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Working Paper n. 13 - 2010

THE MULTI-FACES OF PROCRASTINATION

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Giugno 2010

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Preliminary Draft

June 3, 2010

Abstract

Often people procrastinate unpleasant tasks for immediate gratification in doing nothing today. Therefore many scholars have been engaged in designing incentive schemes to avoid it. We think the process is very complicated and many features need to be analyzed, as the subjective evaluations of succeeding and rewards. Moreover, sometime people procrastinate because they feel insecure, investing to improve their performance hoping in a better result in the long run. This process can be dangerous, producing as result that we call "*the curse of perfectionism*". Nevertheless procrastination may also have positive consequences if people spend their time in alternative activities, also useful for other ex post best rewarded tasks. We call this case as "*productive procrastination*". In this paper we explore all these possibilities and underline conditions for they happen. We also discuss our results according to the difference between naive and sophisticated subjects.

Key words: Time-Inconsistent Preferences, Optimal Effort, Procrastination,Inter-temporal Choice.

Jel Numbers: A12, D03, D11, D74, D91.

1 Introduction

There is a growing interest in economics literature about effects of procrastination and how to design incentives schemes to let people completing their task early. Both psychological and economics researches, as well as common intuition, find that people procrastinate because of their time-inconsistent preferences for immediate gratification. According to these studies, immediately available rewards have a disproportionate effect on preferences relative to more delayed rewards.
Time-inconsistent preferences and self-control problems[1] have been the subject of many theoretical analysis (Ainslie, 1991 [1]; Hoch and Loewenstein, 1991 [13]; Baumeister and Muraven, 2000 [6]; O'Donoghue and Rabin, 1999 [16], [17]; 2000 [18]; Prelec, 2004 [20]; Strotz, 1956 [25]; Shefrin and Thaler, 1981 [24]; Shafir and Tversky, 1992 [23]; Bargh and Gollwitzer, 1994 [5]; Laibson, 1994 [14]; Laibson, Repetto and Tobacman , 1998 [15]; etc.). Nevertheless number of researchers have also empirically tested how these models of hyperbolic discounting can explain trends in data better than models based on exponential discounting (see for instance, Laibson, Repetto, Tobacman, 1998 [15]; Angeletos, Laibson, Repetto, Tobacman, and Weinberg, 2001 [2]; Ariely and Wertenbroch, 2002 [3]; Shui and Ausubel, 2004 [4]; Della Vigna and Paserman, 2005 [9]; Shapiro, 2005 [22]; Gruber and Mullainathan, 2005 [12] and Della Vigna and Malmendier, 2006 [8]).
Many researches on procrastination applied these models to underline that people put off unpleasant tasks in a way that their long-run selves do not appreciate (O'Donoghue and Rabin, 1999 [16] and [17]; 2001 [18]). Therefore they are aimed to design incentives schemes to let people to complete their task in the short-run (O'Donoghue and Rabin, 1999 [17]). These studies show that, because of their biased perceptions, people may not behave in their own long-run best interest, so there is scope for firms, policymakers, friends and family, and the people themselves to create incentives for "better" behaviors.

In this paper we aim to show that despite procrastination has always been looked as a negative concept, it is a more complicated process, with many features to take into account and which could also sometime have positive effects in increasing the agent's well-being. This obviously may happen when people postpone a task and at the same time they invest this delayed time to improve their performance, so to reach better results in the future. But this issue concerns inter-temporal choice of effort allocation, which can also arise when people have inconsistent preferences, and it implies that people will finish their task in the future. In this case subjects may experiment a loss in current welfare which is more than compensated by a future welfare increase. On the contrary, the term procrastination is more specifically used to mean a process implying that people delay tasks until a not defined time, maybe forever. Therefore, procrastination has always been considered as a negative process and scholars have searched ways to rescue from this "illness".
In the present work we aim to analyze the process more deeply. Our starting point is an article of the psychologist Brasini M.,2008[7], who highlighted many features of this phenomenon and in this framework we aim to take them into high consideration. In particular the objective of this paper is to analyze the reasons inducing people to procrastinate and their possible consequences. According to this analysis it is possible to distinguish between bad and good

[1] A self-control problem arises, inside the approach of inter-temporal choice with hyperbolic agents preferring immediate gratification, because the agent, despite understanding what should be his better behavior, is not able to self-control successfully (for more details see D.Dragone, 2005[10]

procrastination: the first has absolutely negative consequences, the second one may give positive results.
First of all, we must consider that an agent's informative set may often be incomplete, and when he decides whether or not procrastinate he uses his subjective evaluations, which may also be incorrect. In fact, according to Brasini, M[7], individual decisional choices are based on subjective evaluations, self-estimation of individuals' expectations, values, trends, attributions. Nothing is objective. The variables measured by the subject who must decide about whether and when to do the task depend on his particular vision of the reward and the task, and, more in general, of the world. In particular, the initial assessment of the importance of the task and the probabilities of success may be very important for the consequences of procrastination. For instance, procrastination may be a positive event if ex post it is known that task was less important then expected, i.e. less rewarded and satisfying. Moreover, we must also consider how the task is realized: if people do the task but with a failure (so that it does not imply any reward) it might be better never to do it and procrastinate forever. Our objective is to try to translate in an economic model the several features of procrastination above mentioned and their consequences.

To sum up these features, we may say that procrastination is bad when doing the task is important and at least one of the following conditions is satisfied[2]:
1)The task can be successfully accomplished but people procrastinate it either because they fear of not being able to realize it or because they have a general attitude for procrastination[3] or because they want to reach easy results with minimal efforts (like the Italian syndrome of "*tronista*"). 2) While procrastinating a task people do not use that time for alternative activities. They only spend that time in doing nothing or in totally useless activities. 3) A person procrastinates to do a task with greater intensity in the future but this harms the agent, as he fails to complete the task adequately in a vain attempt of perfection. 4)People engage themselves in costs to do tasks that won't be never accomplished; so these costs are just "losses of money" because nothing is realized.
On the contrary, procrastination may be a positive event under at least some of the following conditions: 1)Individuals have overestimated the importance of the task. 2)Subjects have overestimated their probabilities of success. 3) People do not the task because they fear of failure, but they are right; they are at all not able to do it, so if they did the task they have failed. 4)People use the time while procrastinating for other useful or more satisfying activities (such as producing social capital or relational goods, like spending more time with family and friends, etc.) or to make productive investments to improve their performance. Nevertheless they don't use these investments for the initial planned task but for an alternative ex post better rewarded activity. This maximizes the agent's welfare more than if he had realized the initial planned task.

In the paper there are 6 sections including introduction and conclusions, and it is organized as follows. In the next sections 2 and 3 we analyze respectively variables affecting decisions about whether to do the task and the related consequences. In section 4 we analyze the case

[2]Obviously, because of the complexity of the phenomenon, we are probably missing some cases. Anyway our approach is, on our knowledge, one of the first attempt to look at the procrastination in a more extensive way. Nevertheless we think that we need further analyzes and researches and they are the purpose of our future analysis.

[3]For instance, because they are lazy, or because they want a easy live, expecting others to do the task for them

of people who procrastinate for perfectionism: if they underestimate too much the possibility to do the task in t, probably they will invest in effort to improve their performance. Anyway the final result depends on the cost of the effort and it is lower for high values of the delayed time and higher for high values of the effort. Therefore, it there may be a level of effort and timing with the first effect prevailing on the second one, so it would be better to stop procrastinating and do the task. In this case, if a person still procrastinates then we have the effect we call "*the curse of perfectionism*". In section 5 we aim to define a "*productive procrastination*" and we analyze the case when procrastinators invest for an initial planned task, but they procrastinate it and instead they use that investment in other activities, whose reward increases individual welfare more than if the initially planned task would have been accomplished. In each section we discuss our results according to the distinction between naive e sophisticated subjects to extend our analysis so to include considerations about individuals' problems of self-control. We show that sophisticated subjects, depending or their informative set, may not only benefit from good procrastination, but they can also avoid the "*curse of perfectionism*", while a naive subjects mainly suffer from bad procrastination. They may take advantages from the "*productive procrastination*" only if they have not self-control problems also on the alternative activities.

2 The Basic Model

2.1 Tasks and inconsistent preferences

Our starting point is the *present-biased preferences* model used by Laibson D.,1994 [14] to model time inconsistency within an individual[4]. This is a two-parameter model which represents a simple modification of the standard one-parameter exponential discounting, where now is assumed that people have time-inconsistent preferences for immediate gratification. Formally, let u_t be the instantaneous utility a person gets in period t, her inter-temporal preferences at time t, U^t can be represented by the following utility function:
For all t,

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

The parameter δ represents standard "time-consistent" impatience, whereas the parameter β represents the time-inconsistent preference for immediate gratification. For $\beta = 1$, these preferences are time-consistent, and for $\beta < 1$ at any given moment the person has an extra bias for now over the future.

Following O'Donoghue and Rabin, 2001[18], we first imagine that an agent must choose whether and when to do the task x, which implies costs and rewards (c, ν), where c is paid immediately today while $\nu \geq 0$ starts from $\tau + 1$. We assume the agent may do only a task x, therefore, the only admissible set of actions available in each period is $A \equiv x \cup \emptyset$, where the action x means "to complete the task x" and the action $\emptyset$ means "doing nothing". In addition, we assume that x also means "how good the task is accomplished". That is the task $x + k$, for $k > 0$, represents a better performance. For instance, if the task x consists in

[4]The model was originally developed by Phelps and Pollak,1968 [19], in the context of intergenerational altruism.

producing a number of piece of a product, the agent who makes $x+k$ pieces has better done than one who produced only x. Obviously, the reward will be higher for a better performance, that is $\nu(x+k) > \nu(x)$ for all $k > 0$. We define a strategy $s = (a_1, a_2, ...)$ the decision to accomplish in the period t the action $a_t \in A$ (for instance people may choose to do nothing in t, nor in $t+1$, etc. and to do it only in τ. In this case his strategy may be represented with the set: $s \equiv (\emptyset, \emptyset, ..., a_t, \emptyset, \emptyset, ...)$, where $a_\tau = x$. We denote by $\tau(s)$ the period in which the person completes the task by following this strategy: $\tau(s) = min(t \mid a_t \neq \emptyset)$ and $x(s) = a_{\tau(s)}$, that is, the task x is realized in τ following the strategy s.

The subject does nothing in each t and procrastinates forever if: $\tau(s) = \infty$ and $a_t = \emptyset$ for all t.
$\hat{s} \equiv (\hat{a}_{t+1}, \hat{a}_{t+2}, ...)$ represents the person's period-t beliefs about her future behavior, where $\hat{a}_x^t$ represents the person's belief in period t on what action she would choose in τ if she starts the new period without completing the task before. Given the person's beliefs $\hat{s}_t$, $V^t \equiv \hat{a}_t, \hat{s}_t, \beta, \delta)$ represents the person's period-t preferences over her current actions conditional on following strategy $\hat{s}_t$ beginning in period $t+1$. Then $V^t \equiv (\hat{a}_t, \hat{s}_t, \beta, \delta)$ is equal to:

$$\begin{cases} -c + [\beta \dfrac{\delta}{1-\delta}]\nu & \text{if} \quad a_t = (c, \nu) \\ \beta(\delta^\tau)[-c + \dfrac{\delta}{1-\delta}\nu] & \text{if} \quad a_t = \emptyset,\ \tau = \min\{d > 0 \mid a_{t+d} \neq \emptyset\},\ a_{t+d} = (c, \nu) \\ 0 & \text{if} \quad a_t = \emptyset \quad \text{and} \quad a_{t+d} = (c, \nu) \quad \text{for} \quad \text{all} \quad d > 0 \end{cases}$$

The three cases in this equation correspond to three different possibilities, that is:
1) The person completes the task today and therefore she does not discount the immediate cost c by β, but she does discount the delayed reward $\nu\delta(1-\delta)$ by β.
2) The person expects to complete the task in τ periods, that is she delays until $t+d$, where d is her admitted delayed time. Therefore she must discount both costs and rewards by β.
3) The person does nothing at all in each t and her payoff is zero. Therefore a person in period t chooses her current action a_t to maximize her current preferences V^t given her beliefs $\hat{s}_t$.

Still following O'Donoghue and Rabin, 2001[18] it is convenient to accomplish today the task x, or the task x is *β-worthwhile*, if $[\beta\delta\nu/(1-\delta)] \geq c$.

Our objective in the next sections of this paper is to try to introduce in this economic model also the variables mentioned in the Introduction which may influence individuals' decisions about procrastination and its consequences, which can let procrastination to be a bad or good event.

2.2 Variables influencing procrastination

Referring to Brasini, 2008 [7] and Sears, 2008 [21], first of all we consider two features of procrastination affecting the task's accomplishment. One is the expectation of success, that is the probability p to successfully realize the task x. In the basic version of the model this implies that if an individual decides to realize x in t, p_t measures his expectation in t to succeed

and that the action $a_t = x > 0$ implies a reward $\nu(x) > 0$[5]. The probability of success that individuals take into consideration is the result of their own subjective evaluations. Therefore it is an estimated probability $\hat{p}(I_t)$ which is a function of the available information in t and which may be different from the true probability of success p_t. These two probabilities are the same if the informative set is complete; instead in case of incompleteness they may be different and if the first is higher than the second one this means individuals have overestimated their abilities to succeed. In the opposite case they are underestimating themselves. Notice that if individuals have in their informative set the information that they have already failed in the past, their probability of success should be lower. In fact, if individuals procrastinate the task until $t+1$ their informative set includes the information that up to $t+1$ they have failed in doing x, because they have not accomplished it until that time, and this implies a lower probability of success in p_{t+1}.
The second important variable of this problem is the value of the reward $\nu(x,t) > 0$, which is higher for high values of x, and such that $\nu(x+k,t) > \nu(x,t)$, that is if people realize the task in the best way so to accomplish a $x+k > x$, then they would receive a higher reward [6]. The reward is also lower for high values of t: $\nu(x,t+1) < \nu(x,t)$, that is rewards are lower if more time is used to realize x.

The other two variables in the formula of Sears, 2008 [21] concern the general attitude for procrastination and procrastination's consequences. About the first variable, we assume that a very important factor is motivation. Subjects do not procrastinate because they are lazy, but because they are unmotivated and they expect not to succeed or because they think that doing x is not really important. Higher the value that people attach to the task, the more they strive to achieve it: in this case they estimate a higher value of the reward. In fact, people usually procrastinate tasks they think are annoying or not useful.
Anyway, the total effect on the final payoff is not clear. To better understand it we need to take into account many features and in particular if the task is really not useful or the estimates are incorrect (for instance this happens because the world around us sends conflicting messages, telling that the task is not important or less rewarded [7]).
In an hypothetical scale of motivations, on the other side, there are perfectionists: they procrastinate and at the same time invest in higher effort letting them reaching a better performance in the future. In an excess of perfectionism they probably put off a task whose importance, and whose reward, will be lower as the delay increases. So they spend their time in improving themselves so to accomplish in the future a task which instead will be no longer important. In the meanwhile they declined to do other things, like staying whit friends, more important activities, etc., which could have given them higher welfare
Moreover, it makes sense thinking that higher expectation of success induces people to do a task, while a lower one induces to procrastinate it. Being p a variable subjectively estimated we may also conclude that procrastinators are individuals with low self-esteem or with a low estimated probability of success. On the other side, we must also take into consideration the hypothesis that individuals' expectations of failure are right, so that procrastination could be

[5] Notice that in case of a failure it would be $a_t \neq \emptyset$ and $a_t = x$, but $x = 0$)

[6] For instance, this is the result people expect when they invest in an effort which let them to realize an improved x, or a $x+k > x$

[7] For instance such messages may be "defer the task until other people do it for you"; or suggestions from television that the most important things in life are beauty, richness, fame, etc. People may reach them just because naturally endowed for them and lucky, but with not effort, this the apathy of *tronista*: winning with not efforts is their maximum aspiration.

the right choice, the better strategy.
Finally, for what concerns consequences of procrastination, we can say that more serious are the consequences of a failure and more a person tends to procrastinate. These consequences afford the expected final payoff, which also depends on all the variables above mentioned and on their interaction. In particular it depends on how much subjective expectations agree with that actually happens in reality. Therefore the final expected payoff may be measured as: $\hat{V}^t \equiv (\hat{a}_t, \hat{s}_t, \beta, \delta, \hat{p}_t, \hat{\nu}_t)$

3 Bad and Good Procrastination

In this section we aim to introduce in the basic model our previous considerations and in particular those about the real and estimated values of p and ν. For simplicity, in a initial approach, we assume, that the person who procrastinates a task is a *pathological procrastinator*: she does not take into consideration the possibility to devote her delayed time to other activities, but she does absolutely nothing.
In this first analysis we start without considering the distinction between naive and sophisticated subjects. In addition, to take into account the possibility that a pathological procrastinator may also benefit from doing nothing, we assume that $u(a_t) \geq 0$, also for $a_t = \emptyset$, and in particular $u(a_t(\emptyset)) = \underline{u}$.
According to our previous considerations, we denote by $\hat{p}_t = \hat{p}(I_t)$ a measure of the subjective probability of succeed in doing x [8]. This expectation depends on the informative set I_t, that is on the available information in t. If subjects expect they procrastinate until $\tau > t$, their informative set also includes this information, which they could interpret as their failure until τ. Consequently, expectations of the agent to realize x in τ should be lower than in t ("if have not been able to do the job so far, probably I will not be so in the future", therefore the agent's self-esteem decreases). Consequently, we may assume people expect to fail in τ more than in t: $\hat{p}_t < \hat{p}_\tau$, where $\hat{p}_\tau$ measures the subjective expectation in t to succeed in τ.

The other variable that we must take into account is $\hat{\nu}(.)$, which measures how much people expect the task will be rewarded. It gives us some information on how much people think the task is important. The value they attach to that task and its accomplishment is equal to $\hat{\nu}(x,t)$ in t and $\hat{\nu}(x,\tau)$ in $\tau > t$. The first represents the reward expected in t if the task x is realized in t, and the second one the reward expected in t but if x is realized in $\tau > t$. Because we are assuming agents are pathological procrastinators, it makes sense to assume that postponing a task can not imply higher reward so that: $\hat{\nu}(x,t) < \hat{\nu}(x,\tau)$. Therefore we may rewrite conditions 1-3 as it follows:

i) if the person completes the task in t, her expected payoff is:

$$-c + \hat{p}_t \left\{ \beta \frac{\delta}{1-\delta} \hat{\nu}(x,t) \right\}$$

ii) if she never realizes it, in 3) we must add the possibility for a positive reward attached to do nothing: $u(\emptyset) = \underline{u} \geq 0$ if $a_\tau = \emptyset$, and this is for each $\tau \geq t$. That is, for simplicity, we

[8] Therefore it measures how much people expect in t, the action $a_t = x$, implies that they can realize $x > 0$, and earn a positive reward.

assume it is constant in each period so that the reward of doing nothing in t is the same of doing nothing in $(t+1, t+2, ...)$[9].
Therefore the present value of the expected utility of doing nothing until τ is:

$$\beta \frac{\delta}{1-\delta}(\tau - 1)\underline{u}$$

iii) if the person expects he realizes the task x in $\tau \geq t$, her expected payoff is:

$$\beta(\delta^{\tau}) \left\{ -c + \frac{\delta}{1-\delta}[(\tau - 1)\underline{u} + \hat{p}_{\tau}\hat{\nu}(x,t)] \right\}$$

if $a_t = \emptyset$, $\tau = \min(d > 0 \mid a_{t+d} \neq \emptyset)$ and $\hat{a}_{t+d} = (c, \hat{\nu}(x,\tau))$
where $(\tau - 1)\underline{u}$ measures the full expected reward of having done nothing until τ and it is given by the sum of all the $\underline{u}$ until τ itself[10].

Definition 3.1 *A positive expectation that realizing x in t is worth-while implies that:*

$$\hat{p}_t \left\{ \beta \frac{\delta}{1-\delta} \hat{\nu}(x,t) \right\} > \underline{u} + c$$

This is more probably verified for higher values of $\hat{p}_t$ and $\hat{\nu}(x,t)$.

When is it more probable that a person decides to procrastinate? If she thinks the task is more worth-while in τ than in t. That is, the payoff expected in t if she accomplish x in τ must be higher than the expected payoff if the task is realized in t(and this must be true for each $\tau \geq t$, so that she postpones forever), and on its turn this must be higher than the expected utility of doing nothing in τ itself or forever (in this case there is not a definite abandon of the plan of doing task in a certain period of time τ, and the person still procrastinates).

Definition 3.2 *The pathological procrastinator is a person who estimates:*

$$\beta(\delta^{\tau}) \left\{ -c + \frac{\delta}{1-\delta}[(\tau - 1)\underline{u} + \hat{p_{\tau}}\hat{\nu}(x,t)] \right\} > \beta(\delta^{\tau}) \frac{\delta}{1-\delta} \tau \underline{u} \qquad \forall \tau \geq t \tag{2}$$

$$-c + \hat{p}_t \left\{ \beta \frac{\delta}{1-\delta} \hat{\nu}(x,t) \right\} < \beta(\delta^{\tau}) \left\{ -c + \frac{\delta}{1-\delta}[(\tau - 1)\underline{u} + \hat{p}_{\tau}\hat{\nu}(x,t)] \right\} \quad \forall \quad \tau > t \tag{3}$$

Therefore, a person procrastinates if she thinks that $\forall \tau > t$ her payoff will be higher than in t (3) and if she also thinks it is worth-while doing the task before or later, so that she does not abandon the plan (2). In other words, according to (2) a person procrastinates if doing x in τ implies an higher expected payoff than doing nothing in τ itself[11].

[9] We could also imagine that this reward decreases over the time, because less I do more I will be bored, or less I do and less I want to do because I get accustomed to laziness so that I feel better only if I still do not the task. For simplicity, we do not take into consideration this possibility, not strictly important for our analysis. Nevertheless we aim to insert this approach in a dynamical analysis of the problem in future researches. Instead, in this paper we assume only that the reward of doing nothing is not too high and constant over the time.

[10] If we measure the periods of time as $t = 1, 2, ..., \tau, ...$, then this sum is equal to $\tau\underline{u}$.

[11] notice that we do not use the definition of O'Donoghue and Rabin, 2001 [18], according to which to procrastinate means to do absolutely nothing today even if the task is worth-while, because we want add the possibility that doing nothing today may have positive consequences.

Definition 3.3 ***Bad and Good Procrastination.***
a)Procrastination has ex post negative consequences if a person procrastinates the task x (Definition 3.2), but the task was worth-while in t and the real payoff in τ is lower than the real payoff in t. Therefore if sub (2)and (3), the following conditions are satisfied:

$$-c + p_t \left\{ \beta \frac{\delta}{1-\delta} \nu(x,t) \right\} \geq \underline{u} \tag{4}$$

and

$$-c + p_t \left\{ \beta \frac{\delta}{1-\delta} \nu(x,t) \right\} > \beta(\delta^\tau) \left\{ -c + \frac{\delta}{1-\delta} [(\tau - 1)\underline{u} + p_\tau \nu(x,t)] \right\} \quad \forall \tau > t \tag{5}$$

with

$$\beta(\delta^\tau) \left\{ -c + \frac{\delta}{1-\delta} [(\tau - 1)\underline{u} + p_\tau \nu(x,t)] \right\} \geq \beta(\delta^\tau) \left\{ -c + \frac{\delta}{1-\delta} [(\tau - 1)\underline{u} + \hat{p}_\tau \hat{\nu}(x,t)] \right\}$$

b)Procrastination is a good decision if:

$$\underline{u} > -c + p_t \left\{ \beta \frac{\delta}{1-\delta} \nu(x,t) \right\} \tag{6}$$

and

$$\beta(\delta^\tau) \left\{ -c + \frac{\delta}{1-\delta} [(\tau - 1)\underline{u} + p_\tau \nu(x,t)] \right\} < \beta(\delta^\tau) \frac{\delta}{1-\delta} \tau \underline{u} \quad \forall \tau > 0 \tag{7}$$

That is, in each period of time, the utility of doing nothing is higher than that of doing the task, or in other words the task should not be worth-while nor in t (6) nor in τ.
In this case it is much more probable that a person decides to procrastinate and ex post this is revealed have been a good decision if (6) and (7) are verified, because:

$$\beta(\delta^\tau) \left\{ -c + \frac{\delta}{1-\delta} [(\tau - 1)\underline{u} + p_\tau \nu(x,t)] \right\} < \beta(\delta^\tau) \frac{\delta}{1-\delta} \tau \underline{u}$$

$$\leq \beta(\delta^\tau) \left\{ -c + \frac{\delta}{1-\delta} [(\tau - 1)\underline{u} + \hat{p}_\tau \hat{\nu}(x,t)] \right\}$$

Therefore, a person thought the task was worth-while in τ, but in τ she postponed the task again, for fear of a failure, or rethinking the importance of x, so she did not x even in τ. Nevertheless this was the best decision because doing x instead would imply higher losses or a lower welfare.

Proposition 3.4 *For a pathological procrastinator, procrastination has always negative consequences if the task is worth-while in t.*

Proof: If a procrastinator is pathological and follows (2) and (3), he therefore expects to earn in the future more than today, and therefore he also expects the task is less worth-while in t than in τ. Notice that, because we are assuming that procrastinator is pathological, he makes not additional investments to improve himself if he realizes the task in τ. Therefore costs do not increase, while it is always possible that the reward is lower as the delay increased, and

it is more probable that a person has become less and less able to do the task in the future so that $p_\tau < p_t$ and $\nu(x,\tau) < \nu(x,t)$ and consequently (5) is satisfied.

To sum up, the person procrastinated but her payoff in t would have been higher than in τ. She has losses from this behavior only if her payoff from doing x in t would have been positive, that is if the task is worth-while in t; or in other words if (4) is satisfied.

From the previous considerations we may conclude that:
i) A person is more used to procrastinate as more incorrect their estimates of $\hat{p}$ and $\hat{\nu}$ are. In this case she thinks (4) is satisfied while the true expression is (5). This means that she procrastinates if she underestimates her probability of succeed in doing the task today and/or she overestimates the rewards of doing the task in the future compared whit that she gets if she realizes it immediately.
ii)If the procrastinator is pathological to take the right decision the most important thing is to make a good estimate of the current situation in t. If the task is worth-while in t and the person can realize it now, then procrastination will surely have negative consequences.

3.1 Naive and sophisticated subjects

Now we want to extend our analysis to the distinction between naive and sophisticated subjects. To this purpose, we must briefly remember the definition in Rabin e O'Donoghue, 2001 [18], according to which naive subjects are fully unaware of their future self-control problems, while sophisticated subjects are fully aware of her future self-control problems [12]. In our model, following Rabin and O'Donoghue, 2001 [18], we assume that a person's beliefs should be a function of her perception of her future self-control problem. We also require that beliefs are dynamically consistent[13].
To be dynamically consistent beliefs must be both: i) internally consistent, i.e. they must consist of a behavior path such that each period's action is optimal given that the person will stick to that behavior path in the future, and ii) externally consistent, that is person's belief of what she will do in a period must be the same in all $t < \tau$.
Any set of dynamically consistent beliefs can be represented by a single vector of period-1 beliefs $\hat{s}^t(\hat{\beta},\delta) = (\hat{a}_{t+1}(\hat{\beta},\delta), \hat{a}_{t+2}(\hat{\beta},\delta), ...)$
According to this definition, we may distinguish three cases: i)A person with time-consistent preferences is characterized by $\hat{\beta} = \beta = 1$ and for such a person there is a unique perception-perfect strategy[14] $s*$ that maximizes her long-run utility. ii) A completely sophisticated person is characterized by $\hat{\beta} = \beta < 1$ and for such a person a perception-perfect strategy is

[12]"Naivete about future self-control problems leads a person to be over-optimistic about how soon she would complete the task if she were to delay now, and hence is an important determinant of procrastination" (Rabin e O'Donoghue, 2001 [18])

[13]In mathematical formulas (Rabin e O'Donoghue , 2001 [18]) this implies that given $\hat{\beta} \leq 1$ and δ, a set of beliefs $(\hat{s}_1, \hat{s}_2, ...)$ is *dynamically consistent* if
(i) For all $\hat{s}^t$, $a^t_\tau = argmax_{a\in A} V^\tau(\hat{a}_t, \hat{s}_t, \beta, \delta)$ for all τ
(ii)For all $\hat{s}^t$ and $\hat{s}^{t'}$ with $t < t'$, $\hat{a}^t_x = \hat{a}^{t'}_\tau$ for all $\tau > t'$.

[14]Rabin e D'Onoghue, 2001 [18]define a perception-perfect strategy as a set of plans where in each period the person chooses an action to maximize her current preferences given dynamically consistent beliefs about future behavior:
To be more precise a *perception-perfect strategy* for a $(\beta,\hat{\beta},\delta)$ agent is $s^{PP} \equiv (a_1(\beta,\hat{\beta},\delta), a_2(\beta,\hat{\beta},\delta), ...)$ such that there exists dynamically consistent beliefs $\hat{s}(\hat{\beta},\delta)$ where $a_t(\beta,\hat{\beta},\delta) = argmax_a V^t(a, s(\hat{\beta},\delta),\beta,\delta)$

identical to her corresponding dynamically consistent beliefs. iii) A completely naive person has $\hat{\beta} = \beta > 1$. At all times she believes she will behave like a time-consistent person in the future, because for such a person it does exist a set of dynamically-consistent beliefs $s*$.

Proposition 3.5 *Only a naive subject may be a pathological procrastinator.*

Proof: O'Donoghue and Rabin, 2001 [18] showed that only naive subjects may procrastinate forever. We see as this conclusion is also true in our model where we added considerations about subjective evaluations of the person who must decide if and when to do a task. For this purpose we must see what happens to the variables p_t and $\nu(x,t)$. As we have seen above, for a pathological procrastinator the estimated probability of success is lower for high values of the time. This is because it makes sense to assume that if a person can not do the task today, she also won't be able (or will be less able) to do it in the future, if she does not additional investments to improve her performance. For a similar reason we may assume that this probability is lower if a person has incorrect perception of her self-control problem, which implies she doesn't know for how long she will delay the task. That is, if a person knows that she will take too much time to do the task and that she will postpone it for many periods, her probability of success will be lower. Therefore we can imagine that it is: $\hat{p}_t = \hat{p}_t(\hat{\beta})$ and such that $p_t(\hat{\beta}) > p_t(\hat{\beta}')$ for $\beta > \beta'$ (If a person evaluates she is impatient and she can realizes the task immediately, she has an higher estimation of her probability of success in t). In general for a naive subject it is $\hat{p_\tau} = \hat{p_\tau}(\hat{\beta}^n) > \hat{p_\tau} = \hat{p_\tau}(\hat{\beta}^s)$, where $\hat{\beta}^s$ is the estimation of a sophisticated subject of his self-control problem and $\hat{\beta}^n$ is that of a naive subject. Therefore it is more probable that a naive subject overestimates his possibilities, while for a sophisticated subject it is $\hat{\beta}^s = \beta \rightarrow \hat{p}_t = \hat{p}_t(\hat{\beta}) = \hat{p}_t(\beta) = p_t \pm \varepsilon$. That is, the sophisticated subject estimates his probability of success equal to the true probability, because he knows very well his true β. Nevertheless he can make a marginal error ε due to the incompleteness of his informative set for the other variables different from the self-control problem. More complete the informative set is, lower it is this error, and in this case the subjective evaluation of a sophisticated person is more correct. This implies that, based on (ii) of the Proposition 3.4, the sophisticated subject won't decide to procrastinate forever, but he realizes x in t if he thinks the task is worth-while in t, otherwise he will never realize it. For what concerns the reward we can make similar considerations. If the reward is lower for high values of the delay and if the subject has a wrong perception of his self-control problem, so that he thinks he will realize the task in less time than in the really tolerated delay, then he will expect a higher reward than the true one. In this case it is more likely that the naive subject overestimates the true reward.

In general, we may rewrite (4) for a pathological procrastinator, taking into account his self-control problem, as:

$$-c + \hat{p}_t(\hat{\beta}) \left\{ \frac{\delta}{1-\delta} \hat{\nu}(x,t,\hat{\beta}) \right\} < \hat{\beta}(\delta^\tau) \left\{ -c + \frac{\delta}{1-\delta} [(\tau - 1)\underline{u} + \hat{p}_\tau(\hat{\beta}) \hat{\nu}(x,\tau,\hat{\beta})] \right\}$$

and similarly (3) becomes:

$$\hat{\beta}(\delta^\tau) \left\{ -c + \frac{\delta}{1-\delta} [(\tau - 1)\underline{u} + \hat{p}_\tau(\hat{\beta}) \hat{\nu}(x,\tau,\hat{\beta})] \right\} > \hat{\beta}(\delta^\tau) \frac{\delta}{1-\delta} \tau \underline{u}$$

Now we assume that the person estimates it is convenient to do the task in $\tau* \geq t$, this implies that each $\tau > \tau*$ is not optimal. If the subject is sophisticated with $\beta = \hat{\beta}$, because of his dynamically-consistent beliefs, he stops in this optimal $\tau*$ and does the task. Therefore the

following expression is satisfied:

$$\hat{\beta}(\delta^{\tau})\left\{-c+\frac{\delta}{1-\delta}[(\tau-1)\underline{u}+\hat{p}_{\tau}(\hat{\beta})\hat{\nu}(x,\tau,\hat{\beta})]\right\}<$$

$$\hat{\beta}(\delta^{\tau*})\left\{-c+\frac{\delta}{1-\delta}[(\tau*-1)\underline{u}+\hat{p}_{\tau*}(\hat{\beta})\hat{\nu}(x,\tau*,\hat{\beta})]\right\}$$

Because we said that for a pathological procrastinator it is better doing a task only if it is worth-while in t, this means either that $\tau* = t$ or that it is better never to do it. Therefore, for the sophisticated subject, having $\hat{\beta} = \beta$, it is:

$$c+\frac{\delta}{1-\delta}[\hat{p}_{\tau}(\hat{\beta})\hat{\nu}(x,t,\hat{\beta})] =$$

$$= c+\frac{\delta}{1-\delta}[\hat{p}_{\tau}(\beta)\hat{\nu}(x,t,\beta)] > \beta(\delta^{\tau})\left\{-c+\frac{\delta}{1-\delta}[(\tau-1)\underline{u}+\hat{p}_{\tau}(\beta)\hat{\nu}(x,\tau,\beta)]\right\}$$

(4) is not satisfied and it is impossible that he delays the task over t. Obviously this happens only if he thinks the task is wort-while in t. On the contrary, if he mistakenly believes that this is not true he abandons definitely the task since t itself. Anyway, in both cases he won't procrastinate forever. In other words, the rational sophisticated agent, who is fully aware of his self-control problem, knows that if he delays the task, instead of doing it now, it is better never to do it. Consequently, his optimal strategy can be only to do x in t if the task is worth-while today or never to do it otherwise. Anyway, if the task was worth-while in t and the sophisticated subject wrongly estimated it was not worth-while, his welfare loss is equal to:

$$W_{loss} = \frac{\delta}{1-\delta}[p_t\nu(x,t)]^{15}$$

If the task is not worth-while in t, and instead he estimated it was better doing it, his effective welfare loss is just the cost c supported to realize it. For $\varepsilon = 0$ there is complete information so that:

$$-c+\frac{\delta}{1-\delta}[\hat{p}_t(\beta)\hat{\nu}(x,t,\beta)] = -c+\frac{\delta}{1-\delta}[p_t(\beta)\nu(x,t,\beta)]$$

that is the expected evaluated payoff for a sophisticated subject is correct and he has not welfare losses, because he takes the right decision.

On the contrary the naive subject has $\hat{\beta} > \beta$, so that his optimal timing is always a $\tilde{\tau} > \tau* = t$. That is, the naive subject wrongly estimates his self-control problem and thinks he may realize the task in a certain period in the future. He always overestimates his probability of success and his expected reward being $\hat{p}(\hat{\beta}) > \hat{p}(\beta)$ and $\hat{\nu}(\hat{\beta}) > \hat{\nu}(\beta)$ also for $\varepsilon = 0$.

For a naive subject it is:

[15] In this case the sophisticated subject obviously has no costs today having decided not to do the task at all.

$$\hat{\beta}(\delta^{\tau*})\left\{-c+\tfrac{\delta}{1-\delta}[(\tau*-1)\underline{u}+\hat{p}_{\tau*}(\hat{\beta})\hat{\nu}(x,\tau*,\hat{\beta})]\right\}<$$

$$\hat{\beta}(\delta^{\tilde{\tau}})\left\{-c+\frac{\delta}{1-\delta}[(\tilde{\tau}-1)\underline{u}+\hat{p}_{\tilde{\tau}}(\hat{\beta})\hat{\nu}(x,\tilde{\tau},\hat{\beta})]\right\}$$

and

$$-c+\frac{\delta}{1-\delta}[\hat{p}_t(\hat{\beta})\hat{\nu}(x,t,\hat{\beta})]<\hat{\beta}(\delta^{\tilde{\tau}})\left\{-c+\frac{\delta}{1-\delta}[(\tilde{\tau}-1)\underline{u}+\hat{p}_{\tilde{\tau}}(\hat{\beta})\hat{\nu}(x,\tilde{\tau},\hat{\beta})]\right\}$$

he will never realize the task, also because in each $\tilde{\tau}$ he always still think it is better postpone the task again.

We must also notice that, if the task was worth-while in t, the welfare loss for a naive subject, because he thinks he may realize the task x in $\tilde{\tau}>t$, is:

$$W_{loss}=c+\frac{\delta}{1-\delta}[p_t\nu(x,t)]$$

It not only includes the lost expected payoff but also the cost supported to realize it. Therefore welfare losses for a naive subject are higher than for a sophisticated subject, if the task was worth-while in t but he wrongly estimated it is was better not do it in t. Welfare losses are the same for both subjects and equal to the cost c otherwise, that is if the task was not worth-while in t. In any case, we must also notice that, unlike the sophisticated subject, the naive subject will certainly suffer from one of these losses, even if $\varepsilon=0$. This is because he ever makes mistakes in his subjective estimates of his true β, also with complete information on all the other variables not concerning the self-control problems.

4 The curse of perfectionism

We have seen that a person is more likely to procrastinate, and that this has negative consequences, if she overestimates the values of p_τ and $\nu(x,\tau)$. In the reality there are few possibilities that a rational individual makes this kind of mistake if he knows he does nothing to improve his performance while he procrastinates. On the contrary, if we assume that a procrastinator is not pathological, but he only procrastinates because he fears of failure, he will probably invest his delayed time in an effort ρ so that in τ he may have either a higher reward and/or a higher probability of success. We insert these considerations in our model assuming that $p_\tau(\rho)>p_\tau(0)$ for $\rho>0$ and that by investing in this effort the subject may realize in τ the task $x(\rho)>x(0)$ and such that $x(\rho)>x(\rho')$ for $\rho>\rho'$
Neverthless the full effect on the final reward is uncertain, because the reward is higher for high values of the effort but lower for high values of the time. Therefore the final result of investing in effort depends on what effect prevails and on the cost supported for this effort.
In this section our objective is to analyze the case when it is convenient for a person to stop delaying and do the task, before that losses are higher than benefits of the investment.
This happens in the case of an obsessed procrastinator who wants to do the task as better as possible and procrastinates to improve his performance, but he does not understand that

this excess in procrastinating may be dangerous. This happens when a) he invests more than necessary (he would be able to realize successfully the task sooner and with a lower level of effort) and b) earnings from this improvement are lower than losses related to the delay. If these losses prevail on the rewards we will have what we call "*the curse of perfectionism*".
A key thing in the curse of perfectionism is fear of failure which makes the submission of a work acutely painful. The thought that with time it will be improved can be a way to put off that painful experience. It is an excuse motivated by time preference (which preference is not exponential so there is time inconsistency).
Things may be worst because often people not only wait for something happen but they invest to improve their performance but without never realize the task. So there are additional losses from doing nothing.

Once again we start by assuming no differences between naive and sophisticated subjects. The agent may also decide not to do the task x today but to invest today in the effort ρ at a cost $c(\rho)$. For simplicity, we also assume the person supports only today an additional cost for the effort, which produces a positive earning only in τ.
We also assume that the reward ν is proportional both to the time where the task is realized and to the outcome realized. Therefore we set $\nu \equiv x(\rho), t)$. So ν is higher for high values of $x(\rho)$ and lower for high values of the period[16].
We can also imagine that there is a limit to the maximum effort $\rho*$ behind it the individual's performance cannot be increased any more: $x(\rho) = x(\rho*)$ for all $\rho \geq \rho*$.
Under these new assumptions the previous system would change into:

$$\begin{cases} -c + \hat{p}_t(0)\left\{\beta\frac{\delta}{1-\delta}\hat{\nu}(x(0),t)\right\} & \text{if} \quad a_t = (c, \nu(x(0),t) \\ \\ \beta(\delta^\tau)\left\{-c + \frac{\delta}{1-\delta}[(\tau-1)\underline{u} + \hat{p}_\tau(0)\hat{\nu}(x(0),\tau)]\right\} & \text{if} \quad a_t = \emptyset, \tau = \min\{d > 0 \mid \hat{a}_{t+d} \neq \emptyset\}, \\ & \qquad \text{and } \hat{a}_{t+d} = (c, \hat{\nu}(x(0),\tau) \\ \\ \beta\frac{\delta}{1-\delta}\tau\underline{u} & \text{if} \quad a_t = \emptyset \quad \text{and} \quad \hat{a}_{t+d} = \emptyset \quad \forall \quad d > 0 \\ \\ \beta(\delta^\tau)\{-(c + c(\rho)) + (\delta/(1-\delta))[(\tau-1)\underline{u} + \hat{p}_\tau(\rho)\hat{\nu}(x(\rho),\tau)]\} & \text{if} \quad a_t = \emptyset, \\ & \tau = \min\{d > 0 \mid \hat{a}_{t+d} \neq \emptyset\}, \hat{a}_{t+d} = (c, c(\rho)\hat{\nu}(x(\rho),\tau) \text{ with } \rho > 0 \end{cases}$$

In the first case she does the task today in t under the cost c, without investing in any effort. In the last case she does the task in $\tau > t$ and invests the time t in improving her performance so to realize in τ a task $x(\rho) < x(0)$. In the second case she puts off her task without investing in any efforts. Finally in the third case she does nothing in t and this is true for each $t \geq 0$.

Because people can't procrastinate forever and after they have reached their better performance is not more worth-while postponing, it there will be an optimal period of time $\tau*$ and an optimal effort level $\rho*$ such that:

[16] An example of this behavior may be related to students' behavior who postpone taking an examination today to improve themselves and get higher scores in the aftermaths. But the benefit (the higher score) has also a cost (studying more intensively and more time, paying taxes, paying rents for students living outside,or getting the maximum score in an examination but taking it when too old, etc.)

$$(\rho*, \tau_\rho*) = \text{argmax}\beta(\delta^\tau)\left\{-c - c(\rho) + \frac{\delta}{1-\delta}[(\tau-1)\underline{u} + p_\tau(\rho)\nu(x(\rho),\tau)]\right\} \tag{8}$$

under the following constraints:

- $\beta(\delta^\tau)\left\{-c - c(\rho) + \frac{\delta}{1-\delta}[(\tau-1)\underline{u} + p_\tau(\rho)\nu(x(\rho),\tau)]\right\} >$

$$\beta(\delta^\tau)\left\{-c + \frac{\delta}{1-\delta}[(\tau-1)\underline{u} + p_\tau(0)\nu(x(0),\tau)]\right\}$$

- $x(\rho) = x(\rho*) \quad \forall\rho \geq \rho* \quad \text{and} \quad x(\rho) < x(\rho*) \quad \forall\rho < \rho*$

- $\nu(x(0),\tau) < \nu(x(\rho*),\tau) < \nu(x(\rho*),\tau*) \quad \forall\tau \geq t, \tau \neq \tau*$

Because people don't know the true values of probabilities and rewards, they will try to realize the optimal strategy s that maximizes the expected payoff:

Definition 4.1 ***The effort-time perfect strategy.*** *For a (β,δ) agent is $S^{ET} \equiv (\rho, a_1(\beta,\delta), a_2(\beta,\delta), ...)$ such that*

$$(\rho, a_\tau(\beta,\delta)) = argmaxV(a,\beta,\delta,\rho)$$

for all t.

The optimal values of effort and timing chosen are $(\tilde{\rho},\tilde{\tau})$ which maximize the function:

$$\beta(\delta^{\tilde{\tau}})\left\{-c - c(\tilde{\rho}) + \frac{\delta}{1-\delta}[(\tilde{\tau}-1)\underline{u} + p_{\tilde{\tau}}(\tilde{\rho})\nu(x(\tilde{\rho}),\tilde{\tau})]\right\}$$

and they may obviously been different from the real optimal values $(\rho*, \tau*)$ if the subjective evaluation of probabilities of success and rewards are incorrect.

Definition 4.2 ***The curse of perfectionism.*** *A person procrastinates for too long time and invests in too much effort so to incur in the curse of perfectionism when:*

$$\beta(\delta^{\tilde{\tau}})\left\{-c - c(\tilde{\rho}) + \frac{\delta}{1-\delta}[(\tilde{\tau}-1)\underline{u} + p_{\tilde{\tau}}(\tilde{\rho})\nu(x(\tilde{\rho}),\tilde{\tau})]\right\} <$$

$$\beta(\delta^{\tau*})\left\{-c - c(\rho*) + \frac{\delta}{1-\delta}[(\tau*-1)\underline{u} + p_{\tau*}(\rho*)\nu(x(\rho*),\tau*)]\right\} \tag{9}$$

and simplifying

$$\{-c(\tilde{\rho}) + c(\rho*)\} < \left\{\frac{\delta}{1-\delta}[(\tau*-\tilde{\tau})\underline{u} + p_{\tau*}(\rho*)\nu(x(\rho*),\tau*) - p_{\tilde{\tau}}(\tilde{\rho})\nu(x(\tilde{\rho}),\tilde{\tau})]\right\} \tag{10}$$

but individuals estimates the wrong relation:

$$\beta(\delta^{\tilde{\tau}})\left\{-c - c(\tilde{\rho}) + \frac{\delta}{1-\delta}[(\tilde{\tau}-1)\underline{u} + \hat{p}_{\tilde{\tau}}(\tilde{\rho})\hat{\nu}(x(\tilde{\rho}),\tilde{\tau})]\right\} >$$

$$\beta(\delta^{\tau*})\left\{-c - c(\rho*) + \frac{\delta}{1-\delta}[(\tau*-1)\underline{u} + \hat{p}_{\tau*}(\rho*)\hat{\nu}(x(\rho*),\tau*)]\right\} \tag{11}$$

This condition is more probably verified when:
i) the additional cost supported for the not necessary effort is higher than the real optimal one, that is $c(\rho*) < c(\tilde{\rho})$ (in this case the left part of the (10)is low);
ii) the time where it is optimal doing noting is higher than the time to stop procrastinating, so that the first member in the right part of (10) has high value), that is $(\tau * - \tilde{\tau})\underline{u}$;
iii)the difference $(p_{\tau*}(\rho*)\nu(x(\rho*), \tau*) - p_{\tilde{\tau}}(\tilde{\rho})\nu(x(\tilde{\rho}), \tilde{\tau}))$, is big. Because probabilities and rewards are higher for high values of the effort and lower for high values of timing, this conditions is much more probably verified when the optimal timing to realize the task is lower than that estimated as strategically relevant. The effect of a too high effort instead seems to go in the opposite direction,; that is, an effort higher than the necessary increases the expected probability of success and reward so that it would be $p_{\tau*}(\rho*) < p_{\tilde{\tau}}(\tilde{\rho})$ and $\nu(x(\rho*), \tau*) < \nu(x(\tilde{\rho}), \tilde{\tau}))$ and the (10) could not be verified so that there is not *curse of perfectionism*. The final effect depends on how much the increases in p and in rewards are more than compensated from the increase in the cost attached to a higher effort (condition (i)).

Now we extend the analysis to the distinction between naive e sophisticated subjects. In particular, the following Proposition is worth.

Proposition 4.3 *Sophisticated agents might ever do a task adequately as a commitment device to tirelessly pursuing perfection. In particular, the effort-time perfect strategy of a sophisticated subject with complete information is the same as the real one. For the naive subject instead suffering from the curse depends on the cost of the effort and on his perception of his self-control problem, that is the bias of the estimation of β. The naive subject could suffer from the curse of perfectionism even under complete information.*

In the case of the *curse of perfectionism* in fact a sophisticated subject could make himself free from the curse because if he estimates that an optimal levels of effort and timing exist to do the task x, being he beliefs dynamically consistent, he won't procrastinate the task any more and won't invest in too high level of effort. Therefore he will stop procrastinating and will realize the task x in that optimal time and with that optimal level of effort.
In particular, for a sophisticated subject if $\varepsilon = 0$, his subjective estimations are coincident with the true values of variables affecting the expected payoff and his effort-time perfect strategy coincides with the real optimal one:

$$\hat{s}^{ET_s} \equiv (\rho, \hat{a}_1(\hat{\beta}, \delta), \hat{a}_2(\hat{\beta}, \delta), ...) = s^{ET} \equiv (\rho, a_1(\beta, \delta), a_2(\beta, \delta), ...)$$

As in Par.3.1 if the sophisticated subject found the optimal values of τ and ρ, which may also be different from the real one, depending on the incompleteness in the informative set, in any case he will realize the task in this optimal estimated time at that optimal estimated level of effort.
The loss welfare function is:

$$\beta(\delta^{\tilde{\tau}}) \left\{ -c - c(\tilde{\rho}) + \tfrac{\delta}{1-\delta}[(\tilde{\tau} - 1)\underline{u} + \hat{p}_{\tilde{\tau}}(\tilde{\rho})\hat{\nu}(x(\tilde{\rho}), \tilde{\tau})] \right\} -$$

$$\beta(\delta^{\tau*}) \left\{ -c - c(\rho*) + \frac{\delta}{1-\delta}[(\tau * -1)\underline{u} + \hat{p}_{\tau*}(\rho*)\hat{\nu}(x(\rho*), \tau*)] \right\}$$

If his informative set is complete enough this welfare loss can be very low, in particular it is equal to zero if $\varepsilon = 0$

On the contrary for a naive subject it would be more difficult or impossible to avoid the "curse" if the cost for the effort is low enough and if his bias of β is too high. This happens because it will always exist a $\tau > 0$ that satisfies (11), being incorrect his estimates of probabilities and rewards depending on his incorrect estimates of β. Consequently he always postpones the time to realize the task and he always procrastinates. In other words, if there are optimal ρ and τ satisfying (11) also $\rho + 1$ and $\tau + 1$; or $\rho + 2$ and $\tau + 2$, and so on, will satisfy (11), given that rewards and probabilities are higher for high values of β, so he will suffer from the "curse".

Therefore a naive subject shifts his optimal timing for infinitive periods, because he always estimates a higher β than the real one so that (11) is always satisfied for a higher timing than the optimal one. We can see that by comparing each member in the right side of this expression with members in the left part of it. Because the subject is naive: $\beta(\delta^{\tau}) < \hat{\beta}(\delta^{\tau})$ while the utility of doing nothing is higher for higher values of the time: $\tau * \underline{u} < \tilde{\tau}\underline{u}$
Therefore to the (11) be true it is sufficient that:

$$-c(\tilde{\rho}) + \frac{\delta}{1-\delta}[\hat{p}_{\tilde{\tau}}(\tilde{\rho})\hat{\nu}(x(\tilde{\rho}), \tilde{\tau})] > -c(\rho*) + \frac{\delta}{1-\delta}[\hat{p}_{\tau*}(\rho*)\hat{\nu}(x(\rho*), \tau*)]$$

or

$$c(\tilde{\rho}) - c(\rho*) < \frac{\delta}{1-\delta}([\hat{p}_{\tilde{\tau}}(\tilde{\rho})\hat{\nu}(x(\tilde{\rho}), \tilde{\tau})] - [\hat{p}_{\tau*}(\rho*)\hat{\nu}(x(\rho*), \tau*)])$$

if the cost of the effort is very low or a person procrastinates for a little time with respect to the optimal one, so that only a little effort is done and its associated cost is not too high, the term in the left part is very low and tends to be equal to zero.
The term in the right part is positive if

$$\hat{p}_{\tilde{\tau}}(\tilde{\rho})\hat{\nu}(x(\tilde{\rho}), \tilde{\tau}) > \hat{p}_{\tau*}(\rho*)\hat{\nu}(x(\rho*), \tau*)\} \tag{12}$$

and it is much more high as higher it is the difference between the two members of this last expression. High values of effort and β have a positive influence on this probability and rewards both directly and through the effect on x. The opposite effect is that related to timing, being probabilities and rewards lower for higher values of it. The (12) will more probably be satisfied as lower is the weight subjects attach to it. Because we are considering an obsessed procrastinator, i.e. the one who thinks he can better realize in the future the task tanks to that effort, he will probably attach a low weight to effect of timing with respect to the effects of effort and the value of β.
For instance, if we assume that:

$$p_{\tau} = \alpha_1\beta^{\tau} - \lambda_1\tau + \mu_1\rho + \varepsilon_1$$

and

$$\nu_{\tau} = \alpha_2\beta^{\tau} - \lambda_2\tau + \mu_2\rho + \varepsilon_2$$

the expression (12) becomes:

$$[\alpha_1\beta^{\tilde{\tau}} - \lambda_1\tilde{\tau} + \mu_1\tilde{\rho} + \varepsilon_1][\alpha_2\beta^{\tilde{\tau}} - \lambda_2\tilde{\tau} + \mu_2\tilde{\rho} + \varepsilon_2] > [\alpha_1\beta^{\tau*} - \lambda_1\tau* + \mu_1\rho* + \varepsilon_1][\alpha_2\beta^{\tau*} - \lambda_2\tau* + \mu_2\rho* + \varepsilon_2]$$

which is ever true for low values of λ_1 and λ_2.

5 Productive Procrastination.

In this section we assume that procrastinators invest for the time between t and τ to improve their performance and to do x better in the future. Nevertheless if x is never realized they may also use that investment for an alternative activity y which produces a positive reward only in τ: $\nu(y,\tau) > 0$, while $\nu(y,t) = 0$ for $t < \tau$. Alternatively we can also imagine that a person uses her delayed time not just for a productive task but for some other activities (as relational goods like spending time with friends, family, as volunteers, etc.) which produce in that meanwhile a higher satisfaction $\bar{u}$ than the utility of doing nothing at all $\underline{u}$. In this case procrastination is not only a waste of time, but it may become a good strategy implying welfare increases. This happens under the following condition: the payoff of procrastinating until τ increases thanks to the increase in the reward for y in τ or for the welfare increases due to relational goods. This increase must be higher than the payoff of doing x in t. Notice that productive procrastination is not just doing something else as in a problem of multi-choice tasks, the central issue here is that reward of y is due to the investment made for x but not used for this last, given that the subject never realizes x. This happens because agents do not have to choose what task accomplish (x or y), but by using ex post for y resources they have initially planned to use for x they can realize y in better way. If they have never planned to do x they would have never invested in these resources which increased their welfare from y. Alternatively, we may have productive procrastination because while procrastinating x the agents devote their time to "relational goods" and this also increases their welfare. They can do that just because they have planned x (and refused to do whatever other task z), but they are not doing it and they can't do z any more, so they have free time to devote to these goods. The agents have never done that if they had done x or z. To sum, x becomes a sort of "hidden" incentive to do y (or to do y better) or for relational goods: planning x but not doing it may be useful for y which increases the agent's welfare more than x itself or can imply a huge $\bar{u} > \underline{u}$ coming from relational goods.

Now we want to translate all these considerations in analytical terms, under the assumption that investing for x is costly, but this investment is also useful to realize y in the future. We denote with ρ_{xy} the effort made for x but also useful to do y in the future and for simplicity, we also assume that this effort let people certainly realize and with success y so that: $p(xy) = 1$.

Definition 5.1 *Under the above assumption we will have productive procrastination in τ if:*

$$\beta(\delta^{\tau})\{-(c + c(\rho_{xy}) + (\delta/(1-\delta))[\alpha\tau\bar{u} + \gamma\hat{\nu}(y,\tau,\rho_{xy})]\} > -c + p_t\{\beta\frac{\delta}{1-\delta}\nu(x,t)\} \quad \forall\tau > t$$

If this condition is satisfied people could procrastinate forever with not negative consequences because even if $p_\tau\nu(x,\tau) = 0$ and x is never realized, nevertheless there is a positive reward from doing y, $\hat{\nu}(y,\tau,\rho_{xy}) > 0$ if ρ_{xy}. This results is not always true, but it is depends on the cost of the effort and how much high it is with respect to the reward of y[17], which is lower for high values of τ. Therefore it does exist a optimal couple $(\tau*, \rho_{xy}*))$, given the expectations of

[17]Notice that once again, for simplicity, we are managing a static analysis and we do not take into consideration values of variables, like costs of the effort, etc., changing over time, but we assume that they are made only at the beginning of the time in t. Nevertheless it would be interesting and it is the purpose of our future researches, see how things change in a dynamical environment.

the subject on probabilities and rewards, such that the result of the productive procrastination is maximized

$$\beta(\delta^{\tau})\left\{-(c+c(\rho_{xy}))+\frac{\delta}{1-\delta}[\alpha\tau\bar{u}+\gamma\hat{\nu}(y,\tau,\rho_{xy})]\right\}$$

or:

$$(\tau*,\rho_{xy}*)=\text{argmax}\{\beta(\delta^{\tau})\left\{-(c+c(\rho_{xy}))+\frac{\delta}{1-\delta}[\alpha\tau\bar{u}+\gamma\hat{\nu}(y,\tau,\rho_{xy})]\right\}$$

such that

$$\beta(\delta^{\tau})\left\{-(c+c(\rho_{xy}))+\frac{\delta}{1-\delta}[\alpha\tau\bar{u}+\gamma*\hat{\nu}(y,\tau,\rho_{xy})]\right\}>-c+\hat{p}_t\left\{\beta\frac{\delta}{1-\delta}\hat{\nu}(x,t)\right\}$$

$$\nu(y,\tau,\rho_{xy}*)>\nu(y,\tau,\rho_{xy})\quad\forall\quad\rho_{xy}\neq\rho_{xy}*$$

Definition 5.2 ***Productive Procrastination perfect Strategy.*** *We define that a Productive Procrastination (PP) does exist in a multi-tasks environment when there is a task x-worthwhile, but it also does exists una couple $(\tau*,\rho*_{xy})>0$ such that*

$$(\tau*,\rho*_{xy})=argmax(\sum_{j\neq x}(V_j+V_x).$$

Moreover, the action $(\rho*_{xy},a_t*=(c,\nu*(\rho*_{xy}),\tau*))$ is the best person choice that corresponds to

$$argmaxV(c,\hat{\nu}*(\rho*_{xy},y,\tau*),\hat{\nu}*(x,\tau*)).$$

In particular if the subject never realize x, his payoff is:

$$V(c,\hat{\nu}*(\rho*_{xy},y,\tau*))$$

If we distinguish between naive and sophisticated subjects, it is easy to understand that under complete information the sophisticated subject evaluates whether he is able to realize and at what time the task x, so if he thinks he can do x in $\tau*$ he will use the investment for x, otherwise he will directly invest for y. The problem arises under incomplete information, in this case the sophisticated subject can make incorrect estimates of the real payoffs. If he estimates it is better doing x he will suffer from a welfare loss equals to the difference between the estimated payoff of doing x in $\tilde{\tau}$ and the potential payoff associated with y, that he may get by using the investment initially made for x, or that associated with $\bar{u}$. Therefore productive procrastination is a concept more related to the behavior of the naive subjects. In fact, they may procrastinate x without never realize it, so they won't use the investment for x, but for y or, in the meanwhile procrastinating, they may devote to alternative activities with a reward $\bar{u}$. In this case procrastination of x forever may have positive effects if the reward of y or $\bar{u}$ are higher than the cost of the effort, so that Definition is satisfied. Nevertheless if the naive subject has problem of self-control on his perception of β for y, there are not possibilities for a *productive procrastination.*

In particular, if the subject has an incorrect perception of β both for x and y, a *productive procrastination* is impossible if:

$$\beta(\delta^{\tau})\left\{-(c+c(\rho*_{xy}))+\frac{\delta}{1-\delta}[\alpha\tau\bar{u}+\gamma\hat{\nu}(y,\tau,\rho*_{xy},\beta)]\right\}>-c+p_t\left\{\beta\frac{\delta}{1-\delta}\nu(x,t)\right\}$$

and

$$-c + p_t \left\{ \beta \frac{\delta}{1-\delta} \nu(x,t) \right\} > \hat{\beta}(\delta^\tau) \left\{ -(c + c(\tilde{\rho}_{xy})) + \frac{\delta}{1-\delta} [\alpha \tau \bar{u} + \gamma \hat{\nu}(y, \tau, \tilde{\rho}_{xy}, \hat{\beta})] \right\}$$

Moreover, he may mistakenly procrastinate y in a vain attempt of improvement by falling in the *curse of perfectionism* on y if:

$$\hat{\beta}(\delta^\tau) \left\{ -(c + c(\tilde{\rho}_{xy})) + \tfrac{\delta}{1-\delta} [\alpha \tau \bar{u} + \gamma \hat{\nu}(y, \tau, \tilde{\rho}_{xy}, \hat{\beta})] \right\} >$$

$$\beta(\delta^\tau) \{ -(c + c(\rho *_{xy}) + (\delta/(1-\delta))[\alpha \tau \bar{u} + \gamma \hat{\nu}(y, \tau, \rho *_{xy}, \beta)]$$

6 Conclusions

Procrastination is a rather strange behavior because it implies that people ontinually delay a task they need to complete. Many factors can be in action for that, in particular under time-inconsistent preferences people prefer doing nothing today if this cause them immediate-gratification, while it could be in their best long-run interest complete it sooner.
In this framework we add considerations about the possibility that procrastination may be a positive behavior if today is not the optimal time to realize a given task, and if a person uses the time until the deadline approaches to improve his performance. So we try to define define theoretical conditions for this may happen. We also define the problem of curse of perfectionism which may arise when people procrastinate over the optimal timing, investing in the no optimal effort level. Moreover, we analyze the case of a productive procrastination which is related to the importance of investment for alternatives activities, but not used for the initial planned task.
We find that only naive subjects may be pathological procrastinator; while sophisticated ones may suffer from the *curse of perfectionism* conditional to the problem of incomplete information. The welfare losses are lower as more complete the informative set is. On the contrary the naive subjects may suffer from the curse also with complete information, depending on their self-control problem and the cost of the effort. Similarly, the naive subjects may not benefit from productive procrastination if their self-control problem for the initial task concerns also the other alternative activities.
Nevertheless we think more deeply analyzes could better highlight problems related to procrastination, as a dynamically analyzes with variables like probabilities, rewards, costs, etc. changing over time. Similarly empirical analyzes in this direction should be usefully managed to see if people use postponing in a productive way or this is just a waste of time. Interesting empirical and experimental analyzes could be managed for instance in the fields of undergraduate students decisions about when taking an examinations, in the job search, or in starting up a new activity, etc.

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