time frame</td>
<td>47%</td>
<td>77%</td>
<td>33%</td>
<td>40%</td>
</tr>
<tr>
<td>Long time frame</td>
<td>37%</td>
<td>47%</td>
<td>37%</td>
<td>20%</td>
</tr>
</tbody>
</table>

Table 1: Redemption percentage of gift certificates per condition pair


Table 1 sums up the redemption data gathered in the experiment. In line with the findings of experiments presented above, participants procrastinate less with a shorter expiration period. In addition, an increase in benefits reduces procrastination significantly. More interestingly, these results support Shu and Gneezy's assumption that an increase in the future benefits relative to future costs would grow the difference in procrastination levels between short and long time frames. However, an increase in costs
does not have the same effect. This supports the observation that people discount future costs more strongly compared to future benefits. Finally, the framing does not seem to have any significant effect on procrastination. The follow-up survey was conducted exactly in the same way as in the French pastry café experiment, and the results were very similar. Participants who redeemed the certificate were content, whereas those who did not redeem it blamed hurry, regretted their choice, and admitted that they thought they would redeem it later. [Shu and Gneezy, 2010].

2.4.2 Saving

People’s saving behavior has long been one of the main interests of economists studying time-inconsistent preferences and procrastination. The nature of saving is well-fitting for the procrastination model as the agents must postpone consumption in the current period to achieve future benefits by saving. Laibson (1997) uses the golden eggs model to explain individuals’ saving behavior. In this model, the term golden egg is used to describe investments in illiquid assets that yield benefits evenly but are hard to sell and are seen as commitment instruments. In other words, these golden eggs provide a steady stream of benefits in the long run which cannot be realized immediately. Examples of these golden eggs are buying a home or consumer durables and investing in one’s personal business. In the golden eggs model, the agents may invest in two different assets: in liquid assets denoted by $x$ and in illiquid assets denoted by $z$. Liquid assets can be consumed immediately, whereas a decision to sell illiquid assets creates a cash flow that is available for consumption in the next period at the earliest. Agents can borrow against their illiquid assets $z$, but the borrowed money is available in the next period at the earliest. Furthermore, it is assumed that the rate of return is the same for all assets, prices are deterministic, and the agents have exogenous assets holdings at the beginning of this model ($x_0, z_0 \geq 0$). The model has periods $t \in \{1, 2, \ldots, T\}$, and each period consists of the following four subperiods:

1. Production: The agent receives a gross return for their assets ($x_{t-1}$ and $z_{t-1}$), denoted $R_t = 1 + r_t$, and supplies a unit of labor.

2. Cash flow: The agent receives their deterministic salary $y_t$ and liquid savings $R_t x_{t-1}$.

3. Choice of consumption: The agent decides which proportion to consume, considering the following constraint: $c_t \leq y_t + R_t x_{t-1}$.

4. Choice of asset allocations: The agent decides how to divide their savings between
liquid and illiquid assets taking into account the following constraints:

\[ y_t + R_t(x_{t-1} + z_{t-1}) - c_t = x_t + z_t, \]
\[ x_t, z_t \geq 0. \]

[Laibson, 1997].

The agents have the following quasi-hyperbolic utility function:

\[ U_t = E_t[u(c_t) + \beta \sum_{\tau=1}^{T-t} \delta^\tau u(c_{t+\tau})]. \]

This utility function leads to dynamically inconsistent preferences, as discussed in the section covering present bias and hyperbolic discounting. To formally model the agents’ behavior, this decision-making process is thought of as a dynamic game between temporal selves, and the corresponding solution concept is a subgame perfect equilibrium. Laibson argues that the golden eggs model has a unique solution that is resource-exhausting. All the resources are used in the equilibrium since as the agents act optimally, the last period self chooses to use all liquid assets, and in the period before the last one, the agent foresees that there is no reason to save, thus they liquidate all illiquid assets. According to this model, individuals can set their future selves’ liquidity constraints by choosing how much to save in illiquid assets. However, these constraints have only a limited effect on individuals’ consumption behavior since it is not possible to constraint the cash flow from salary. [Laibson, 1997].

Laibson offers two different explanations for the decline in the U.S. savings rate during the 1980s based on the golden eggs model. The first explanation is founded on the fact that cash flow to consumers was significantly higher in the 1980s compared to the 1970s. However, even though the golden eggs model suggests that agents are prone to use a remarkable portion of their current cash flow on consumption, it does not explain why the cash flow to consumers was higher in this period. Therefore, Laibson prefers the second explanation, which focuses on the development of the U.S. credit market. During the 1980s, agents’ access to instantaneous credit increased, which lead to the relevance of commitment instruments like golden eggs to decline. As discussed above, individuals’ only way to constrain future selves’ consumption was through commitment instruments. Thus, if consumption cannot be constrained, then the savings rate decreases, as happened in the States in the 1980s. Formally, the access to instantaneous credit changes the consumption constraint as follows:

\[ c_t \leq y_t + R_t x_{t-1} + R_t z_{t-1}, \]

since the agent is allowed to borrow instantaneously against their illiquid assets. Illiquid
assets become liquid as well, and the agents have no way to constrain their future consumption. [Laibson, 1997].

Laibson’s theory supports the existence and prevalence of time-inconsistent preferences as he argues that a decreased possibility to use commitment instruments decreases the savings rate. That is to say, individuals do not save if they cannot use commitment instruments. That suggests that individuals have in general time-inconsistent preferences and suffer from strong present bias, which leads them to choose instantaneous utility from consumption instead of the long-run optimal share of savings.

2.4.3 Gym membership and attendance

DellaVigna and Malmendier (2006) study consumers’ behavior regarding gym memberships and if it can be explained by standard preferences and beliefs. They use a panel data set consisting of information about clients’ contractual choices and attendance. The data is gathered from three different gyms located in New England. They build a standard model to form predictions about agents’ behavior related to contract choice and gym attendance at enrollment. In this model, the agent purchases a contract \((L', p', T')\), pays the flat fee \(L'\) and is then allowed to exercise in the gym for a fee \(p'\) for \(T'\) days. In the three gyms included in the panel data, the contract choices are either flat-rate contracts or pay-per-visit contracts. With flat-fee contracts the agents pay the flat fee \(L'\), \(p' = 0\) and two different options exist, monthly and annual contracts. With pay-per-visit contract the agents pay the fee \(p'\) when attending the gym, but there is no flat fee \((L' = 0)\). The first prediction is that for the agents who choose a flat-rate contract:

\[
\frac{L}{E_F[v]} a(T) \leq p,
\]

where \(E_F[v]\) denotes the expected number of visits during the chosen flat-rate contract and \(a(T) \equiv \frac{(1-\delta T)}{1-\delta}\) is a time-adjustment coefficient needed since the fees \(L\) and \(p\) are paid in different periods. The agents choose a flat-rate contract only if their payment per expected visit is smaller than \(p\). In other words, only the agents who expect to visit the gym regularly are willing to choose a flat-rate contract. The second prediction is as follows:

\[
E_A[v] > E_M[v].
\]

Agents who choose an annual flat-rate contract have a higher average initial attendance compared to the agents who choose a monthly flat-rate contract. The agents who expect to attend more regularly to the gym choose the annual option. The final prediction is that the agents are able to forecast their future gym attendance correctly. [DellaVigna and Malmendier, 2006].

Interestingly, DellaVigna and Malmendier’s empirical findings contradict most of the
predictions based on the standard model. First, the agents who choose a flat-rate contract pay averagely a lot higher price per visit than the agents who choose a pay-per-visit contract. Under a fourth of the agents who choose a flat-rate contract pay less per visit than they would pay if they chose the pay-per-visit contract. Most of the agents would be better off with the pay-per-visit contract. Second, the agents are not able to forecast their future gym attendance correctly, but they overestimate it severely. The average actual attendance in the panel data is 4.17 visits per month, and the average forecasted attendance is 9.5 visits per month, thus the difference is significant. Finally, the only prediction in line with the empirical findings is that the agents choosing the annual flat-rate contract have a higher average attendance compared to those choosing the monthly option. Therefore, the agents who attend the gym more regularly end up choosing the annual contract as assumed based on the standard model. [DellaVigna and Malmendier, 2006].

DellaVigna and Malmendier make four additional predictions regarding the agents’ contract choices over time. These predictions are based on standard preferences and rational beliefs. First, they assume that the agents attending the gym irregularly with a monthly membership do not delay the cancellation of their contract (few days at maximum). This prediction is based on the fact that the agents are allowed to attend the gym with a pay-per-visit contract, which is economically wiser for irregular users. Furthermore, cancellation is easy and quick to do. Second, they predict that annual members are more likely to renew/continue their contract after one and two years compared to the agents with a monthly contract. This is based on the former prediction, in line with the empirical findings, that annual members are more frequent users, and thus more likely to continue using gym services. Third, the expected attendance is higher for annual members who have renewed their contract once, compared to new annual members. This follows from the assumption that the agents who do not attend the gym regularly will not renew their annual contracts. Finally, among monthly members, the expected attendance should grow every month as low-attenders cancel their contracts. [DellaVigna and Malmendier, 2006].

DellaVigna and Malmendier’s findings partly contradict their predictions. They find that on average monthly members delay cancellation of their contracts more than two months. This result is significantly different from the predicted delay of few days at most. Even though cancellation costs are quite low (< $15), the agents use on average $187 on their monthly fees after their last visit. Second, the agents with monthly flat-rate contracts are outstandingly more likely to continue their contracts after 14 months compared to annual members. This finding contradicts the prediction that annual members, more regular users of the gym, are more likely to renew their contracts. Third, the panel data shows that the average monthly attendance is significantly higher among monthly members during the first six months of their contract compared to any
later six-month period, even though the model predicts the reverse. Finally, the only prediction in line with the empirical findings is that the attendance is higher for annual members who have renewed their contract once, compared to new annual members. [DellaVigna and Malmendier, 2006].

As shown above, most of the predictions based on standard preferences and rational beliefs are incorrect in light of the empirical evidence. Based on the panel data, the agents seem to overestimate their future attendance and procrastinate with contract cancellation. The standard model is incapable of explaining these results, but time-inconsistency with partial naivete is proposed instead. Naive or partially naive agents are not fully aware of their self-control problems and may overestimate their future attendance and sign up for a flat-rate contract even though a pay-per-visit contract would be a better option in reality. Furthermore, the agents with \((\beta, \delta)\)-preferences suffering from naivete may procrastinate with an activity, as contract cancellation, for a long period as showed by Akerlof (1991) and O’Donoghue and Rabin (2001). Therefore, DellaVigna and Malmendier calibrate O’Donoghue and Rabin’s (2001) model of partial naivete to this panel data, and it yields results similar to those obtained from the empirical analysis. The model of partial naivete is capable of explaining the empirical finding that the agents delay on average over two months before canceling their monthly contracts. They argue that while gym employees may persuade the agents to act as they do and this could explain some of the findings, persuasion does not explain the agents’ overestimation of attendance, and thus time-inconsistency and partial naivete are the only explanations rationalizing all of the findings. [DellaVigna and Malmendier, 2006].

2.5 Welfare

In the section that follows, I represent different concepts to analyze and measure the welfare effects of procrastination. Furthermore, I compare the welfare effects of procrastination for different types of agents in different situations.

It is problematic to analyze the welfare effects of procrastination as agents have time-inconsistent preferences. The same agent has different preferences in different periods so from which perspective the welfare should be analyzed? In most cases there does not exist a consumption plan which is optimal for the agent in all periods. To tackle this problem O’Donoghue and Rabin use a concept called long-run perspective to measure the welfare effects of procrastination. They create an imaginary period 0 where the agent makes no decision but weights all upcoming periods equally. The agent’s utility in period 0 is called the long-run utility and denoted by \(U^0(\tau) \equiv v_\tau - c_\tau\). This concept can be used to compare the welfare effects of procrastination for different kinds of agents. With both immediate costs and immediate rewards, sophisticates never complete the action after
naïfs since they are fully aware of their future self-control problems. When it comes to immediate costs, this leads to the result that \( U^0(\tau_n) \geq U^0(\tau_n) \). The sophistication effect prevents sophisticates from procrastinating as long as naïfs and sophisticates always get at least as much utility as naïfs. Therefore, with immediate costs, it is profitable to be a sophisticate. However, with immediate rewards, the situation is more complicated. Sometimes excessive preproportioning may cause sophisticates to lose possible utility in the future, but it might also save sophisticates from large future costs. That is to say, the welfare implication of sophistication effect, in this case, cannot be pinned down in general. O’Donoghue and Rabin compare welfare gained by sophisticates and naïfs to that of the standard type with time-consistent preferences. They characterize the welfare loss caused by procrastination as the differences in the long-run utilities between agents with present-biased preferences and the standard type, formally \( U^0(\tau_c) - U^0(\tau_n) \) and \( U^0(\tau_c) - U^0(\tau_n) \). This comparison demonstrates that even a small bias, \( \beta \) close to 1, for the present can lead to major welfare losses. There exist two different cases when this is possible. The first case is when rewards and costs are remarkably large, and even a one-shot decision can cause major welfare losses. For instance, this happens when an agent with a small present bias grabs a large immediate reward even though they will face an even larger delayed cost in the future. However, this particular case is not especially interesting. The second case considers a situation where an upper bound is placed on rewards and costs, but repetitive procrastination may cause severe welfare losses. Even though welfare losses from one-shot decisions are very small, when agents face self-control problems repeatedly and procrastinate over and over again, those small individual welfare losses may combine into a large total welfare loss. Formally:

\[
\lim_{\beta \to 1} (\sup_{(v,c)} [U^0(\tau_c) - U^0(\tau_n)]) = 0 \text{ and }
\sup_{(v,c)} [U^0(\tau_c) - U^0(\tau_n)] = 2\bar{X} \quad \text{for any } \beta < 1,
\]

where it is assumed that costs are immediate and \( \bar{X} \) is an upper bound for both costs and rewards \( (v_t \leq \bar{X} \text{ and } c_t \leq \bar{X} \text{ for all } t) \). Since it is assumed that costs are immediate, present-biased preferences may cause agents to procrastinate. However, sophisticates are fully aware of their self-control problems, thus they know when they will do the activity if they choose to procrastinate. In other words, sophisticates’ decision to procrastinate is one single decision, and with a fixed upper bound, it cannot create large welfare losses as noted in the upper row. On the other hand, naïfs do not understand the magnitude of their self-control problems which may lead them to procrastinate over and over again when these small welfare losses combine into a large total loss. Therefore, as noted in the lower row, naïfs may suffer from severe welfare losses when immediate costs occur.
With immediate rewards, the situation is reversed:

$$\lim_{\beta \to 1} (\sup_{(v,c)} [U^0(\tau_c) - U^0(\tau_c)]) = 0 \quad \text{and}$$

$$\sup_{(v,c)} [U^0(\tau_c) - U^0(\tau_c)] = 2\bar{X} \quad \text{for any } \beta < 1.$$ 

Now it is assumed that rewards are immediate, and $\bar{X}$ is an upper bound for both costs and rewards ($v_t \leq \bar{X}$ and $c_t \leq \bar{X}$ for all $t$). Now naifs believe that if they wait, they will do the activity when a standard type with time-consistent preferences would do it. Thus, naifs' decision to preproperate is one single decision, and with a fixed upper bound, it cannot create large welfare losses. At the same time, sophisticates with present-biased preferences are prone to make multiple preproperating decisions one after the other, which leaves them with multifold small welfare losses. That is, sophisticates may face severe welfare losses with immediate rewards. Finally, the same concept can be expressed more weakly by using Pareto comparisons. With immediate rewards, naifs always act along with the Pareto-optimal strategy, whereas with immediate costs, sophisticates do. [O’Donoghue and Rabin, 1999].

Akerlof agrees with O’Donoghue and Rabin that even a small bias for the present can cause major welfare losses when agents make multiple procrastination or preproperating decisions one after the other. He emphasizes that especially in situations where the immediate cost is significant relative to the rewards, even a tiny bias for the present can cause considerable delay. A deadline does not stop the agent from procrastinating, but with a deadline, the cost of procrastinating may be that one must pull an all-nighter. [Akerlof, 1991].

A "Pareto criterion" is commonly used to discuss welfare implications of procrastination caused by time-inconsistent preferences. O’Donoghue and Rabin (2001) introduce the following Pareto-model in their article. A strategy $s$ is Pareto-efficient if there does not exist an alternative strategy $s’$ such that $U^t(s’, \beta, \delta) \geq U^t(s, \beta, \delta)$ for all $t$ and $U^t(s’, \beta, \delta) > U^t(s, \beta, \delta)$ for some $t$, where:

$$U^t(s, \beta, \delta) \equiv \begin{cases} 
-c + \beta \delta v \frac{1}{1-\delta}, & \text{if } x(s) = (c, v) \text{ and } \tau(s) = t \\
\beta \delta r(s) - t (-c + \delta v) \frac{1}{1-\delta}, & \text{if } x(s) = (c, v) \text{ and } \tau(s) > t \\
0, & \text{if } x(s) = \emptyset \\
v + \beta \delta v \frac{1}{1-\delta}, & \text{if } x(s) = (c, v) \text{ and } \tau(s) < t.
\end{cases}$$

Pareto-efficiency means that with a strategy $s$, the agent gets at least the same utility in every single period than with a strategy $s’$, and at least in one period, they get a higher utility. An important feature of the Pareto-criterion is that it only tells whether
the agent is choosing a Pareto-efficient strategy or not, i.e., whether the agent is hurting
themselves or not. That is to say, if the agent is not following the Pareto-efficient
strategy, this criterion says nothing about the scale of the welfare loss they are facing.
Furthermore, even if a strategy is significantly better in all but one period, it is not
Pareto-optimal. Compared to the long-run perspective, Pareto criterion is stronger and
it does not provide a way to discuss the magnitudes of welfare losses. [O’Donoghue and
Rabin, 2001].

Another criterion, called the long-run utility, is defined to measure the magnitude of
welfare loss caused by procrastination and is denoted by $U^{LR}(s, \delta) = U^{1}(s, 1, \delta)$. The
agent’s welfare loss is defined as follows according to this criterion:

$$U^* = \max_s U^{LR}(s, \delta),$$
and let $c^*$ be the cost of the task chosen (immedi-
ately) to maximize $U^{LR}(s, \delta)$. If the agent follows a strategy $s$, then their
welfare loss is $WL(s, \delta) = \frac{|U^* - U^{LR}(s, \delta)|}{c^*}$.

The welfare loss is the difference between the agent’s achieved long-run utility and their
best possible long-run utility normalized by dividing with the cost of the long-run-best
task. The best possible long-run utility is achieved when the agent chooses a strategy
that maximizes their long-run utility. This approach allows us to compare the behavior
of a present-biased agent to that of an agent with time-consistent preferences since
the agent with time-consistent preferences always chooses a strategy maximizing the
long-run utility. In other words, time consistency is considered as rational, utility max-
mizing behavior in this approach. By using this approach, a unit-independent measure
for the welfare loss is attained. However, measure alone is not sufficient, but scale must
be defined as well. Welfare loss is defined as small if $WL(s, \delta) < \frac{1-\beta}{\beta}$, where $\frac{1-\beta}{\beta}$ is the
maximum welfare loss that can be attained by choosing immediate gratification in one
period. However, it is more interesting to focus on large welfare losses, which can occur,
for example, in cases where the agent chooses immediate gratification over and over
again. The proposition below describes different ways in which the agents may cause
themselves welfare losses according to the two welfare criteria introduced:

PROPOSITION 2: For all $\beta, \hat{\beta}, \delta$, and $X$,

1. If $S^{pp}(\beta, \hat{\beta}, \delta, X) = \{s^p\}$, then

   (a) $s^p$ is Pareto-inefficient if and only if it is procrastination; and

   (b) $WL(s^p) > \frac{1-\beta}{\beta}$ only if $s^p$ is procrastination.

2. If $S^{pp}(\beta, \hat{\beta}, \delta, X) \neq \{s^p\}$, then

   (a) there exist $s \in S^{pp}(\beta, \hat{\beta}, \delta, X)$ that is Pareto-efficient and has $WL(s) < \frac{1-\beta}{\beta}$,
(b) any \( s \in S^{pp}(\beta, \hat{\beta}, \delta, X) \) is Pareto-inefficient if and only if \( \tau(s) > d(\beta|\delta) + 1; \)
and\n
(c) for any \( s \in S^{pp}(\beta, \hat{\beta}, \delta, X) \), \( WL(s) > \frac{1-\beta}{\delta} \) only if \( \tau(s) > d(\beta|\delta) + 1. \)

The first item covers the case when the agent never completes any task. Part a) states that this behavior is only Pareto-inefficient if it is procrastination. The agent is following their optimal strategy by not completing any task if there does not exist a \( \beta \)-worthwhile one. However, if there exists a \( \beta \)-worthwhile task and the agent is procrastinating in every single period, then their strategy is Pareto-inefficient and they may face a large welfare loss due to their behavior. The second item covers the case when the agent completes a task in some period. Part a) states that there always exists a perception-perfect strategy that is Pareto-efficient, and by choosing this strategy the agent will not face large welfare losses. For example, completing the \( \beta \)-best task in the first period is always a perception-perfect strategy. Part b) states that a perception-perfect strategy is Pareto-inefficient only if the task is completed after a too-long delay, thus welfare loss is caused by procrastination. Finally, part c) states that large welfare losses can only be caused by delaying the completion of a perception-perfect strategy too long, thus by procrastination. [O’Donoghue and Rabin, 2001].

Economists have been interested in how naivete affects welfare loss caused by time-inconsistent preferences. According to proposition 2, only procrastination may cause severe welfare losses. However, O’Donoghue and Rabin (2001) claim that sophisticated agents never procrastinate, and thus sophisticated agents never face severe welfare losses. It is important to notice that in this article, preproportion is not considered.

As earlier stated, it is possible to find an environment where an agent with even the smallest degree of naivete procrastinates. Therefore, agents suffering from any degree of naivete may procrastinate and cause themselves severe welfare losses. It is not shown that procrastination would lead to severe welfare losses in all cases, but it depends on the situation.

**PROPOSITION 3:** For any \( \beta \) and any \( \hat{\beta} > \beta \),

1. for any \( \delta \), there exists \( X \) such that \( S^{pp}(\beta, \hat{\beta}, \delta, X) = \{s^\alpha\} \) and \( WL(s^\alpha) > \frac{1-\beta}{\delta}; \)
and\n
2. for any \( Z > 0 \), there exist \( X \) and \( \delta \) such that \( S^{pp}(\beta, \hat{\beta}, \delta, X) = \{s^\alpha\} \) and \( WL(s^\alpha) > Z. \)

Proposition 3 states that there does not exist any upper bound for welfare losses caused by naive procrastination. Therefore, procrastination carried on over a long time can harm a person significantly. [O’Donoghue and Rabin, 2001].
2.6 Welfare-improving devices

As explained in the previous chapter, procrastination caused by time-inconsistent preferences can cause severe welfare losses for the agents. These welfare losses do not only harm the agents at the individual level but affect society on a larger scale. An employee procrastinating with their tasks harms their employer, smokers procrastinating with quitting smoking cause themselves more severe health problems and burden public health care, etc. On that account, it is important to find ways to decrease the welfare loss and reach more efficient outcomes. Within this chapter, I will introduce different ways to reduce procrastination and related welfare loss.

2.6.1 Self-rewards

People commonly use self-rewards to overcome procrastination. For example, one might decide to enjoy a dinner with friends once completed a term paper or buy a bottle of luxury wine once finished an important work presentation. [Koch et al., 2014]. Self-rewards can increase the agents’ motivation to complete tasks on time and thus reduce procrastination. A model of self-rewards by Koch et al. is discussed in detail in the following pages.

In this model, there are three periods \( t \in \{0, 1, 2\} \) and a single sophisticated agent who has present-biased preferences \((\beta, \delta)-\text{preferences}\). In the first period \((t = 0)\), the agent sets a goal \((\hat{e})\) for their future effort and chooses a self-reward strategy, which states the expected reward for all possible levels of effort. The utility derived from the reward is denoted by \(b\), and the related cost is denoted by \(\gamma b\). Cost and utility concerning the self-reward realize in the second period \((t = 1)\). In the second period, the agent needs to decide how much effort \((e \in \mathbb{R}_+^+)\) to exert for the task. Immediate costs concerning effort are denoted by \(c(e)\), and delayed reward gained in the last period by \(f(e)\). Furthermore, if the agent does not exert effort at all, both the related cost and reward are zero \((c(0) = f(0) = 0)\). Additional assumptions needed for the model are stated in appendix A. The agent’s utility is denoted as follows:

\[
U_t = u_t + \beta \left[ \sum_{\tau > t} u_\tau \right],
\]

where the immediate utility in period \(t\) is denoted by \(u_t\). It is important to note that in the first period the agent weights utilities in the second and third period equally, whereas in the second period, the agent discounts the last period differently due to their present-biased preferences. It is assumed that the agent chooses a self-sustaining goal and plan in the first period. If there are several such goals and plans, then the agent chooses the one that maximizes their utility. A self-sustaining goal is defined as being consistent with real effort and a self-sustaining plan as being consistent with the real
purchase decision. [Koch et al., 2014].

The immediate utility in each period is assumed to be composed of two components as follows:

\[ u_t = m_t + \mu(m_t - \hat{m}_t), \]

where

\[ \mu(x) = \begin{cases} \eta x & \text{if } x > 0 \\ \eta \lambda x & \text{if } x \leq 0. \end{cases} \]

\( \eta > 0 \) and \( m_t \) stands for the consumption utility gained from the outcomes in period \( t \). In other words, it is the utility in the current period considering immediate costs and rewards. \( \mu(x) \) stands for the reference-dependent part of the utility. It means that the agent gets disutility from not reaching the reference point and utility from reaching it. The agent’s past expectations determine the reference points, and thus, the reference points are \( \hat{m}_1 = -c(\hat{e}) \) and \( \hat{m}_2 = f(\hat{e}) \). Lastly, loss aversion is \( \lambda \geq 1 \). [Koch et al., 2014].

Let’s first cover the case when the agent cannot reward themselves but can only set goals. Then, marginal benefits and marginal costs of effort should be equal as follows:

\[ f'(e_0^*) = c'(e_0^*). \]

However, we need to check whether the optimal level of effort is a self-sustaining goal or not. If the agent deviates from this level in the second period, their utility is:

\[ \beta f(e) - c(e) + \eta(c(\hat{e}) - c(e)) - \eta \beta \lambda (f(\hat{e}) - f(e)). \]

Therefore, the agent does not deviate from the optimal level of effort if:

\[ \beta(1 + \eta \lambda) f'(\hat{e}) \geq (1 - \eta)c'(\hat{e}). \]

The maximal self-sustaining goal \( \bar{e}_N \) solves the equation above. Similarly, the minimal self-sustaining goal \( \underline{e}_N \) solves:

\[ \beta(1 + \eta \lambda) f'(\underline{e}_N) = (1 + \eta \lambda)c'(\underline{e}_N). \]

It is evident that \( \bar{e}_N > \underline{e}_N \) for \( \lambda > 1 \), and there exists a continuum of self-sustaining goals, from which the agent can choose the utility-maximizing one. The optimal level of effort belongs to the interval if \( \beta \geq \frac{1 + \eta \lambda}{1 - \eta \lambda} \). So a patient enough agent can reach the optimal level of effort. Furthermore, the greater the \( \lambda \), the easier it is for the agent to overcome the self-control problem. [Koch et al., 2014].

Next, I demonstrate how the self-reward strategy can help the agent to overcome their
self-control problem when goal setting does not help ($\hat{e} > \bar{e}_N$). In this chapter, I focus
on neutral rewards, which means that both the costs and the rewards realize in the
second period. In the second period, the agent has an incentive to deviate from the
goal because if they deviate to $e$, they get the following gain in utility:

$$\Psi(\hat{e}, e) \equiv \int_{\hat{e}}^e [(1 + \eta)c'(z) - \beta(1 + \eta \lambda)f'(z)] \, dz.$$  

However, we know that the optimal deviation for the agent is to choose $\bar{e}_N$, and thus we get:

$$\Phi(\hat{e}) \equiv \Psi(\hat{e}, \bar{e}_N) = (1 + \eta)[c(\hat{e}) - c(\bar{e}_N)] - \beta(1 + \eta \lambda)[f(\hat{e}) - f(\bar{e}_N)].$$  

For the self-reward to help the agent to overcome their self-control problem, the utility
from the reward must be at least equal to the optimal gain in utility derived from deviation. Formally, the incentive constraint is denoted by:

$$\Phi(\hat{e}) \leq b(1 - \gamma).$$  

Therefore, the maximal self-sustaining goal ($\bar{e}_R$), when neutral self-rewards can be
used and when $\gamma < 1$, is greater than the maximal self-sustaining goal ($\bar{e}_N$), when
self-rewards cannot be used. In other words, the self-reward helps the agent to overcome
the self-control problem. [Koch et al., 2014].

It needs to be shown that a self-sustaining self-rewards exists. In other words, the agent
cannot get the reward if they do not reach the goal. If the agent expected to get the
reward, it is optimal for them to actually get it if:

$$b - \gamma b \geq -\lambda \eta b + \gamma \eta b.$$  

The agent gets the reward if the utility derived from it is greater than the utility derived
from not getting it. We can rewrite the equation to the following form:

$$\gamma \leq \frac{1 + \lambda \eta}{1 + \eta} \equiv \bar{\gamma}. $$  

$\bar{\gamma}$ is interpreted as the maximal cost for the self-sustaining reward. This cost can
be interpreted as, for example, a price of a certain good. The minimal cost for a
self-sustaining reward is derived in a similar manner:

$$\gamma \geq \frac{1 + \eta}{1 + \lambda \eta} \equiv \gamma'.$$  

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The agent will always get the reward if its cost is too low and never get it anyway if its cost is too high. Therefore, the cost of self-sustaining reward must belong to the interval \([\gamma, \bar{\gamma}]\). [Koch et al., 2014].

Self-rewards do not have to be neutral but costs and benefits can realize in different periods. From now on, goals are denoted by \(\hat{c}_R(t, \tau)\) such that the related self-reward brings benefits in period \(t \in \{1, 2\}\) and costs in period \(\tau \in \{1, 2\}\). Following this notation, the goal with neutral self-reward is denoted by \(\hat{c}_R(1, 1)\). If self-reward has immediate benefits but delayed costs, it is called a vice reward. Cigarettes and other intoxicants are examples of vice rewards. The lower and upper bound for the cost of vice reward can be attained by using a similar manner as with neutral rewards. The results are as follows:

\[
\gamma(1, 2) = \frac{1 + \eta}{\beta(1 + \eta\lambda)} \quad \text{and} \quad \bar{\gamma}(1, 2) = \frac{1 + \eta\lambda}{\beta(1 + \eta)}.
\]

The maximal self-sustaining goal is:

\[
\Phi(\hat{c}_R(1, 2)) = b(1 - \beta\gamma).
\]

From these equations, it is important to note that the lower bound for cost is above one \((\gamma(1, 2) > 1)\). As vice rewards have immediate benefits and delayed costs, they are especially tempting for agents. Therefore, the related costs must be high enough, otherwise the agent would always get the reward. Self-reward can have immediate costs and delayed benefits in which case it is called a virtue reward. An example of a virtue reward is exercising. The lower and upper bound for the cost of virtue reward are:

\[
\gamma(2, 1) = \beta \frac{1 + \eta}{1 + \eta\lambda} \quad \text{and} \quad \bar{\gamma}(2, 1) = \beta \frac{1 + \eta\lambda}{1 + \eta}.
\]

The maximal self-sustaining goal is:

\[
\Phi(\hat{c}_R(2, 1)) = b(\beta - \gamma).
\]

Finally, a self-reward can also have both delayed benefits and costs. These rewards are called delayed rewards and they can be, for instance, delayed neutral rewards such as having a dinner with friends. The lower and upper bound for the cost of delayed reward are:

\[
\gamma(2, 2) = \frac{1 + \eta}{1 + \eta\lambda} \quad \text{and} \quad \bar{\gamma}(2, 2) = \frac{1 + \eta\lambda}{1 + \eta}.
\]
\[ \bar{\gamma}(2, 2) = \frac{1 + \eta \lambda}{1 + \eta}. \]

The maximal self-sustaining goal is:

\[ \Phi(\bar{c_R}(2, 2)) = b/\beta(1 - \gamma). \]

[Koch et al., 2014].

Figure 3 demonstrates how different credible self-rewards can expand the set of self-

![Figure 3: Self-sustaining goals with different types of credible self-rewards](image)


...sustaining goals. The colored dashed downward sloping lines are the incentive constraints for each type of self-reward. The first area, colored in blue, demonstrates the effect of virtue goods. The figure shows that this type of self-reward does not expand the set of self-sustaining goals anywhere near as much as neutral or vice rewards. It is obvious that self-rewards that have immediate costs and delayed benefits are not the best option to mitigate procrastination. The second area colored in red illustrates the effect of neutral self-rewards and the third area colored in grey describes delayed neutral self-rewards. Intuitively, delayed rewards expand the set of self-sustaining goals less than neutral rewards. Furthermore, the third area is included entirely in the second area. Thus, all potential self-sustaining goals with delayed rewards are also possible...
with neutral rewards. Finally, the fourth area colored in green demonstrates vice goods. Very intuitively, this area is the biggest. For agents with present bias, rewards with immediate benefits and delayed costs are very attractive. However, even though vice rewards expand the set of self-sustaining goals more, the maximal possible goal is the same for neutral and vice rewards. Furthermore, this maximal goal is significantly greater than that of virtue and delayed rewards. The horizontal width of the area illustrates the range of costs that is possible for self-sustaining goals. Hence, vice rewards support the largest scale of reward costs, whereas virtue rewards support the smallest share. [Koch et al., 2014].

2.6.2 Deadlines

Deadlines are common in our everyday life. Our term papers, work projects, and applications usually have deadlines. Interestingly, people also set voluntary deadlines when there are no binding ones. Therefore, economists have been interested in whether people try to control their self-control problems by setting these deadlines. Within this chapter, I will introduce two models and one empirical experiment that discuss the effects of deadlines for procrastination. The first model is from Ariely and Wertenbroch’s paper (2002), the second one is from Herweg and Müller’s paper (2011) and the experiment is from Shu and Gneezy’s paper (2010).

Ariely and Wertenbroch (2002) conducted two separate studies to answer the following three questions:

1. Do people set themselves costly deadlines to decrease procrastination?

2. Do these self-imposed deadlines improve performance (i.e., are they effective)?

3. Are these deadlines set optimally?

The first study was conducted in an MIT course for professionals. The students were divided into two different groups, named as no-choice and free-choice. All the students in the course had to write three short papers. The students in the no-choice group received fixed, evenly spaced deadlines for the papers, whereas the students in the free-choice group had the freedom to decide their own deadlines. However, the students in the free-choice group needed to submit their papers at the latest in the last lecture and declare their chosen deadlines before the second lecture. In addition, the chosen deadlines were binding so that they could not be changed, and a delay would cause a penalty in the paper’s grade. Lastly, there were no grade advantages on early submissions as neither feedback nor grades were provided for the students before the course ended. This was explained to the students so that they did not have incentives to submit papers early. On the contrary, the students could have had the most flexibility,
time to work with the papers and time to learn about the topics, and the smallest probability to suffer from penalties by setting deadlines for all the papers on the last possible day. It is important to note that the students were allowed to submit their papers early, thus they could have planned privately to submit papers earlier but still choose the last possible day to minimize the risk of penalties.[Ariely and Wertenbroch, 2002].

<table>
<thead>
<tr>
<th></th>
<th>The average distance from the last day of class</th>
<th>t(44)</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>The first paper</td>
<td>41.78</td>
<td>8.41</td>
<td>p &lt; .001</td>
</tr>
<tr>
<td>The second paper</td>
<td>26.07</td>
<td>8.10</td>
<td>p &lt; .001</td>
</tr>
<tr>
<td>The third paper</td>
<td>9.84</td>
<td>4.97</td>
<td>p &lt; .001</td>
</tr>
</tbody>
</table>

Table 2: Results of the first study

Figure 4: Frequency distribution of the declared deadlines in the first study


Table 2 summarizes the results from the first study, and Figure 4 shows the frequency distribution of the declared deadlines. Interestingly, the students in the free-choice group divided the deadlines quite evenly throughout the course. Table 2 shows that, on
average, the students chose deadlines significantly before the last possible day for all the papers. Furthermore, Figure 4 shows that only 27% of the students in the free-choice group chose the latest possible deadline for all the papers, and only 32% of all the deadlines were set for the last week. The results obtained from the first study suggest that people indeed set themselves costly deadlines to decrease procrastination. [Ariely and Wertenbroch, 2002].

In the second study, 60 students were hired to proofread other students’ papers and their salary depended on the quality of their work. They earned 10¢ for each correctly spotted error but lost $1 for each day of delay. They needed to proofread three 10-pages long papers, which each had 100 linguistic errors. The students were randomly divided into three experimental groups. The first group had evenly-spaced deadlines, the second group needed to choose their deadlines by themselves (as in the first study), and the final group had the same deadline for all the three papers, which was at the end of the project. All the students were allowed to submit their work early, but it did not increase their earnings. [Ariely and Wertenbroch, 2002].

Figure 5: Results of the second study


Figure 5 illustrates the performance-related results of the second study. It shows that the group with evenly-spaced deadlines performed best: they spotted the most errors, had the least delays in submissions, and earned the most. Respectively, the group with the end deadline performed worst: they spotted the least errors, had the most delays in submissions, and earned the least. The group with self-imposed deadlines
ranked in between. Ariely and Wertenbroch then compare the group with evenly-spaced
deadlines with those students in the self-imposed deadlines group who decided to space
their deadlines evenly. Interestingly, these two groups performed in the same way. The
group with self-imposed deadlines performs worse because the students in the group
do not set deadlines optimally. However, these students perform better than those
who have the end deadline for all the papers. Hence, self-imposed deadlines improve
performance and are, to some extent, effective. Nevertheless, evenly spaced deadlines
improve performance the most. [Ariely and Wertenbroch, 2002].

Herweg and Müller (2011) model the effects of deadlines on the behavior of present-
bias agents in their paper. They consider a model which has two periods \( t \in \{1, 2\} \)
and two independent tasks denoted by \( i \in \{A, B\} \). In each period, the agent decides
how much effort \( (e_i \geq 0) \) to invest in each task. Investing effort causes immediate
time-invariant costs denoted by \( c(e_i) \). Finally, the agent receives the delayed reward
separately for both tasks in period 3. The reward is a function of the total effort
invested in each task as follows \( g_i(e_{i1} + e_{i2}) \). Further assumptions needed for the model
are represented in Appendix A. The agents’ intertemporal preferences are modeled as
follows:

\[
U_t(u_t, u_{t+1}, \ldots, u_T) = u_t + \beta \sum_{\tau=t+1}^{T} \delta^{T-\tau} u_{\tau}.
\]

The equation is very similar to those presented in chapter 2.1.1. and is not discussed in
greater detail here. The agent is modeled as a sequence of autonomous selves. Each self
is in charge of one period, and they observe all choices in the past periods but cannot
constrain the behavior of future selves in any way. Furthermore, three types of agents
are considered: time-consistent agents, sophisticates, and naifs. Finally, concerning
deadlines, two different settings are considered. In the first setting, there is no interim
deadline, but both tasks must be submitted by the end of the second period. In the
second setting, the is an interim deadline as task \( A \) must be submitted by the end of the
first period and task \( B \) by the end of the second period. [Herweg and Müller, 2011].

When the time-consistent agent faces no interim deadline, their utility in the first period
is denoted as follows:

\[
U_1^{TC\text{ND}} = -c(e_{A1} + e_{B1}) - c(e_{A2} + e_{B2}) + g(e_{A1} + e_{A2}) + g(e_{B1} + e_{B2}),
\]

where the double-superscript notes the setting considered (ND corresponds to the
setting with no deadline and D to the setting with an interim deadline). As the agent
maximizes their utility, we get the following result:

\[
c'(e_1^{TC\text{ND}}) = c'(e_2^{TC\text{ND}}) = g'(e_A^{TC\text{ND}}) = g'(e_B^{TC\text{ND}}).
\]
In other words, the time-consistent agent divides their effort evenly between tasks and between periods. However, they do not care in which period they invest effort in which task. That is to say, it does not matter to them if they focus only on task A in period 1, and respectively on task B in period 2, or the other way around. Furthermore, it does not matter to them if they invest effort in both tasks in both periods. Therefore, the interim deadline is not effective for them. If they need to submit task A by the end of period 1, they work only in task A in period 1 and focus on task B in period 2. The interim deadline does not improve their performance in any way. [Herweg and Müller, 2011].

Now consider the sophisticated agent and the setting with no interim deadline. As the agent knows about their present-biased preferences, their decision process can be modeled as a game between temporal selves and solved by backward induction. The results are obtained similarly compared to the time-consistent agent and thus left to Appendix A. The sophisticated agent also smooths effort between tasks but not between periods. The agent procrastinates in the first period and invests more effort in the second period. When the agent faces an interim deadline, they end up investing effort equally in both tasks. Furthermore, they smooth effort also between periods. It means that the agent focuses only on task A in period 1, and respectively only on task B in period 2. Details of the model are presented in Appendix A. Compared to the setting with no interim deadline, the agent always invests more effort both in period 1 and altogether in both periods. From a long-run perspective, the sophisticated agent receives a greater utility when placed under an interim deadline ($U_0^{SD} > U_0^{SNND}$). The interim deadline is effective because it helps the agent allocate their effort more efficiently between the two periods. Since task A must be submitted by the end of period 1, the agent cannot procrastinate with it. However, the optimal level of effort is that invested by a time-consistent agent, and the sophisticated agent does not reach it even with an interim deadline. [Herweg and Müller, 2011].

With the naive agent, the model can be solved very similarly compared to the sophisticated agent. Therefore, the details of the model are not presented here. In the setting with no interim deadline, the agent invests the same amount of effort in both tasks but procrastinates in the first period and thus $e_1^{NND} < e_2^{NND}$. Not surprisingly, the interim deadline works very similarly for the naive agent as for the sophisticated one. When the agent faces an interim deadline, they cannot procrastinate with task A, and therefore they focus solely on it in period 1. As the agent invests in both tasks equally, it can be denoted as follows:

$$ e_1^{ND} = e_A^{ND} = e_B^{ND} = e_2^{ND} = e^{ND}. $$

From a long-run perspective, the naive agent receives a greater utility when placed under an interim deadline ($U_0^{ND} > U_0^{NND}$). The interim deadline is effective as it helps
the agent structure their work more efficiently between the periods. To conclude, agents with time-consistent preferences do not benefit from deadlines as those only restrict their behavior and choices. Conversely, agents with present-biased preferences benefit from deadlines as those decrease procrastination and help agents structure the workload more efficiently between periods. In other words, deadlines are performance-enhancing for agents with time-inconsistent preferences. [Herweg and Müller, 2011].

With both unpleasant and pleasant tasks, procrastination can be reduced by setting a fixed deadline by which the task must be completed. Shu and Gneezy conducted a field experiment to study the effect of a limited time window for procrastination regarding pleasant activities. They observe how many landmarks residents visit in their home city compared to tourists. They predicted that tourists visit more landmarks as they have a fixed, limited time window which reduces procrastination, whereas residents have no deadline at all. They found that tourists do indeed visit more landmarks compared to residents. Furthermore, most of the residents visit landmarks in their home city with out-of-town-visitor, when they actually have a limited time window to do it. In addition, they also conducted a separate experiment looking at whether residents planning to move out from the city visit landmarks just before their departure to see if the limited time window affects their behavior. They found that most of the landmark visits of those participants took place in the last months of their residency. Thus, both of these experiments support the idea that fixed deadlines and limited time windows reduce procrastination. [Shu and Gneezy, 2010]

2.6.3 Cooperation

The section below describes cooperation as a way to reduce procrastination. The section is based on Cerrone’s (2021) article, and it presents a model analyzing cooperation’s effects on procrastination. It also offers recommendations about how to pair agents to achieve the most efficient outcome.

Cerrone (2021) studies how cooperation affects procrastination when the agent must perform their individual task in another person’s presence. The model is called the procrastination game (G). It is assumed that the agent suffers from present bias, i.e., their preferences are time-inconsistent. Furthermore, the agent is assumed to be sophisticated, which means they are fully aware of their time-inconsistent preferences. Agent’s preferences are quasi-hyperbolic, and their intertemporal utility in the first period is denoted by:

\[ U_i^1 \equiv u_1 + \beta_i \delta u_2 + \beta_i \delta^2 u_3, \]

where \( u_t \) stands for the agent’s utility in period \( t \), \( \delta \) is a time-consistent discount factor and \( \beta_i \) represents time-inconsistent present bias. It is assumed that \( 0 < \beta_i < 1 \) and \( \delta = 1 \). Furthermore, the agent enjoys the company, and therefore they prefer to complete their
task at the same time with another agent. The agent must complete their individual task exactly once during three periods \((t = 1, 2, 3)\). If the agent has not completed their task before the final period, they have no other choice than do it then. Tasks are assumed to have immediate costs and future benefits. A task’s cost schedule is denoted by \(c = (c_1, c_2, c_3)\) and \(c_t \geq 0\) for each period \(t\). The cost of completion increases over time \((c_3 > c_2 > c_1)\) and is smaller when a task is done at the same time with another agent. These assumptions describe many real-life activities, for example, writing an essay, applying for a job, or filing taxes. The cost of completion may increase as time passes since performing an activity gets more stressful as the deadline approaches. [Cerrone, 2021].

The procrastination game \((G)\) has two players \(\{A, B\}\) who can choose from two actions \(a_{i,t} \in \{0, 1\}\) in each period \(t\). Action 0 means that the agent does not complete their task in the current period but chooses to wait, whereas action 1 means that the agent completes the task in the current period. It is assumed that the procrastination game is a game of complete information, i.e., the players are fully aware of others’ tendencies to procrastinate. The period when an agent \(i\) chooses to complete their task is denoted by \(\tau_i\), and the other player’s completion period is denoted by \(\tau_{-i}\). Agent’s intertemporal utility from completing the task in period \(\tau_i\) is given as follows:

\[
U_i^t(\tau_i|\tau_{-i}) \equiv \begin{cases} 
-c_{\tau_i} & \text{if } \tau_i = t \neq \tau_{-i} \\
-c_{\tau_i}(1-\kappa) & \text{if } \tau_i = t = \tau_{-i} \\
-\beta_i c_{\tau_i} & \text{if } \tau_{-i} \neq \tau_i > t \\
-\beta_i c_{\tau_i}(1-\kappa) & \text{if } \tau_i = \tau_{-i} > t,
\end{cases}
\]

where \(\kappa \in (0, 1 - \max\{\frac{c_2}{c_1}, \frac{c_3}{c_2}\})\) describes how much the agent values company. The first case describes the situation when the agent chooses to complete the task alone in the current period and faces that period’s cost \((c_{\tau_i})\). The second line corresponds to the situation when the agent chooses to complete the task in the current period together with the other agent. Then they face that period’s cost, which is however reduced by the fact that they have a company which makes it less onerous to perform the task. The third line relates to the situation when the agent completes the task alone after the current period and thus faces that period’s cost discounted by their present bias coefficient \((\beta_i)\). Finally, the last line represents the situation when the agent performs their task at the same time as the other player but after the current period. [Cerrone, 2021].

Cerrone’s model is similar to that of O’Donoghue and Rabin’s (2001) with the addition of preference for a company \((\kappa)\). If \(\kappa = 0\), these models become the same. The same solution concept, a perception-perfect strategy, is used here. A perception-perfect
strategy in a procrastination game means that each agent must choose optimally in each subgame given their knowledge of the game. Furthermore, it is assumed that all players are peer-sophisticated, i.e., they can correctly forecast the opponent’s behavior. [Cerrone, 2021].

Cerrone characterizes the different types of sophisticated agents and remarks that the agent’s type affects significantly the outcome of cooperation. Cerrone defines agents’ types under sophistication as follows when \( \frac{a_1}{c_3} < \frac{a_4}{c_2} \):

1. Severe procrastinator if \( \beta_i < \frac{a_1}{c_3} \).

2. Moderate procrastinator if \( \frac{a_1}{c_2} > \beta_i \geq \frac{a_4}{c_2} \).

3. Impatient non-procrastinator if \( \frac{a_4}{c_3} > \beta_i \geq \frac{a_4}{c_4} \).

4. Non-procrastinator if \( \beta_i \geq \frac{a_4}{c_2} \).

She finds out that cooperation between a severe procrastinator and a moderate procrastinator weakly reduces procrastination. The mechanism is divided into two components, avoidance of bad company and mutual reduction of procrastination. The presence of a severe procrastinator may drive the moderate procrastinator to complete their task earlier than in isolation. This may happen if the severe procrastinator has such a large present bias that they always choose to complete their task in the last period no matter the possibility of company. Then the moderate procrastinator acknowledges that if they do not complete their task in the first period, they will not be able to resist the temptation to procrastinate in the second period. If the moderate procrastinator acted in isolation, they would procrastinate for one period and complete the task in the second period. In the presence of a severe procrastinator, they want to avoid the bad company, and thus they end up completing their task earlier than in isolation. It is important to note that this behavior crucially depends on the assumption of sophistication since the moderate procrastinator must foresee their future self-control problem in the second period in order to avoid it. Considering mutual reduction of procrastination, the only difference compared to the case presented above is that now the severe procrastinator has a smaller present bias. Consequently, they want to perform their task at the same time with moderate procrastinator and in the equilibrium both players complete their tasks in the first period, and procrastination is reduced. [Cerrone, 2021].

Cooperation between a procrastinator (severe or moderate) and a non-procrastinator (impatient or not) may have a different effect depending on the extent of the agents’ present bias, hence it can not be said whether it reduces or exacerbates procrastination. On the other hand, cooperation between two procrastinators of the same type weakly mitigates procrastination, and cooperation between two non-procrastinators of the same type exacerbates it. Therefore, to decrease the welfare loss caused by procrastination,
it would be profitable to team up procrastinators and let non-procrastinators perform their tasks in isolation. For example, employers could utilize this information to cut off unnecessary slack. Nevertheless, to take advantage of this finding, employers must know the agents’ type, i.e., their tendency to procrastinate, which is not always possible. Cerrone then embeds this in a matching model to study whether efficient matching is stable to find out if agents can be allowed to match freely. A matching \( \mu \) is defined as stable if no agent prefers being single over their pairing and there does not exist such two agents who would like to switch places. She finds out that this is not the case. It is very intuitive since in the efficient matching, severe procrastinators are matched with moderate procrastinators, which leads the moderate procastinator to complete their task earlier than in isolation, and the severe procrastinator to complete their task alone in the last period. However, the severe procrastinator would always prefer to be matched with another severe procrastinator and complete their tasks together in the last period. It means that if agents’ types are not known, it is better to do the matching randomly than let agents choose their pairs freely. [Cerrone, 2021].

2.6.4 Promises

The following part of this thesis moves on to discuss promises as a way to reduce procrastination in greater detail. I will first introduce Carrillo and Dewatripont’s (2008) theoretical model and then move on to discuss a field experiment conducted by Himmel et al. (2019).

Carrillo and Dewatripont (2008) analyze the optimal use of promises as a commitment devise for sophisticated agents with time-inconsistent preferences. They assume that present-biased agents discount a period \( t + s \) \((s \geq 1)\) by \( \beta \delta^s \), where \( \beta \leq 1 \) and \( \delta = 1 \). This model has two periods, and in the first one, the agent must choose how much effort \((e)\) to invest in a task. Investing effort yields an immediate cost denoted by \( \psi(e) \) and a future reward \((e)\) which is equal to the effort invested. The reward materializes in the second period. Furthermore, it is assumed that \( \psi'(e) > 0 \) and \( \psi''(e) > 0 \). In the first period, the agent’s surplus is as follows:

\[
\beta e - \psi(e).
\]

From a long-run perspective (in period 0) agent’s surplus is as follows:

\[
\beta [e - \psi(e)].
\]

From a long-run perspective the agent would like to invest more effort in period 1. However, once the period arrives, they change their mind and procrastinate. That is where promises can help to overcome the incentive problem. When promises are
included in the model, the agent is able to make a promise before the first period to invest an amount \( e^* \) of effort in the task when period 1 arrives. In this model, the promise is assumed to be made to another person. If the agent does not fulfill the promise, they will suffer a cost \( f(e^*-e) \). There are two possible causes for the related cost. Either the agent suffers a reputation loss from not being reliable, or there is a probability that an external monitor detects their shirking. As we see from the cost function, the cost can be avoided by keeping the promise or by investing more effort than promised. It can be summarized:

\[
    f(e^*-e) = 0 \text{ for all } e \geq e^* \text{ and } f'(e^*-e) > 0 \text{ for all } e < e^*.
\]

[Carrillo and Dewatripont, 2008].

The agent’s intertemporal utility function in period 0 is:

\[
    W(e, e^*) = \beta [e - f(e^*-e) - \psi(e)].
\]

Respectively, the agent’s utility in the first period is denoted by:

\[
    V(e, e^*) = \beta [e - f(e^*-e)] - \psi(e).
\]

The agent in period 0 would like to maximize their utility function \((W(e, e^*))\), whereas the agent in period 1 would like to maximize theirs \((V(e, e^*))\). That leads to a situation where \( e_1(0) < e_0(0) \). To prevent the agent in the first period from procrastinating, the agent can make a costly promise in period 0. To formally state the possible outcomes, it is denoted:

1. If \( f'(0) > \frac{1-\beta}{\sigma} \), then \( e^* = e_0(0) \text{ and } e_1(e^*) = e^* \).

2. If \( f'(0) < \frac{1-\beta}{\sigma} \) and \( \beta f''(0) < \frac{f'(0)\psi'(\sigma)}{1-\psi'(\sigma)} \), then \( e^* = \bar{e} < e_0(0) \text{ and } e_1(e^*) = e^* \).

3. If \( f'(0) < \frac{1-\beta}{\sigma} \) and \( \beta f''(0) > \frac{f'(0)\psi'(\sigma)}{1-\psi'(\sigma)} \), then \( \bar{e} < e_1(e^*) < e_0(0) \text{ and } e_1(e^*) < e^* \).

The first case corresponds to a situation where the agent in period 0 promises to invest the level of effort that maximizes the period 0’s utility function. In this case, the promise is kept either because the self-control problem is mild or because it is very costly to break the promise. The second and third cases correspond to a situation when the agent in period 0 promises to invest a lower level of effort than the utility-maximizing one. In the second case, the promise is kept because the marginal cost is not adequately increasing in the deviation between effort and promise. In the third case, the situation is the opposite, and the promise is broken. It is important to note that the promised
level of effort always complies with the following equation:

\[ e_1(0) < e^* \leq e_0(0). \]

Intuitively, the agent in period 0 can promise a high level of effort either if the self-control problem is mild or if it is very costly to break the promise. However, if this is not the case, it can be more reasonable for the agent in period 0 to set mild promises that will be fulfilled. Nevertheless, the agent needs to consider that small deviations from the promised level of effort are not that costly, and therefore the agent in period 0 can decrease procrastination by setting higher promises. All in all, the agent must weigh all these possible effects before making the final decision. [Carrillo and Dewatripont, 2008]. Himmler, Jäckle, and Weinschenk (2019) approach the topic from a different perspective. They want to study how a soft commitment device, such as a promise, affects students procrastination. They organize a field experiment where incoming students of business administration at a university are divided into two treatment groups and one control group. All the students receive a similar introduction lecture in the beginning of their studies where they are advised how to organize their studies and graduate on time. They are provided with the information about recommended course schedule, sign-up procedures, deadlines, and exam preparation. Students in the first treatment group receive remainder letters about the course schedule and exam weeks. With this treatment group the researchers want to find out whether students lag behind the target schedule simply because they do not remember to sign-up for exams etc. In the second treatment group, the students are offered a possibility to sign an agreement, which states that the student will follow the recommended study schedule. This agreement is considered as a soft commitment device since it does not cause any consequences. The students are not punished in any way if they violate the agreement. Students make a promise to themselves and the university to follow the recommended study schedule and this promise shifts students reference point. All of the students in the second treatment group that were present in the introduction lecture chose to sign the agreement. [Himmler et al., 2019].

The researchers measure three outcomes in the experiment:

- for how many exams the students sign up,
- in how many exams the students participate,
- how many exams do the students pass.

They find out that the students in the second treatment group sign up for more exams than the students in the control group. Furthermore, they also participate in the exams more often. Finally, most importantly, the students in the second treatment group also
pass more exams than the students in the control group. Interestingly, the researchers find no significant effects between the first treatment group and the control group. Therefore, it can be concluded that the students do not lag behind the recommended schedule because they do not remember to sign up or prepare for the exams. Furthermore, the researchers combine the data from the field experiment with the data about the students’ university applications. They are able to recognize procrastinators from the university application data and show that the soft commitment device helps mostly those students who are prone to procrastinate. To conclude, procrastination severely weakens academic performance and extends studentships. However, soft commitment devices can mitigate procrastination and decrease the problem. [Himmler et al., 2019].
3 Model: Scheduling as a commitment device

Within this section, I develop a model addressing the question of whether scheduling can work as a commitment device and decrease procrastination. I analyze how scheduling affects the decision-making of a presented-biased agent and under what circumstances it decreases procrastination. Finally, I compare scheduling as a soft commitment device to its hard commitment counterpart, deadlines.

3.1 The model

I use the framework presented by Rabin and O’Donoghue (1999) (presented in Chapter 2.3) as a basis for my model. The agent must complete one task exactly once during a finite number of periods, denoted by $T$. However, unlike in Rabin and O’Donoghue, the agent is allowed to use a soft commitment device, scheduling, beforehand. In period 0, the agent is allowed to do a schedule, i.e., choose in which period they would like to complete the task. As in Rabin and O’Donoghue’s model, if the agent has not completed the task by period $T$, they must perform it then, since it must be performed exactly once. Completing the task yields an immediate, constant cost denoted by $c$ and a delayed reward in period denoted by $v \equiv (v_1, v_2, \ldots, v_T)$. The agent receives the reward always in period $T$, while the magnitude of the reward depends on when the agent completes the task. $c, v_t \geq 0$ for each $t \in \{1, 2, \ldots, T\}$ and the reward is the higher the earlier the task is completed. This is a very intuitive assumption when considering tasks like saving, investing, and stopping addictive behavior (smoking, drug abuse). For instance, if the task in question is stopping smoking, the agent faces a constant, immediate cost when completing the task and receives a delayed benefit. The benefit is the higher the earlier the task is completed, since the agent’s health has not been harmed that much. However, if the agent procrastinates, the benefit decreases as their health worsens.

The agent’s behavior strategy is denoted by $s \equiv (s_1, s_2, \ldots, s_T)$, where $s_t \in \{Y, N\}$ for all $t \in \{1, 2, \ldots, T\}$. $Y$ means that the agent decides to perform the activity in the current period and $N$ stands for waiting. Let $\tau$ denote the period when the agent completes the task and let $\tau^*$ denote the period when they have scheduled to complete the task. The agent is assumed to have the following intertemporal utility function:

$$U^t(u_t, u_{t+1}, u_{t+2}, \ldots, u_T) \equiv \delta^t u_t + \beta \sum_{\tau=t+1}^{T} \delta^\tau u_\tau$$

for all $t$, $\beta > 0$ and $\delta \leq 1$. $\delta$ is interpreted as a long-run, time-consistent discount factor and $\beta$ as the bias for the present. If $\beta = 1$, there exist no present bias, and the equation becomes a simple exponential discounting model. Whereas, if $\beta < 1$, there exists a bias
for the present; the agent values period $\tau$ more relative to future periods in period $\tau$ than they did in previous periods. The preferences represented by this model are called $(\beta, \delta)$-preferences. Without loss of generality, it is assumed that $\delta = 1$.

Scheduling works as a promise to oneself, and thus it shifts the agent’s reference point as in Hoch and Loewenstein’s paper (1991) (see chapter 2.1.1). Therefore, not reaching the reference point causes the agent an immediate utility loss, whose magnitude depends on the distance between the real outcome and the reference point. The utility loss is entirely caused by the agent’s personal experience of deprivation. There is no external punishment for not following the schedule. Figure 6 demonstrates the reference point shift caused by scheduling in a three period case. The two exponentially decreasing functions represent the utility loss depending on the scheduled completion date $\tau^\ast$. The agent’s reference points are located at the intersection of the utility loss function and x-axis. The thinner 'No adaptation' line corresponds to both of the cases, when $\tau^\ast = 3$ and when there is no schedule at all, whereas the thicker 'Adaptation' line corresponds to the case when $\tau^\ast = 1$. We can see from the figure that if the agent does not complete the task when scheduled, i.e., if the agent does not reach their reference point, they face a utility loss. Furthermore, the utility loss is increasing exponentially in the magnitude of deviation from $\tau^\ast$.

![Figure 6: Reference point shift caused by scheduling](image)

The agent’s intertemporal utility is assumed to be composed of three components in
period $t \leq \tau$ as follows:

$$U^t(\tau, \tau^*) = \begin{cases} 
\beta v_\tau - c - \omega(\tau, \tau^*) & \text{if } \tau = t \\
\beta(v_\tau - c - \omega(\tau, \tau^*)) & \text{if } \tau > t,
\end{cases}$$

where

$$\omega(\tau, \tau^*) = \begin{cases} 
\lambda^{\tau - \tau^*} (v_{\tau^*} - v_\tau) & \text{if } \tau - \tau^* > 0 \\
0 & \text{if } \tau - \tau^* \leq 0.
\end{cases}$$

$\omega(\tau, \tau^*)$ stands for the reference-dependent part of the utility function. As already explained, the agent gets disutility from not reaching the reference point. $\lambda$ represents the agent’s loss aversion and it is assumed that $\lambda > 1$. In other words, the reference-dependent part satisfies:

$$\omega(\tau, \tau^*) = 0 \text{ for all } \tau \leq \tau^* \text{ and } \omega'(\tau, \tau^*) > 0 \text{ for all } \tau > \tau^*.$$

There is no utility loss nor utility gain if the task is completed when scheduled or in advance. Furthermore, the reference-dependent utility loss is exponentially increasing in delay, meaning that larger departures from the scheduled period are relatively more costly than smaller departures. This feature of the utility loss function is demonstrated in Figure 6. $D_1$ states the utility loss when $\tau^* = 1$ and $\tau = 2$. Accordingly, $D_2$ states the utility loss when $\tau^* = 1$ and $\tau = 3$. It can be seen from the picture that both functions are decreasing exponentially, and thus $D_2 > 2D_1$. In addition, the utility loss depends on the difference between the reward in the scheduled period and the reward in actual completion period. This means that the reference-dependent utility loss is linked with the underlying decision problem such that procrastination with high stake tasks is more costly.

To close this model, I introduce a self at time 0, who weights all upcoming periods equally. This self’s utility in period 0 is called the long-run utility and denoted as follows:

$$U^0(\tau) = v_\tau - c - \omega(\tau, \tau^*).$$

The period 0 self is able to observe the situation as they were time-consistent. As the cost is constant and the reward is higher the earlier the task is completed, an agent with time-consistent preferences would like to complete the task in the first period. However, this is not necessarily the case with a present-biased agent.

### 3.2 Analysis

I use the solution concept introduced in O’Donoghue’s and Rabin’s (1999) article, i.e., a perception-perfect strategy. The agent chooses a task that maximizes their current
utility in each period taking into account their current preferences and their assumption about their future preferences. Based on this concept, an agent with time-consistent preferences always completes the task in the first period because the cost is constant and the reward is the higher the earlier the task is completed. Accordingly, a sophisticated agent always schedules such that they will follow their plan as they know their $\beta$. To formally model agents’ preferences, their belief in their future self-control problems is noted by $\hat{\beta}$. As sophisticates are fully aware of their future self-control problems, for them $\hat{\beta} = \beta$. Naifs believe their preferences are time-consistent, thus for them $\hat{\beta} = 1$. Partial naifs belong somewhere between sophisticates and naifs. They are not fully aware of the magnitude of their future self-control problems, nor do they think they have time-consistent preferences. Formally noted, for them $\hat{\beta} \in (\beta, 1)$.

**Sophisticated agent**

A sophisticated agent is completely aware of their self-control problem so they are willing to use a commitment device to constraint their future behavior. However, they do not want to face the utility loss from not following the schedule. Therefore, they want to schedule such that they will follow the plan when the time comes. With a sophisticated agent, this model can be thought of as a game between different temporal selves of the agent. It is a finitely repeated game of complete information and can be solved by backward induction.

**The case with $\tau^* = 3$ and $T = 3$ / no schedule**

Consider the case when the agent plans to complete the task in the last period $\tau^* = 3$ and the number of periods is 3. This situation corresponds to the case with no schedule at all since the schedule is not binding in any way. In other words, the agent can choose the period they wish since there is no cost nor reward for completing the task earlier than planned. Let’s solve this game by backward induction. If the agent has not completed the task by period 3, they have no choice but to complete it then. Therefore, we do not need to analyze the last period in more detail because there is no choice involved. In the second period when the agent has to choose whether to perform the task then or leave it until the last period. The agent completes the task in the second period if and only if:

$$\beta v_2 - c - \omega(2, 3) \geq \beta (v_3 - c - \omega(3, 3)).$$

This yields:

$$\beta \geq \frac{c}{v_2 - v_3 + c}.$$

(8)
Now we know that the agent does not procrastinate until the last period if their $\beta$ meets condition 8 above. Finally, consider the choice in the first period. If condition 8 holds, then the agent completes the task in the first period if and only if:

$$\beta v_1 - c - \omega(1, 3) \geq \beta(v_2 - c - \omega(2, 3)).$$

This yields:

$$\beta \geq \frac{c}{v_1 - v_2 + c}.$$ 

If condition 8 fails, then the agent completes the task in the first period if and only if:

$$\beta v_1 - c - \omega(1, 3) \geq \beta(v_3 - c - \omega(3, 3)).$$

This yields:

$$\beta \geq \frac{c}{v_1 - v_3 + c}$$

which is impossible considering that condition 8 must fail. Therefore, if condition 8 fails, the agents completes the task in the last period. This scenario is not discussed in detail with other schedule options. Hence, if $\tau^* = 3$, we can conclude:

- $\tau = 1$ iff $\beta \geq \frac{c}{v_1 - v_3 + c}$
- $\tau = 2$ iff $\frac{c}{v_2 - v_3 + c} \leq \beta < \frac{c}{v_1 - v_2 + c}$
- $\tau = 3$ iff $\beta < \frac{c}{v_2 - v_3 + c}$.

**The case with $\tau^* = 1$ and $T = 3$**

Consider the situation when the agent plans to complete the task in the first period ($\tau^* = 1$). The agent completes the task in the second period if and only if:

$$\beta v_2 - c - \omega(2, 1) \geq \beta(v_3 - c - \omega(3, 1)).$$

This yields:

$$\beta \geq \frac{\omega(2, 1) + c}{v_2 - v_3 + c + \omega(3, 1)}.$$  

(9)

Now we know that the agent does not procrastinate until the last period if their $\beta$ meets condition 9 above. Finally, consider the choice in the first period. If condition 9 holds, the agent completes the task in the first period if and only if:

$$\beta v_1 - c - \omega(1, 1) \geq \beta(v_2 - c - \omega(2, 1)).$$
This yields:

\[ \beta \geq \frac{c}{v_1 - v_2 + c + \omega(2, 1)}. \]  

(10)

If condition 9 fails, the agent completes the task in the last period. Therefore, we know that the agent follows the schedule and completes the task in the first period if their \( \beta \) meets condition 10. Hence, when \( \tau^* = 1 \) we can conclude:

- \( \tau = 1 \) iff \( \beta \geq \frac{c}{v_1 - v_2 + c + \omega(2, 1)} \)
- \( \tau = 2 \) iff \( \frac{\omega(2, 1) + c}{v_2 - v_3 + c + \omega(3, 1)} \leq \beta < \frac{c}{v_1 - v_2 + c + \omega(2, 1)} \)
- \( \tau = 3 \) iff \( \beta < \frac{\omega(2, 1) + c}{v_2 - v_3 + c + \omega(3, 1)} \).

As the sophisticated agent is completely aware of their self-control problem, they know their \( \beta \), and therefore they only plan to complete the task in period 1 if they know that they are able to follow the schedule.

**The case with \( \tau^* = 2 \) and \( T = 3 \)**

Now we analyze the subgame when the agent plans to complete the task in the second period. The agent completes the task in the second period if and only if:

\[ \beta v_2 - c - \omega(2, 2) \geq \beta(v_3 - c - \omega(3, 2)). \]

This yields:

\[ \beta \geq \frac{c}{v_2 - v_3 + c + \omega(3, 2)}. \]  

(11)

The agent does not procrastinate until the last period if their \( \beta \) meets condition 11. If condition 11 holds, the agent completes the task in the first period if and only if:

\[ \beta v_1 - c - \omega(1, 2) \geq \beta(v_2 - c - \omega(2, 2)). \]

This yields:

\[ \beta \geq \frac{c}{v_1 - v_2 + c}. \]

If condition 11 fails, the agent completes the task in the last period. Hence, if \( \tau^* = 2 \), we can conclude:

- \( \tau = 1 \) iff \( \beta \geq \frac{c}{v_1 - v_3 + c} \)
- \( \tau = 2 \) iff \( \frac{c}{v_2 - v_3 + c + \omega(3, 2)} \leq \beta < \frac{c}{v_1 - v_2 + c} \)
- \( \tau = 3 \) iff \( \beta < \frac{c}{v_2 - v_3 + c + \omega(3, 2)} \).
Scheduling decision of a sophisticated agent

Now we can solve the choice that the agent makes in period 0 about their schedule. It is as follows:

- $\tau^* = 1$ iff $\beta \geq \frac{c}{v_1 - v_2 + c + \omega(3,1)}$, $\tau = 1$
- $\tau^* = 2$ iff $\frac{c}{v_2 - v_3 + c + \omega(3,2)} \leq \beta < \frac{c}{v_1 - v_2 + c + \omega(2,1)}$, $\tau = 2$
- $\tau^* = 3$ iff $\beta < \frac{c}{v_2 - v_3 + c + \omega(3,2)}$, $\tau = 3$.

Figure 7 demonstrates the scheduling decision of a sophisticated agent visually. As

![Figure 7: Scheduling decision of a sophisticated agent](image)

Note: Cost and rewards are fixed as follows: $c = 5$, $v_1 = 8$, $v_2 = 7$, $v_3 = 4$.

the sophisticated agent knows the magnitude of their self-control problem (they know their $\beta$), they never schedule their task such that they will not follow the schedule. Furthermore, scheduling can never cause the agent harm, but it can only help them. More importantly, scheduling can indeed decrease procrastination. However, for sophisticated agents with too severe self-control problems (in Figure 7 the area below the orange line where $\beta < \frac{c}{v_2 - v_3 + c + \omega(3,2)}$), scheduling does not help because the additional cost from not following the schedule is never high enough to overcome the self-control problem, and
the agent always procrastinates until the last period. Respectively, if the agent’s self-control problem is milder ($\beta \geq \frac{c}{\nu_2 - \nu_3 + c + \omega(3,2)}$), scheduling can decrease procrastination. If the agent’s self-control problem is too mild ($\beta \geq \frac{c}{\nu_1 - \nu_2 + c}$), scheduling does not decrease procrastination because the agent would not procrastinate in anyway. It can be concluded that regarding sophisticated agents, scheduling decreases procrastination in two cases:

- $\frac{c}{\nu_1 - \nu_2 + c + \omega(2,1)} \leq \beta < \frac{c}{\nu_1 - \nu_2 + c}$
- $\frac{c}{\nu_2 - \nu_3 + c + \omega(3,2)} \leq \beta < \frac{c}{\nu_2 - \nu_3 + c}$

Figure 8 demonstrates the two cases when scheduling decreases procrastination for a sophisticated agent (cost and rewards are fixed). The first case corresponds to the situation when the agent would procrastinate until the second period if they could not use the schedule, but the schedule helps them to overcome procrastination and complete the task in the first period (the upper grey area in Figure 8). The second case corresponds to the situation when the agent would procrastinate until the last period.
period if they could not use the schedule, but the schedule helps them to overcome procrastination and complete the task earlier (the lower grey area in Figure 8).

**Naive agent**

Naifs do not foresee their future self-control problems, and hence they do not see any need for commitment devices as they believe they will behave time-consistently. Therefore, if a naive agent is commanded externally to make a schedule, they will always schedule as they were time-consistent. This means that they believe they complete the task in the first period, and thus they are indifferent between all possible schedule options. This follows from the fact that completing the task earlier than scheduled does not cause a utility loss nor utility gain. If the agent has even the smallest preference for following the schedule, they schedule to complete the task in the first period \((\tau^* = 1)\). I focus solely on this scenario in this paper. The agent realizes their self-control problem when the first period arrives, and then the agent faces the exact same situation as a sophisticated agent does. Therefore, they complete the task in the first period if and only if:

\[
\beta v_1 - c - \omega(1, 1) \geq \beta (v_2 - c - \omega(2, 1)).
\]

This yields:

\[
\beta \geq \frac{c}{v_1 - v_2 + c + \omega(2, 1)}.
\]  

(12)

If \(\beta\) does not meet condition 12 above, then the agent procrastinates. Their situation in the second period is exactly similar to that of the sophisticated agent. They complete the task in the second period if and only if:

\[
\beta v_2 - c - \omega(2, 1) \geq \beta (v_3 - c - \omega(3, 1)).
\]

This yields:

\[
\beta \geq \frac{\omega(2, 1) + c}{v_2 - v_3 + c + \omega(3, 1)}.
\]

Therefore, we can conclude for the naive agent the following. The naive agent does not see any reason to schedule as they believe they have time-consistent preferences. If they are commanded to schedule anyway, they will always plan to complete the task in the first period. When the period arrives, they face a self-control problem and choose the period to complete the task as follows:

- \(\tau = 1\) iff \(\beta \geq \frac{c}{v_1 - v_2 + c + \omega(2, 1)}\)
- \(\tau = 2\) iff \(\beta \geq \frac{\omega(2, 1) + c}{v_2 - v_3 + c + \omega(3, 1)}\) \leq \beta < \frac{c}{v_1 - v_2 + c + \omega(2, 1)}\)
- \(\tau = 3\) iff \(\beta < \frac{\omega(2, 1) + c}{v_2 - v_3 + c + \omega(3, 1)}\).
Figure 9: Completion decision of a naive agent
Note: Cost and rewards are fixed as follows: $c = 5$, $v_1 = 8$, $v_2 = 7$, $v_3 = 4$.

Figure 10: Cases when scheduling decreases procrastination for a naive agent
Note: Cost and rewards are fixed as follows: $c = 5$, $v_1 = 8$, $v_2 = 7$, $v_3 = 4$. 
Figure 9 demonstrates the completion decision of a naive agent visually. An important difference between naifs and sophisticates is that scheduling can hurt only naifs. As naifs are not aware of their self-control problem, they may schedule to complete the task in the first period but then give in to their self-control problem and procrastinate. In this case, they will bear the utility loss resulting from not following the schedule. However, as with sophisticates, scheduling can decrease procrastination of naive agents if their self-control problem is not too severe (in Figure 9 the area above the orange line where $\beta \geq \frac{\omega(2,1)+c}{v_{2}-v_{3}+c+\omega(3,1)}$). It can be concluded that regarding naive agents, scheduling decreases procrastination in two cases:

- $\frac{c}{v_{1}-v_{2}+c+\omega(2,1)} \leq \beta < \frac{c}{v_{1}-v_{2}+c}$
- $\frac{\omega(2,1)+c}{v_{2}-v_{3}+c+\omega(3,1)} \leq \beta < \frac{c}{v_{2}-v_{3}+c}$

Figure 10 demonstrates the two cases when scheduling decreases procrastination for a naive agent (cost and rewards are fixed). The first case corresponds to the situation when the agent would procrastinate until the second period if they could not use the schedule, but the schedule helps them to overcome procrastination and complete the task in the first period (the upper grey area in Figure 10). The second case corresponds to the situation when the agent would procrastinate until the last period if they could not use the schedule, but the schedule helps them to overcome procrastination and complete the task earlier (the lower grey area in Figure 10).

**Partially naive agent**

A partially naive agent belongs to somewhere between the sophisticated and the naive agent. That is to say, the partially naive agent is aware of their time-inconsistent preferences but underestimates the magnitude of their present bias. We can start to analyze the decision making of a partial naif from the scheduling decision. Since the agent believes they are sophisticated, they make the scheduling decision exactly the same way as sophisticates. They plan to complete the task in the first period, if their $\hat{\beta}$ is high enough and on the other hand, they plan to complete the task later if their $\hat{\beta}$ is lower.

- $\tau^* = 1$ iff $\hat{\beta} \geq \frac{c}{v_{1}-v_{2}+c+\omega(2,1)}$
- $\tau^* = 2$ iff $\hat{\beta} < \frac{c}{v_{3}-v_{4}+c+\omega(3,2)} \leq \hat{\beta} < \frac{c}{v_{1}-v_{2}+c+\omega(2,1)}$
- $\tau^* = 3$ iff $\hat{\beta} < \frac{c}{v_{2}-v_{3}+c+\omega(3,2)}$

Figure 11 demonstrates the scheduling decision of a partially naive agent visually. The only difference compared to a sophisticated agent (Figure 7) is that in the y-axis there is $\hat{\beta}$ and not $\beta$. When the agent schedules to complete the task in the last period, it
Figure 11: Scheduling decision of a partially naive agent
Note: Cost and rewards are fixed as follows: \( c = 5, v_1 = 8, v_2 = 7, v_3 = 4 \).

does not constraint them in anyway, and thus the scheduling decision can neither hurt
the agent nor decrease procrastination. In addition, because \( \hat{\beta} \in (\beta, 1) \) the agent always
wants to complete the task in the last period if they have scheduled so. When the agent
schedules to complete the task in the first or second period the situation is different.
Let’s first consider the case when \( \tau^* = 2 \). If agent’s \( \beta \geq \frac{5}{v_2-v_3+c+\omega(3,2)} \) they end up
following their schedule, but if it’s not, they procrastinate until the last period. Finally,
when \( \tau^* = 1 \), the agent follows their schedule if \( \beta \geq \frac{5}{v_1-v_2+c+\omega(2,1)} \), otherwise they
procrastinate either until the second or third period depending on their \( \beta \). Therefore,
the partially naive agent chooses the period to complete the task as follows:

- iff \( \hat{\beta} < \frac{5}{v_2-v_3+c+\omega(3,2)} \) \( \rightarrow \) \( \tau^* = 3 \) and \( \tau = 3 \)

- iff \( \frac{5}{v_2-v_3+c+\omega(3,2)} \leq \hat{\beta} < \frac{5}{v_1-v_2+c+\omega(2,1)} \) \( \rightarrow \) \( \tau^* = 2 \) and

  - \( \tau = 2 \) iff \( \beta \geq \frac{5}{v_2-v_3+c+\omega(3,2)} \)
  - \( \tau = 3 \) iff \( \beta < \frac{5}{v_2-v_3+c+\omega(3,2)} \)

- iff \( \hat{\beta} \geq \frac{5}{v_1-v_2+c+\omega(2,1)} \) \( \rightarrow \) \( \tau^* = 1 \) and

  - \( \tau = 1 \) iff \( \beta \geq \frac{5}{v_1-v_2+c+\omega(2,1)} \)
\[- \tau = 2 \text{ iff } \frac{\omega(2,1) + c}{v_2 - v_3 + c + \omega(3,1)} \leq \beta < \frac{c}{v_1 - v_2 + c + \omega(2,1)} \]
\[- \tau = 3 \text{ iff } \beta < \frac{\omega(2,1) + c}{v_2 - v_3 + c + \omega(3,1)} \]

We see that the partially naive agent uses the exact same procedure as a sophisticate to decide about the schedule and also when choosing when to complete the task. The only difference is that the partially naive agent makes the scheduling decision based on their belief ($\hat{\beta}$) in their present bias. Due to that, the agent ends up procrastinating if their belief differs significantly from their actual present bias. Scheduling can harm a partially naive agent as they must bear the utility loss resulting from not following the schedule. Nevertheless, scheduling may also decrease procrastination for them. As with sophisticates and naifs, scheduling can decrease procrastination of partially naive agents if their self-control problem is not too severe ($\beta \geq \frac{\omega(2,1) + c}{v_2 - v_3 + c + \omega(3,1)}$). It can be concluded that regarding partially naive agents, scheduling decreases procrastination in two cases:

- $\frac{\omega(2,1) + c}{v_2 - v_3 + c + \omega(3,1)} \leq \beta < \frac{c}{v_1 - v_2 + c}$
- $\beta < \frac{c}{v_2 - v_3 + c}$

Figure 12: Cases when scheduling decreases procrastination for a partially naive agent

Note: Cost and rewards are fixed as follows: $c = 5$, $v_1 = 8$, $v_2 = 7$, $v_3 = 4$.

Figure 12 demonstrates the two cases when scheduling decreases procrastination for a partially naive agent (cost and rewards are fixed). The first case corresponds to the
situation when the agent would procrastinate until the second period if they could not use the schedule, but the schedule helps them to overcome procrastination and complete the task in the first period (the upper grey area in Figure 12). The second case corresponds to the situation when the agent would procrastinate until the last period if they could not use the schedule, but the schedule helps them to overcome procrastination and complete the task earlier (the lower grey area in Figure 12).

Comparison of scheduling and deadlines

Deadlines are the hard commitment counterpart of scheduling. With scheduling, there is no external punishment for not following the schedule, and the task can be completed after the scheduled period as well (if the scheduled period is not the last one). With deadlines, the agent is punished for procrastination as they are not allowed to complete the task later. It is known that people are less willing to use hard commitment devices, and it is especially challenging to convince naive agents to apply them [Himmel et al., 2019]. Soft commitment devices, like scheduling, offer agents more flexibility, and punishments related to procrastination are milder. Therefore, there exists a trade-off between the commitment device’s effectiveness and agents’ willingness to participate. Furthermore, flexibility may be beneficial in uncertain situations. Scheduling offers the agent a possibility to procrastinate and complete the task later if some more urgent and important tasks appear. In other words, the agent can decide to procrastinate with one task to be able to complete a more important one. Deadlines do not offer this chance.

3.3 Applications

The model is based on the assumption that the agent makes a schedule in period 0. It is assumed that the only person aware of this schedule is the agent themself. Interestingly, the model changes significantly if the schedule is public such that other people know about it as well. If that is the case, we must incorporate a component describing the public nature of the schedule. A public schedule is very close to a promise made to another person. If the schedule is public, it is assumed that the agent faces a greater utility loss when not following the schedule compared to the case with a private schedule. This follows from the assumption that the agent may face a reputation loss or embarrassment when not following the public schedule. Formally, the agent’s intertemporal utility in period $t \leq \tau$ is as follows:

$$U^t(\tau, \tau^*) \equiv \begin{cases} \beta(v_r - c - \omega(\tau, \tau^*) - f(\tau, \tau^*)) & \text{if } \tau = t \\ \beta(v_r - c - \omega(\tau, \tau^*) - f(\tau, \tau^*)) & \text{if } \tau > t, \end{cases}$$ (13)
where function $f$ represents the utility loss caused by the fact that other people know that the agent did not follow the schedule. The magnitude of this utility loss depends on the extent of procrastination. The characteristics of function $f$ are discussed in greater detail by Carrillo and Dewatripont (2008) in their paper (see chapter 2.4.5), which covers promises as a way to decrease procrastination and related welfare loss. Intuitively, a public schedule is harder as a commitment device than a private schedule. We see from equation 13 that the utility loss regarding procrastination is larger when the schedule is public. Therefore, a public schedule decreases procrastination more effectively. However, agents’ willingness to participate in public scheduling is weaker compared to private scheduling. In other words, there is always a trade-off between the commitment device’s hardness and agents’ willingness to participate as already discussed in the previous chapter.

Scheduling could be used as a commitment device in various situations. Since it is a soft commitment device, a broader group of people could be caught up with it. COVID-19 has changed the working environment significantly globally and made remote work common. Scheduling could be used to decrease remote workers’ procrastination, for example. This could be carried out by encouraging employees to schedule their work tasks or by commanding employees to share their weekly schedules with employers. The latter utilizes the idea of the public schedule presented above. When it comes to studying, the students could be taught to use scheduling to decrease procrastination and stay on track with their studies. People exercising regularly could make weekly and monthly schedules to mitigate procrastination and secure their progress. The greatest advantage of scheduling is its easiness and adaptability. The examples mentioned here are just few options of numerous possibilities.
4 Research Material and Methods

This chapter introduces the research methods used in this thesis and discusses the trustworthiness and literature collection of the study.

4.1 Research Methods

In general, all academic research is founded on existing studies and knowledge. Obviously, the accuracy and reliability of research depend significantly on the understanding of this fragmented and interdisciplinary knowledge. Considering the rapid speed at which new research is published, it is evident that staying at the forefront is not easy. Therefore, the need for the literature review as a research method is increasing continuously. [Snyder, 2019]. Literature reviews aim to gather and connect prior research [Tranfield et al., 2003]. 'An effective review creates a firm foundation for advancing knowledge. It facilitates theory development, closes areas where a plethora of research exists, and uncovers areas where research is needed.' [Webster and Watson, 2002]. Therefore, it can be concluded that often the totality is greater than the sum of its parts.

The research method used in the literature review of this thesis is a semi-systematic approach. This method is suitable for research that aims to overview a broad topic studied by several researchers from varied disciplines. Furthermore, if the objective of a review is to recognize, understand, and synthesize all the relevant prior research, this method is a good fit. [Wong et al., 2013]. Research questions are usually broad with this method, and the analysis of selected articles can be qualitative or quantitative. Literature reviews conducted by this method contribute by enhancing the state of knowledge, clarifying the research agenda, and supporting the development of new theoretical models. [Snyder, 2019]. The scheduling model presented in chapter 3 is based on the literature review like Snyder suggests.

4.2 Literature collection

The relevant literature for the review was collected from Aalto University's online library (lib.aalto.fi) by an advanced search with the following search terms: time-inconsistent preferences, procrastination, and self-control problem. Only peer-reviewed articles written in English were considered. The search terms were chosen as they present the main concepts concerning the topic of this research. This search yielded 139 eligible articles of which 13 were chosen for the preliminary sample. This selection was made by reading the abstracts of all eligible articles and rejecting those out of this research's scope. However, the final selection was made only after the articles were read entirely. From the preliminary sample of 13 articles, 9 were chosen for the final sample. Furthermore, I went through the references of the selected articles and also the articles that cite them.
from Google Scholar to collect the final sample. The final sample size is 17 articles. Appendix B presents the articles selected for the sample in greater detail. Reason for selection, theme, and source are displayed there. Appendix C presents similar details for articles not selected from the original search.

4.3 Trustworthiness of the study

A successful literature review is both deep and rigorous [Snyder, 2019]. Therefore, it is critical to collect all the relevant articles so that no relevant knowledge is left outside. To minimize this risk the search method goes both backward and forward by considering articles’ citations and also the articles found from Google Scholar that have cited them [Webster and Watson, 2002]. Furthermore, articles must be chosen on merit, and biased choices must be prevented. A researcher should not select articles that merely support their arguments but cover the topic broadly from different perspectives. Contradictory opinions and views should be covered as well. In addition, the selected articles should be read thoroughly to fully understand the authors’ arguments, reasoning, and the quality of the research [Kara, 2019]. To manage these risks, I have evaluated the articles yielded by the search method equally. I have chosen articles from different views, and I present contradictory opinions to discuss the topic thoroughly. Furthermore, I read the selected articles carefully, and I did not skim them through nor cherry-picked points in my research’s favor.

Plagiarism poses another risk for literature reviews as for all other types of research [Kara, 2019]. Therefore, I paid specific attention to cite all the material correctly. Furthermore, I obtained a permission for all the figures I have reprinted in my thesis. At all events, a literature review should be transparent and replicable to enhance the reliability of the research [Snyder, 2019]. Therefore, I documented the search method and selection process in detail and this information can be found in appendixes.
5 Findings

In the following pages, I present the main findings of this thesis. First, I briefly sum up the findings of the literature review, and then I move on to discuss the findings of the model in greater detail.

5.1 The literature review

O’Donoghue and Rabin’s model of procrastination regarding single item choice sets states that naifs always procrastinate with immediate costs and preproperate with immediate rewards when compared to the standard type with time-consistent preferences. Sophisticates always complete the task before naifs which means that they do not procrastinate as much with immediate costs but may preproperate even more with immediate rewards. Therefore, with immediate costs, it is good to be a sophisticate, so to speak, since the sophistication effect makes you perform the activity earlier compared to a naive agent. In this case, the welfare implication of the sophistication effect is positive. With immediate rewards, this is not the case. As sophisticates may preproperate more than naifs, the welfare implication of the sophistication effect is negative in this case.

O’Donoghue and Rabin’s model of procrastination regarding several item choice sets defines procrastination as when the agent delays completion of the task infinitely. They conclude that in this setting, sophisticates never procrastinate but might preproperate. On the other hand, for all agents suffering from even the smallest degree of naivete an environment, where the agent procrastinates can be found. This is an interesting finding since economists agree that severe welfare losses can occur when an agent procrastinates or preproperates multiple times in a row, and there is no upper bound for welfare losses caused by this kind of procrastination. Therefore, naifs may suffer from severe welfare losses when immediate costs occur and they procrastinate multiple times. Reversely, sophisticates may suffer from severe welfare losses when immediate rewards occur and they preproperate multiple times in a row.

The literature review presents two alternative approaches, namely the dual-self model and the model of rational addiction, that can be used to model procrastination. It also discusses three leading applications that provide empirical evidence for the existence and prevalence of time-inconsistent preferences and procrastination. The application concerning procrastination of pleasant activities also shows that procrastination is not limited to a classic setting with immediate costs and delayed rewards. Furthermore, it shows that people discount future time and effort more than future monetary compensation.

The final part of the literature review introduces different commitment devices. Self-
rewards, deadlines, cooperation, and promises are covered as welfare-improving devices. The chapter on self-rewards shows how four different types of rewards can help the agent to overcome procrastination. Virtue goods are the least effective option and delayed neutral self-rewards the second least. However, the maximum possible goal is the same for both of these types of rewards. Neutral self-rewards are the second-best option, while vice rewards work most efficiently in reducing procrastination. These findings are very intuitive, as self-rewards that have immediate costs and future benefits do not work well in mitigating procrastination and accordingly, self-rewards with immediate benefits and delayed costs work most effectively.

The chapter discussing deadlines states that people do set themselves costly deadlines to decrease procrastination and these deadlines are to some extent effective. Agents with time-consistent preferences do not benefit from deadlines as those only restrict their behavior and choices, whereas, for present-biased agents, deadlines are performance-enhancing. Furthermore, evenly spaced deadlines improve performance and reduce procrastination the most, regardless of whether they are set by yourself or by someone else. Finally, deadlines reduce procrastination with both unpleasant and pleasant tasks.

Cooperation can be used as a welfare-improving device since the cost of completing a task is often smaller when a task is done at the same time with another person. Cooperation between two procrastinators of the same severity type weakly mitigates procrastination, whereas cooperation between two non-procrastinators of the same patience type exacerbates it. Therefore, it would be best to team up procrastinators and let non-procrastinators perform their tasks in isolation. If the agents’ procrastination type is not known, it is better to do the matching randomly than let agents choose their pairs freely because agents would like to team up inefficiently.

Finally, promises can be used to prevent procrastination because breaking a promise causes a reputation loss or even an external punishment for the agent. The greater the harm from the reputation loss or external punishment, the more effective the promise is in reducing procrastination. Interestingly, there exists experimental evidence that promises can be effective in reducing procrastination even when those are used as a soft commitment device and no external punishments are involved.

5.2 The model

This paper has identified conditions under which scheduling decreases procrastination and can be used as a soft commitment device. It points out that these conditions differ between agent types, but for each type, scheduling decreases procrastination under the right conditions. In general, it can be concluded that scheduling decreases procrastination when the agent’s present bias is mild or moderate, which leads us to the first proposition.
Proposition 1. Scheduling decreases procrastination when the agent’s present bias is mild or moderate, i.e.:

1. with sophisticates when \( \beta \geq \frac{c}{v_2 - v_3 + c + \omega(3-1)} \) and

2. with naifs and partial naifs when \( \beta \geq \frac{\omega(2-1)+c}{v_2 - v_3 + c + \omega(3-1)} \).

For severe present bias, scheduling does not develop strong enough incentives to avoid procrastination. That said, scheduling is more effective the higher the stakes with the task. When the task has high rewards, scheduling mitigates procrastination for more biased agents as well. These high stake tasks can be thought of as more important tasks.

Proposition 2. Scheduling decreases procrastination more effectively when the task in question is important.

The paper concludes that sophisticates always schedule such that they will follow their schedule. This implies that they never face the reference-dependent utility loss, meaning scheduling can never hurt them. Naifs schedule as they would have time-consistent preferences, meaning they end up procrastinating if their present bias is severe enough. For that reason, they may face reference-dependent utility loss and be harmed by scheduling. Partial naifs schedule as sophisticates but based on their belief in their present bias. This means that if their belief is significantly different from the actual present bias, they end up procrastinating. In this case, they face reference-dependent utility loss and are harmed by scheduling. These findings can be summarized in the following propositions.

Proposition 3. Sophisticates always schedule such that they will follow their schedule \((\tau^* = \tau)\). Naifs always schedule as they would have time-consistent preferences. Partial naifs schedule as sophisticates but based on their belief in their present bias \(\hat{\beta}\).

Proposition 4. Only naifs and partial naifs can be harmed by scheduling.

Another interesting feature of scheduling is the nature of the reference-dependent utility loss. Since it is increasing exponentially in delay, larger delays from the scheduled period cause relatively larger utility losses than smaller delays. This implies that scheduling decreases repeated procrastination effectively for naifs and some partial naifs. If the agent underestimates their present bias significantly and ends up scheduling in an early period, they do not procrastinate repeatedly for several periods because the reference-dependent utility loss increases exponentially. This feature is more relevant the more periods the model has.

Proposition 5. Scheduling decreases repeated procrastination effectively for naifs and partial naifs, who underestimate their present bias significantly.
Finally, the model can be extended to support other applications as well. Public schedules are introduced briefly to demonstrate the model’s adaptability.
6 Discussion

The purpose of this thesis is to explain how procrastination can be modeled economics-wise, what are the welfare effects of procrastination, and how procrastination-related welfare loss can be reduced. By using a semi-systematic literature review and a development of a new theoretical model as research methods, it provides the findings presented in Chapter 5. Procrastination can be modeled in various ways, including Rabin and O’Donoghue’s two models, the dual-self model, and the model of rational addiction. The welfare effects of procrastination are negative as procrastination causes significant welfare losses both at individual and societal levels when agents make repeated procrastination or preprocrastation decisions. Lastly, procrastination-related welfare loss can be reduced by using different commitment devices as deadlines, self-rewards, cooperation, promises, and scheduling. Within this chapter, I discuss the findings regarding the scheduling model in greater detail.

The first proposition states that scheduling decreases procrastination when the agent’s present bias is mild or moderate. This finding is supported by basic economic thinking, which suggests that agents want to avoid additional utility losses. Earlier research also acknowledges that agents suffering from severe present bias do not consider future utilities in their decision-making which is in line with Proposition 1. Therefore, Proposition 1 is in line with earlier research and indicates that the model works as expected. This finding proves that scheduling can be used as a commitment device to decrease procrastination and related welfare loss.

The second and fifth propositions define two situations where scheduling works particularly effectively. The first case is when the task in question is important, and the second case is when an agent underestimates their present bias significantly and would procrastinate repeatedly in the absence of schedule. Both of these findings are in line with earlier research. It is known that people procrastinate less with high stake tasks since the related utilities are higher. Accordingly, the reference-dependent utility loss is higher with important tasks, which makes the effect of scheduling stronger. The finding stated in Proposition 5 is especially interesting and significant. What makes this feature so important is that in both classic papers, namely, in Akerlof (1991) and O’Donoghue and Rabin (1999), repeated procrastination decisions are seen as highly problematic welfare-wise. Therefore, if scheduling can help tackle this problem for two agent types, it is remarkable. These findings suggest that scheduling should be used especially in these two situations.

The third and fourth propositions focus on the scheduling decision and its effects on agents. The third proposition states that sophisticates always schedule such that they will follow their schedule, whereas naifs schedule as they would have time-consistent preferences. Lastly, partial naifs schedule as sophisticates but based on their belief
in their present bias. The fourth proposition states that only naifs and partial naifs can be harmed by scheduling. All of these findings are in line with earlier research. Sophisticates are defined such that they are completely aware of their time-inconsistent preferences, which leads to the fact that they would never use commitment devices that would harm them. Respectively, naifs are defined such that they are perfectly unaware of their time-inconsistent preferences, which leads to the fact that they always believe they act as the standard type. This leads them to schedule as they would have time-consistent preferences. Finally, partial naifs believe they are sophisticates, thus they schedule the same way, only based on their erroneous belief in their present bias. Very intuitively, these definitions lead to the finding stated in Proposition 4. These findings imply that scheduling is a risk-free but effective way to reduce procrastination for sophisticates.

To conclude, this paper proves that scheduling can be used as a commitment device to decrease procrastination and related welfare loss. It further gives two specific examples of situations where scheduling works especially well. Based on these findings, scheduling should be acknowledged as an effective commitment device, and its application in different real-life situations should be encouraged.
7 Conclusions

This chapter concludes my thesis by first summarizing the research briefly, then by discussing the practical implications, and limitations of the study and lastly by providing some suggestions for further research.

7.1 Research summary

The research was conducted by first writing a semi-systematic literature review discussing different approaches of modeling procrastination economics-wise, welfare measurement and implications of procrastination, and welfare-improving devices. Then, based on the knowledge presented in the literature review, I developed a model analyzing scheduling as a soft commitment device. The model shows how scheduling can be implemented in a theoretical framework, how it affects different agents’ decision-making, and how agents decide to schedule. Furthermore, it discusses the differences between scheduling and deadlines.

7.2 Practical implications

This research has a large utilization potential beyond academia as procrastination is a significant part of our everyday life. For instance, employers would benefit substantially from a better understanding of employees’ procrastination behavior and how to prevent it [Cerrone, 2021]. As remote work becomes more common, especially with COVID-19, employers’ opportunities to monitor employees diminish. Therefore, employers need new ways to help employees to control their self-control problems and reduce procrastination [Koch et al., 2014]. To address this concern, the model regarding scheduling discusses whether employees could use scheduling to reduce procrastination in remote work. Similarly, scheduling is a potential solution concept for students lagging behind the graduation schedule. Furthermore, the development of commitment devices and the restriction of instant credit could encourage individuals to save for their retirement, which could decrease elderly poverty [Laibson, 1997]. By developing commitment devices for smokers and other substance abusers to help them quit, huge amounts of society’s resources could be saved. As demonstrated by the examples above, procrastination caused by time-inconsistent preferences is present in various mundane situations, and thus this research is useful broadly outside academia.

7.3 Limitations of the study

This thesis covers procrastination caused by time-inconsistent preferences only from the economics perspective. For instance, the psychological perspective, which has
four different theoretical approaches to explain procrastination, is completely ignored. These four approaches are the differential, the clinical, the motivational and volitional, and the situational perspective. [Klingsieck, 2013]. Furthermore, other self-control problems caused by time-inconsistent preferences, including obedience, impulsive buying, smoking, and drug abuse, are not discussed in detail. Lastly, the thesis does not discuss uncertainty related to any of the topics it covers.

### 7.4 Suggestions for further research

Possible directions for further research could be to try to compare which of the welfare-improving devices are the most effective. The research could, for example, try to find out how procrastination related to remote work can be reduced most effectively as this topic is current because of the pandemic. Concerning the scheduling model, uncertainty could be added to the model such that it would cover situations where the agent is not sure which kind of tasks they will face in the future.
References


A Assumptions and details of the models

Assumptions needed for the self-rewards model presented in the chapter 2.8.1:

\[ f'(e) > 0, \]
\[ f''(e) \leq 0, \]
\[ c'(e) > 0, \]
\[ c''(e) > 0, \]
\[ \lim_{\varepsilon \to 0} \frac{f'(e)}{c'(e)} = \infty \text{ and} \]
\[ \lim_{\varepsilon \to \infty} \frac{f'(e)}{c'(e)} = 0. \]

Assumptions needed for Herweg and Müller’s model presented in the chapter 2.8.2:

\[ c'(x) > 0, \]
\[ c''(x) > 0, \]
\[ c(0) = 0, \]
\[ c'(0) = 0, \]
\[ g'(x) > 0, \]
\[ g''(x) < 0, \]
\[ g(0) = 0, \]
\[ g'(0) > 0 \text{ and} \]
\[ g_A(\cdot) = g_B(\cdot) = g(\cdot). \]

What follows are the details of Herweg and Müller’s model for a sophisticated agent presented in the chapter 2.8.2. As agent’s choices over effort can be modeled as a game between temporal selves and solved with backward induction we start with the function describing agent’s optimal effort in the second period:

\[ c'(e_2^{SNP}(\hat{e}_1)) = \beta g'\left(\frac{1}{2}(\hat{e}_1 + e_2^{SNP}(\hat{e}_1))\right), \]

where \( \hat{e}_1 \) is the given effort level in the first period. The first-order condition that defines the effort level in the first period is denoted as follows:

\[ \beta g'\left(\frac{1}{2}(e_1^{SNP} + e_2^{SNP}(e_1^{SNP}))\right) - c'(e_1^{SNP}) + \]
\[ \frac{de_2^{SNP}(e_1)}{de_1} \beta g'\left(\frac{1}{2}(e_1^{SNP} + e_2^{SNP}(e_1^{SNP}))\right) - c'(e_2^{SNP}(e_1^{SNP})) = 0. \]
From the first-order condition it follows that in the setting with no interim deadline:

\[ e_1^{SN} < e_2^{SN} \text{ and } e_A = e_B = \frac{1}{2}(e_1^{SN} + e_2^{SN}). \]

In the setting with an interim deadline, the agent’s utility in the second period is as follows:

\[ U_2^{SD} = -c(e_{B2}) + \beta g(\hat{e}_A) + \beta g(\hat{e}_{B1} + e_{B2}). \]

By a similar manner as in the setting with no interim deadline, we get the following equations:

\[ c'(e_{B2}'(\hat{e}_{B1})) = \beta g'(\hat{e}_{B1} + e_{B2}'(\hat{e}_{B1})) \text{ and } \]

\[ \frac{de_{B2}^{SD}(e_{B1})}{de_{B1}} = \frac{-\beta g''(e_{B1} + e_{B2}^{SD}(e_{B1}))}{\beta g''(e_{B1} + e_{B2}^{SD}(e_{B1})) - c''(e_{B2}^{SD}(e_{B1}))} \in (-1, 0). \]

And the agent’s utility in the first period is as follows:

\[ U_1^{SD} = -c(e_A + e_{B1}) - \beta c(e_{B2}^{SD}(e_{B1})) + \beta g(e_A) + \beta g(e_{B1} + e_{B2}^{SD}(e_{B1})). \]

The agent chooses the following effort levels:

\[ c'(e_A^{SD}) = \beta g'(e_A^{SD}) \text{ and } c'(e_{B2}^{SD}) = \beta g'(e_{B2}^{SD}). \]
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<td>O'Donoghue, Ted; Rabin, Matthew</td>
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<td>DOING IT WHEN OTHERS DO: A STRATEGIC MODEL OF PROCRASTINATION</td>
<td>Cerrone, Claudia</td>
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<td>Golden Eggs and Hyperbolic Discounting</td>
<td>Laibson, David</td>
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<td>Is Addiction &quot;Rational&quot;? Theory and Evidence</td>
<td>Gruber, J.; Koszegi, B.</td>
<td>2001</td>
<td>The Quarterly Journal of Economics</td>
<td>RATIONAL ADDICTION</td>
<td>Provides criticism for the model of rational addiction</td>
<td>Citations &quot;Doing It Now or Later (1999)&quot; (Google Scholar)</td>
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<td>Paying Not to Go to the Gym</td>
<td>DellaVigna, S.; Malmendier, U.</td>
<td>2006</td>
<td>The American Economic Review</td>
<td>PROCRASTINATION</td>
<td>Provides great examples of procrastination with several item choice sets</td>
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<td>Performance of procrastinators on the value of deadlines</td>
<td>Herweg, Fabian; Muller, Daniel</td>
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<td>Procrastination of Enjoyable Experiences</td>
<td>Shu, S.B.; Gneezy, A.</td>
<td>2010</td>
<td>Journal of Marketing Research</td>
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<td>Provides a great example of procrastination with single item choice set</td>
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<td>Promises, Promises</td>
<td>Carrillo, Juan D.; Diewert, Mathias</td>
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<td>Self-rewards and personal motivation</td>
<td>Koch, Alexander K. et al.</td>
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<td>Soft Commitments, Reminders, and Academic Performance</td>
<td>Himmler, Oliver; Stolle, Robert; Weinschenk, Philipp</td>
<td>2013</td>
<td>American Journal of Applied Economics</td>
<td>WAYS TO REDUCE THE WELFARE LOSS / PROMISES</td>
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<td>Theory of Rational Addiction</td>
<td>Becker, Gary S.; Murphy, Kevin M.</td>
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<td>Journal of Political Economy</td>
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<td>A core research about rational addiction</td>
<td>Reference from &quot;Doing It Now or Later (1999)&quot;</td>
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<td>Time-Inconsistent Preferences and Consumer Self-control</td>
<td>Hoch, S.J.; Loewenstein, G.</td>
<td>1993</td>
<td>Journal of Consumer Research</td>
<td>REFERENCE POINT SHIFT</td>
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<td>2008</td>
<td>The Journal of consumer affairs</td>
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<td>A Multidisciplinary Cognitive Behavioural Framework of Impulse Buying: A Systematic Review of the Literature</td>
<td>Xiao, Sarah Hong ; Nicholson, Michael</td>
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<td>A Randomized Experiment Testing the Efficacy of a Scheduling Nudge in a Massive Open Online Course (MOOC)</td>
<td>Baker, Rachel ; Evans, Brent ; Dee, Thomas</td>
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<td>Adherence to long-term prophylactic treatment: microeconomic analysis of patients’ behavior and the impact of financial incentives</td>
<td>Mann, Klaus ; Mocerini, Michael ; Grosser, Joachim</td>
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<td>Health economics review</td>
<td>ADHERENCE / HEALTH CARE</td>
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<td>Self-Control and Optimal Goals: A Theoretical Analysis</td>
<td>Jain, Sanjay</td>
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<td>Marketing science</td>
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<td>Advanced Versus Delaying Payments and Consumer Time Orientation: A Personal Selling Experiments: ABSTRACT</td>
<td>Aniya, J.; John C.; Mowen</td>
<td>1955</td>
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<td>The Journal of scholarship of teaching and learning</td>
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<td>Anti-Smoking Policies and Smoker Well-Being: Evidence from Britain</td>
<td>Lucester, Andrew ; Lowell, Peter</td>
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<td>Are Defined Contribution Plans a Commitment Device? and obesity in Japanese male workers: a cross-sectional study</td>
<td>Guo, Tao ; Flinke, Michael</td>
<td>2018</td>
<td>Financial counselling and planning</td>
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<td>Association between time preference, present-bias and physical activity: implications for designating behavior change interventions</td>
<td>Hunter, Ruth P et al.</td>
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<td>BMC public health</td>
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<td>Behavioral Economics and Public Policy: A Pragmatic Perspective</td>
<td>Chetty, Raj</td>
<td>2015</td>
<td>The American economic review</td>
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<td>In honor of Matthew Rabin: Winner of the John Bates Clark Medal</td>
<td>Cameron, Colin ; Thaler, Richard</td>
<td>2003</td>
<td>The Journal of economic perspectives</td>
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<tr>
<td>Behavioral Macroeconomics and Macroeconomic Behavior</td>
<td>Akerlof, George A</td>
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<td>MONETARY POLICY</td>
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<td>Behavioural economics, experimentalism and the marketization of development</td>
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<td>Behavioural Economics, Hyperbolic Discounting and Environmental Policy</td>
<td>Hepburn, Cameron J et al.</td>
<td>2010</td>
<td>Environmental &amp; resource economics</td>
<td>POLICY MAKING</td>
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<td>TIME-INCONSISTENCY AND WELFARE PROGRAM PARTICIPATION: EVIDENCE FROM THE NSLY</td>
<td>Farg, Hamming ; Silverman, Dan</td>
<td>2000</td>
<td>International economic review (Philadelphia)</td>
<td>LABOR MARKET</td>
<td>NO</td>
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<td>Betting on weight loss ... and losing: personal gambles as commitment mechanisms</td>
<td>Burger, Nicholas ; Lynham, John</td>
<td>2010</td>
<td>Applied economics letters</td>
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<td>Can Financial Education Improve Financial Literacy and Retirement Planning?</td>
<td>Saul Schwartz</td>
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<td>Choice reversals without temptation: A dynamic experiment on time preferences</td>
<td>Casari, Marco ; Dragna, Davide</td>
<td>2015</td>
<td>Journal of risk and uncertainty</td>
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<td>Choosing for others</td>
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<td>Commitment Contracts</td>
<td>Band, Philip ; Sigurdsson, Gustav</td>
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<td>Competition over Time-Inconsistent Consumers</td>
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<td>Journal of public economic theory</td>
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<td>Contracting with Present-Biased Consumers in Insurance Markets</td>
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<td>The Geneva risk and insurance review</td>
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<td>Ingredients of Self-Control and its Impact on Impulse Buying</td>
<td>Robert, James A ; Manolits, Chris</td>
<td>2012</td>
<td>Journal of marketing theory and practice</td>
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<td>Design of reforms with time-inconsistent voters</td>
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<td>2017</td>
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<td>Designing a linear pension scheme with forced savings and wage heterogeneity</td>
<td>Cremers, Helmut ; De Donder, Philippe et al.</td>
<td>2000</td>
<td>International tax and public finance</td>
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<td>Do Consumers Exploit Commitment Opportunities?</td>
<td>Bernheim, R. Douglas ; Meer, Jonathan ; Novarro, Nova K</td>
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<td>Do Financial Education Interventions for Women from Poor Households Impact Their Financial Behaviors? Experimental Evidence from India</td>
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<td>Technology Infrastructure Investments with growth options</td>
<td>Khan, Sarah S ; Khoury, Moutaz ; Kumar, Ram L</td>
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<td>European journal of information systems</td>
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<td>Entrepreneurial Boldness and Excessive Investment</td>
<td>Brocas, Isabelle ; Carrillo, Juan D</td>
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<td>Journal of economics &amp; management strategy</td>
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<td>Food Choice in an Interdisciplinary Context</td>
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<td>Free will, temptation, and self-control: We must believe in free will, we have no choice (B.B. Singer)</td>
<td>Werlenbroach, Klaus et al.</td>
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<td>Good or Bad, We Want it Now: Fixed-cost Present Bias for Gains and Losses Explains Magnitude Asymmetries in Intertemporal Choice</td>
<td>Hardisty, David J ; Appelt, Kristin C ; Weber, Elke U</td>
<td>2012</td>
<td>Journal of behavioral decision making</td>
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<td>Government interventions to aid choice: Help to self-help or paternalism?</td>
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<td>Health Insurance Coverage and Take-Up: Lessons from Behavioral Economics</td>
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<td>Heterogeneity in intra-Monthly Consumption Patterns, Self-Control, and Savings at Retirement</td>
<td>Mastrobattista, Giovanni ; Werber, Matthew</td>
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<td>High-Power Films Gather Dust: Time-Inconsistent Preferences and Online DVD Rentals</td>
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<td>Hyperbolic discount curves: a reply to Ainslie</td>
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<td>Hyperbolic Discounting and Consumer Patience: The Case of Korea</td>
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<td>Hyperbolic Time Discounting, Offender Time Preferences and Deterrence</td>
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<td>Individual and collective time-consistency</td>
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<td>Input Subsidies, Cash Constraints, and Timing of Input Supply</td>
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<td>Maurer, Jurgen</td>
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<td>Investment and Exit under Uncertainty with Utility from Anticipation</td>
<td>Du, Jianjun ; Yang, Jingang ; Zhou, Zhenhao</td>
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<td>OBESITY</td>
<td>NO</td>
<td>NO</td>
<td>Not part of the research's scope</td>
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<td>What does behavioral economics mean for policy?</td>
<td>Koerneran, P; Prast, H.M</td>
<td>2010</td>
<td>De Economists (Netherlands)</td>
<td>POLICY MAKING</td>
<td>NO</td>
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<td>Which Self Should the Law Target? An Analysis of Behavioral Bias in Criminal-Punishment Games</td>
<td>Hall, Amy H</td>
<td>2019</td>
<td>TexasLaw review</td>
<td>CRIME PREVENTION</td>
<td>NO</td>
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<td>Who cares about the day after tomorrow? Pension issues when households are myopic or time inconsistent</td>
<td>Birsch-Supan, Axel et al.</td>
<td>2015</td>
<td>Review of development economics</td>
<td>SAVING</td>
<td>NO</td>
<td>NO</td>
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<td>Yielding to Temptation: Self-Control Failure, Impulsive Purchasing, and Consumer Behavior</td>
<td>Baumeister, Roy F</td>
<td>2002</td>
<td>The Journal of consumer research</td>
<td>CONSUMPTION CHOICE</td>
<td>NO</td>
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