Competition among Procrastinators*

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Abstract

I consider a situation in which workers have present-biased preferences and have a tendency to procrastinate their tasks, but underestimate the degree of self-control problems that they will face in the future. In such a situation, their manager may want to introduce some form of competition to induce them to finish their tasks earlier. However, I show that the introduction of competition may delay the completion of their tasks. The intuition of the result is simple: The introduction of competition reinforces their belief that they will complete the task soon, which undermines their incentive to undertake the task now. The result holds even when there is only one worker who underestimates the degree of self-control problem, which suggests that the mere existence of a single "irrational" agent can undermine the overall performance of the organization.

Keywords: Present-biased preferences, Naivete, Competition, Self-control, Time inconsistency
JEL Classification: D90, J22, D83

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1 Introduction

How does workers' procrastination affect the performance of the organization? Is there any mechanism within the organization that mitigates workers' procrastination? How does the degree of awareness about future self-control problems affect these questions? In this paper I show that the introduction of competition among workers may delay the completion of their tasks. Moreover, I show that there is a case that the competition delays task completion in which only one worker underestimates the degree of self-control problem. This suggests that the mere existence of a single "irrational" agent can undermine the overall performance of the organization.

I consider a situation in which workers have present-biased preferences and have a tendency to procrastinate their tasks, but underestimate the degree of self-control problem that they will face in the future. Then, I investigate whether the introduction of competition among procrastinators can induce them to finish their tasks earlier.

There are a number of papers that investigate a single representative time-inconsistent agent's behavior or interactions between time-consistent agents and time-inconsistent agents.[1] However, few analyze interactions among time-inconsistent agents. To my knowledge, the only such paper is Brocas and Carrillo (2001). They consider a competition among *sophisticated* agents with present-biased preferences, who are perfectly aware of their future self-control problems, in an infinite-horizon model. Contrary to this paper, they find that the competition always mitigates procrastination. The current paper shows that even when there is only one worker who underestimates the degree of self-control problem, competition may exacerbate procrastination.

To understand the reasoning behind the result, first note that we often procrastinate because we believe that we will perform the tasks in the future. In other words, if we are certain that we will not perform the tasks in the future, we probably do not procrastinate. The introduction of competition has positive and negative effects on earlier completion of tasks. The positive effect is that workers' incentive to complete tasks earlier increases in order to receive the reward before the opponent takes it. The negative effect is that workers' incentive to complete the tasks earlier decreases since workers more strongly believe that their future-selves will complete the tasks earlier in the future. Therefore, the negative effect may outweigh and delay the completion of their tasks.

2 Present-biased Preferences and Beliefs

To analyze agents with time-inconsistent preferences who have a tendency to procrastinate, I assume that agents have present-biased preferences or quasi-hyperbolic preferences, which are introduced by Phelps and Pollak (1968). In particular, an agent's total utility at period t is given by

$$U^t\left(u_t, u_{t+1}, \ldots, u_T\right) \equiv u_t + \beta \sum_{s=t+1}^{T} \delta^{s-t} u_s, \tag{1}$$

[1] See, for instance, Akerlof (1991), Laibson (1997), O'Donoghue and Rabin (1999a, 1999b, 2001, 2008), Gilpatric (2008), Heidhues and Kőszegi (2010), and Bisin et. al (2015).

where u_t represents the instantaneous utility in period t, $\delta \in (0,1)$ and $\beta \in (0,1]$. β captures the degree of present bias. A smaller β signifies a larger bias for the present over the future. For $\beta = 1$, agents have the standard time-consistent preferences, exhibiting no present–bias. For $\beta < 1$, agents have the bias for the present over the future.

Following the formulation of *partial naivete* introduced by O'Donoghue and Rabin (2001), agents may underestimate the magnitude of their present-bias. Particularly, self-t of an agent, his period-t incarnation, believes that his future selves will choose his behavior based on $\hat{\beta}$, not true value β, with $\beta \leq \hat{\beta} \leq 1$, where $\hat{\beta}$ is the agent's beliefs about the degree of self-control problems that his future selves will face. An agent with $\hat{\beta} = 1$ is called *naif*, for he is completely unaware of the fact that he will face self-control problems. An agent with $\hat{\beta} = \beta$ is called *sophisticate*, for he perfectly predicts the degree of his future self-control problems.

3 Benchmark Model: A Single Agent Case

In this section, I investigate a case of a single agent as a benchmark. This benchmark model is essentially identical to O'Donoghue and Rabin (1999a), except that I allow partial naivete. Suppose that there is a task that requires to perform only once within three periods $t = 1,2,3$. Given that the task has not been performed, in each period t, he can choose one of $A \equiv \{D, W\}$. When he chooses D in period t, meaning that he "does" his task, it incurs a cost of $c > 0$ in period t and generates a reward of $v > 0$ in period $t+1$. If he chooses W in period t, meaning that he "waits" to do his task, he will face the same choice in period $t+1$ for $t = 1,2$ and the task becomes unavailable and he receives zero for $t = 3$.

I assume that $-c + \beta\delta v \geq 0$ so that the net value of the task is positive in every period, and $\delta \in (0,1)$ so that waiting is costly. I also assume that the agent chooses D whenever he is indifferent.

I adopt a solution concept called *perception-perfect strategies (PPS)* in O'Donoghue and Rabin (2001). Let $\boldsymbol{s} \equiv (a_1, a_2, a_3)$ represent a strategy profile, where $a_t \in A$ is a strategy in period t. Let $\hat{a}^t_\tau$ represent self-t's belief about self-τ's strategy a_τ for $t < \tau$. Let $\hat{\boldsymbol{s}}^1 \equiv \left(\hat{a}^1_2, \hat{a}^1_3\right)$ and $\hat{\boldsymbol{s}}^2 \equiv \left(\hat{a}^2_3\right)$ be the beliefs about his future strategies held by self-1 and self-2, respectively. Let $U^t\left(a_t, \hat{\boldsymbol{s}}^t, \beta, \delta\right)$ be the agent's total utility at period t by choosing $a_t \in A$ conditional on that he follows self-t's beliefs $\hat{\boldsymbol{s}}^t$ in the future. That is, $U^t\left(a_t, \hat{\boldsymbol{s}}^t, \beta, \delta\right)$ satisfies the following:

$$
\begin{aligned}
&U^1\left(a_1 = D, \hat{\boldsymbol{s}}^1, \beta, \delta\right) = U^2\left(a_2 = D, \hat{\boldsymbol{s}}^2, \beta, \delta\right) = U^3\left(a_3 = D, \beta, \delta\right) \equiv -c + \beta\delta v; \\
&U^1\left(a_t = W, \hat{\boldsymbol{s}}^1, \beta, \delta\right) \equiv \begin{cases} \beta\delta\{-c + \delta v\} & \text{if} \quad \hat{\boldsymbol{s}}^1 = (D, W) \text{ or } (D, D), \\ \beta\delta^2\{-c + \delta v\} & \text{if} \quad \hat{\boldsymbol{s}}^1 = (W, D), \\ 0 & \text{if} \quad \hat{\boldsymbol{s}}^1 = (W, W); \end{cases} \\
&U^2\left(a_2 = W, \hat{\boldsymbol{s}}^2, \beta, \delta\right) \equiv \begin{cases} \beta\delta\{-c + \delta v\} & \text{if} \quad \hat{\boldsymbol{s}}^2 = (D), \\ 0 & \text{if} \quad \hat{\boldsymbol{s}}^2 = (W); \end{cases} \\
&U^3\left(a_3 = W, \beta, \delta\right) \equiv 0.
\end{aligned}
$$

Definition 3.1 *Given $\hat{\beta}$ and δ, self-1's beliefs $\hat{\boldsymbol{s}}^1 = \left(\hat{a}^1_2, \hat{a}^1_3\right)$ and self-2's beliefs $\hat{\boldsymbol{s}}^2 = \left(\hat{a}^2_3\right)$ are* ***dynamically consistent*** *if a pair $\left\{\hat{\boldsymbol{s}}^1, \hat{\boldsymbol{s}}^2\right\}$ satisfies the following two conditions:*

1. $U^3\left(\hat{a}^t_3, \hat{\beta}, \delta\right) \geq U^3\left(a_3, \hat{\beta}, \delta\right), \forall a_3 \in A, t = 1,2;$

2. $U^2\left(\hat{a}_2^1, \hat{a}_3^1, \hat{\beta}, \delta\right) \geq U^2\left(a_2, \hat{a}_3^1, \hat{\beta}, \delta\right), \forall a_2 \in A.$

By condition 1., $\hat{a}_3^1 = \hat{a}_3^2$ always holds. Therefore, dynamically consistent beliefs can simply be written as $\hat{\mathbf{s}}^c\left(\hat{\beta}, \delta\right) = \left(\hat{a}_2^c\left(\hat{\beta}, \delta\right), \hat{a}_3^c\left(\hat{\beta}, \delta\right)\right)$.

Definition 3.2 *Given β, $\hat{\beta}$, δ and dynamically consistent beliefs $\hat{\mathbf{s}}^c\left(\hat{\beta}, \delta\right)$,* $\mathbf{s}^{pp}\left(\beta, \hat{\beta}, \delta\right) \equiv \left(a_1^{pp}\left(\beta, \hat{\beta}, \delta\right), a_2^{pp}\left(\beta, \hat{\beta}, \delta\right), a_3^{pp}\left(\beta, \delta\right)\right)$ *is a **perception-perfect strategy** if a strategy profile $\mathbf{s}^{pp}\left(\beta, \hat{\beta}, \delta\right)$ satisfies the following two conditions:*

1. $U^3\left(a_3^{pp}\left(\beta, \delta\right), \beta, \delta\right) \geq U^3\left(a_3, \beta, \delta\right), \forall a_3 \in A;$
2. $U^t\left(a_t^{pp}\left(\beta, \hat{\beta}, \delta\right), \hat{\mathbf{s}}^c(\cdot), \beta, \delta\right) \geq U^t\left(a_t, \hat{\mathbf{s}}^c(\cdot), \beta, \delta\right), \forall a_t \in A, t = 1, 2.$

Proposition 3.1 *For all $\beta \in (0,1]$, $\hat{\beta} \in [\beta, 1]$ and $\delta \in (0,1)$, there exist a cutoff $\hat{\beta}^* \in (\beta, 1)$ such that $\frac{1-\delta}{1-\hat{\beta}^*\delta}\hat{\beta}^* = \frac{1-\delta^2}{1-\beta\delta^2}\beta$ and:*
For $\hat{\beta} \in \left[\beta, \hat{\beta}^*\right]$,

$$\left\{\mathbf{s}^{pp}\left(\beta, \hat{\beta}, \delta\right), \hat{\mathbf{s}}^c\left(\hat{\beta}, \delta\right)\right\} = \begin{cases} \{(D,D,D),(D,D)\} & \text{if} \quad c \leq \frac{1-\delta}{1-\beta\delta}\beta\delta v; \\ \{(W,W,D),(D,D)\} & \text{if} \quad c \in \left(\frac{1-\delta}{1-\beta\delta}\beta\delta v, \frac{1-\delta}{1-\hat{\beta}\delta}\hat{\beta}\delta v\right]; \\ \{(D,W,D),(W,D)\} & \text{if} \quad c \in \left(\frac{1-\delta}{1-\hat{\beta}\delta}\hat{\beta}\delta v, \frac{1-\delta^2}{1-\beta\delta^2}\beta\delta v\right]; \\ \{(W,W,D),(W,D)\} & \text{if} \quad c > \frac{1-\delta^2}{1-\beta\delta^2}\beta\delta v. \end{cases} \tag{2}$$

For $\hat{\beta} \in \left(\hat{\beta}^*, 1\right]$,

$$\left\{\mathbf{s}^{pp}\left(\beta, \hat{\beta}, \delta\right), \hat{\mathbf{s}}^c\left(\hat{\beta}, \delta\right)\right\} = \begin{cases} \{(D,D,D),(D,D)\} & \text{if} \quad c \leq \frac{1-\delta}{1-\beta\delta}\beta\delta v; \\ \{(W,W,D),(D,D)\} & \text{if} \quad c > \frac{1-\delta}{1-\beta\delta}\beta\delta v. \end{cases} \tag{3}$$

The immediate corollary of Proposition 3.1 is as follows:

Proposition 3.2 ***Corollary 3.1*** *For any beliefs $\hat{\beta}'$ and $\hat{\beta}$ with $\hat{\beta}' \geq \hat{\beta}$, $a_1^{pp}\left(\beta, \hat{\beta}', \delta\right) = D$ implies $a_1^{pp}\left(\beta, \hat{\beta}, \delta\right) = D$.*

4 Competition among Procrastinators

In this section, I introduce a competition between two agents to see if that can mitigate the procrastination. Each agent faces the same task as in Section 3 that requires to perform only once within three periods $t = 1, 2, 3$. However, their manager makes this task unavailable to an agent once the other agent completes it. When both agents are to undertake the task in the same period, each agent performs the identical task. Thus, this competition is innocuous to those who do not procrastinate because each agent is guaranteed the right to perform the task in period 1 regardless of what the other agent does.

Let β_i and $\hat{\beta}_i$ be agent i's present-bias parameter and belief thereof, respectively. Denote $\boldsymbol{\beta} = (\beta_1, \beta_2)$ and $\hat{\boldsymbol{\beta}} = (\hat{\beta}_1, \hat{\beta}_2)$. I assume that $\boldsymbol{\beta}$ and $\hat{\boldsymbol{\beta}}$ are the common knowledge among the agents, which is consistent with the following situations:

1. Agent i believes that his present-bias parameter will be $\hat{\beta}_i$.

2. Both agents think that agent i knows more than agent j does about the degree of present-bias agent i will face in the future.

3. Agent j knows that agent i believes that his present-bias parameter will be $\hat{\beta}_i$.

I also assume that both agents use the identical discount factor $\delta \in (0,1)$ and $c \leq \beta_i \delta v$, $i = 1, 2$.

To investigate the behaviors of multiple partially naive agents, I introduce a solution concept called *perception-perfect equilibrium (PPE)*, which is an extension of the perception-perfect strategies in Section 3. A perception-perfect equilibrium corresponds to a subgame-perfect equilibrium for the game "perceived" by agents. Before formally defining this concept, I introduce several notations similar to those in Section 3. Let $\boldsymbol{s}_i = (a_{i1}, a_{i2}, a_{i3})$ represent a strategy profile of agent i, where $a_{it} \in A$ is a strategy of agent i in period t. Similarly, let $\hat{\boldsymbol{s}}_i^1 \equiv (\hat{a}_{i2}^1, \hat{a}_{i3}^1)$ and $\hat{\boldsymbol{s}}_i^2 \equiv (\hat{a}_{i3}^2)$ be the beliefs about his future strategies held by self-1 and self-2 of agent i, respectively. Denote $\boldsymbol{s} = (\boldsymbol{s}_1, \boldsymbol{s}_2)$ and $\hat{\boldsymbol{s}}^t = (\hat{\boldsymbol{s}}_1^t, \hat{\boldsymbol{s}}_2^t)$, $t = 1, 2$. Let $U_i^t(a_{it,}, a_{jt,} \hat{\boldsymbol{s}}^t, \beta_i, \delta)$ be the agent i's total utility at period t upon choosing $a_{it} \in A$, conditional on that agent j chooses $a_{jt} \in A$ and agents i and j act consistently with the period-t beliefs $\hat{\boldsymbol{s}}^t$ in the future. That is, $U_i^t(a_{it,}, a_{jt,} \hat{\boldsymbol{s}}^t, \beta_i, \delta)$ satisfies the following:

$$
\begin{aligned}
&U_i^1(D, \cdot, \hat{\boldsymbol{s}}^1, \beta_i, \delta) = U_i^2(D, \cdot, \hat{\boldsymbol{s}}^2, \beta_i, \delta) = U_i^3(D, \beta_i, \delta) \equiv -c + \beta_i \delta v; \\
&U_i^1(W, W, \hat{\boldsymbol{s}}^1, \beta_i, \delta) \equiv \begin{cases} \beta_i \delta \{-c + \delta v\} & \text{if } \hat{\boldsymbol{s}}^1 = ((D, \cdot), (\cdot, \cdot)), \\ \beta_i \delta^2 \{-c + \delta v\} & \text{if } \hat{\boldsymbol{s}}^1 = ((W, D), (W, \cdot)), \\ 0 & \text{if } \hat{\boldsymbol{s}}^1 = ((W, \cdot), (D, \cdot)); \end{cases} \\
&U_i^2(W, W, \hat{\boldsymbol{s}}^2, \beta_i, \delta) \equiv \begin{cases} \beta_i \delta \{-c + \delta v\} & \text{if } \hat{\boldsymbol{s}}^2 = ((D), \cdot), \\ 0 & \text{if } \hat{\boldsymbol{s}}^2 = ((W), \cdot); \end{cases} \\
&U_i^1(W, D, \hat{\boldsymbol{s}}^1, \beta_i, \delta) = U_i^2(W, D, \hat{\boldsymbol{s}}^2, \beta_i, \delta) = U_i^3(W, \beta_i, \delta) \equiv 0.
\end{aligned}
$$

Definition 4.1 *Given $\hat{\boldsymbol{\beta}} = (\hat{\beta}_1, \hat{\beta}_2)$ and δ, a pair of beliefs $\{\hat{\boldsymbol{s}}^1, \hat{\boldsymbol{s}}^2\}$ are* ***dynamically consistent*** *if $\{\hat{\boldsymbol{s}}^1, \hat{\boldsymbol{s}}^2\}$ satisfies the following two conditions:*

1. $U_i^3(\hat{a}_{i3}^t, \hat{\beta}_i, \delta) \geq U_i^3(a_{i3}, \hat{\beta}_i, \delta)$, $a_{i3} \in \{D, W\}$, $t, i = 1, 2$

2. $U_i^2(\hat{a}_{i2}^1, \hat{a}_{i3}^1, \hat{\boldsymbol{s}}_2^1, \hat{\beta}_i, \delta) \geq U_i^2(a_{i2}, \hat{a}_{i3}^1, \hat{\boldsymbol{s}}_2^1, \hat{\beta}_i, \delta)$, $a_{i2} \in \{D, W\}$, $t, i = 1, 2$

Hereafter, I simply write dynamically consistent beliefs as $\hat{\boldsymbol{s}}^c(\hat{\boldsymbol{\beta}}, \delta) = \left\{\hat{a}_{i2}^c(\hat{\boldsymbol{\beta}}, \delta), \hat{a}_{i3}^c(\hat{\boldsymbol{\beta}}, \delta)\right\}_{i=1}^2$ since $\hat{a}_{i3}^1 = \hat{a}_{i3}^2$ always holds for $i = 1, 2$.

Definition 4.2 *Given* $\left(\boldsymbol{\beta}, \hat{\boldsymbol{\beta}}, \delta\right)$ *and dynamically consistent beliefs* $\hat{\mathbf{s}}^c\left(\hat{\boldsymbol{\beta}}, \delta\right)$*, a strategy profile* $\mathbf{s}^{PPE} = \left(\mathbf{s}_1^{PPE}, \mathbf{s}_2^{PPE}\right) = \left\{\left(a_{i1}^{PPE}, a_{i2}^{PPE} a_{i3}^{PPE}\right)\right\}_{i=1}^{2}$ *constitutes a* ***perception-perfect equilibrium*** *if the following two conditions are satisfied:*

$$\begin{aligned} &U_i^3\left(a_{i3}^{PPE}, \beta_i, \delta\right) \geq U_i^3\left(a_{i3}, \beta_i, \delta\right), \ \forall a_{i3} \in A, i = 1,2; \\ &U_i^t\left(a_{it}^{PPE}, a_{jt}^{PPE}, \hat{\mathbf{s}}^{t,c}\left(\hat{\boldsymbol{\beta}}, \delta\right), \beta_i, \delta\right) \geq U_i^t\left(a_{it}, a_{jt}^{PPE}, \hat{\mathbf{s}}^{t,c}\left(\hat{\boldsymbol{\beta}}, \delta\right), \beta_i, \delta\right), \\ &\qquad\qquad \forall a_{it} \in A,\ t = 1,2,\ i = 1,2,\ j = 1,2,\ i \neq j. \end{aligned}$$

Proposition 4.1 *For all* $\left(\boldsymbol{\beta}, \hat{\boldsymbol{\beta}}, \delta\right)$*, the perception-perfect equilibrium strategies* $\mathbf{s}^{PPE} = \left(\mathbf{s}_1^{PPE}, \mathbf{s}_2^{PPE}\right)$ *and dynamically consistent beliefs* $\hat{\mathbf{s}}^c\left(\hat{\boldsymbol{\beta}}, \delta\right) = \left(\hat{\mathbf{s}}_1^c\left(\hat{\boldsymbol{\beta}}, \delta\right), \hat{\mathbf{s}}_2^c\left(\hat{\boldsymbol{\beta}}, \delta\right)\right)$ *satisfy the following:*

(1) $$\left(\hat{\mathbf{s}}_1^c\left(\hat{\boldsymbol{\beta}}, \delta\right), \hat{\mathbf{s}}_2^c\left(\hat{\boldsymbol{\beta}}, \delta\right)\right) \in \begin{cases} \left\{\left(\left(D,D\right),\left(D,D\right)\right)\right\} & \text{if } c \leq \frac{1-\delta}{1-\hat{\beta}_{\max}\delta}\hat{\beta}_{\max}\delta v; \\ \left\{\left(\left(W,D\right),\left(W,D\right)\right), \left(\left(D,D\right),\left(D,D\right)\right)\right\} & \text{if } c > \frac{1-\delta}{1-\hat{\beta}_{\max}\delta}\hat{\beta}_{\max}\delta v. \end{cases}$$

(2) $a_{i3}^{PPE}\left(\beta_i, \delta\right) = D,\ i = 1,2.$

(3) $$\left(a_{12}^{PPE}\left(\boldsymbol{\beta}, \hat{\boldsymbol{\beta}}, \delta\right), a_{22}^{PPE}\left(\boldsymbol{\beta}, \hat{\boldsymbol{\beta}}, \delta\right)\right) \in \begin{cases} \left\{\left(D,D\right)\right\} & \text{if } c \leq \frac{1-\delta}{1-\beta_{\max}\delta}\beta_{\max}\delta v; \\ \left\{\left(D,D\right), \left(W,W\right)\right\} & \text{if } c > \frac{1-\delta}{1-\beta_{\max}\delta}\beta_{\max}\delta v. \end{cases}$$

(4) $$\left(a_{11}^{PPE}\left(\boldsymbol{\beta}, \hat{\boldsymbol{\beta}}, \delta\right), a_{21}^{PPE}\left(\boldsymbol{\beta}, \hat{\boldsymbol{\beta}}, \delta\right)\right) \in \begin{cases} \left\{\left(D,D\right)\right\} & \text{if } c \leq \frac{1-\delta}{1-\beta_{\max}\delta}\beta_{\max}\delta v; \\ \left\{\left(D,D\right)\right\} & \text{if } c \in \left(\frac{1-\delta}{1-\beta_{\max}\delta}\beta_{\max}\delta v, \frac{1-\delta^2}{1-\beta_1\delta^2}\beta_1\delta v\right] \\ & \text{and } \hat{\mathbf{s}}^c = \left(\left(W,D\right),\left(W,D\right)\right); \\ \left\{\left(D,D\right), \left(W,W\right)\right\} & \text{if } c \in \left(\frac{1-\delta}{1-\beta_{\max}\delta}\beta_{\max}\delta v, \frac{1-\delta^2}{1-\beta_{\max}\delta^2}\beta_{\max}\delta v\right] \\ & \text{and } \hat{\mathbf{s}}^c = \left(\left(D,D\right),\left(D,D\right)\right); \\ \left\{\left(D,D\right), \left(W,W\right)\right\} & \text{if } c > \frac{1-\delta^2}{1-\beta_{\max}\delta^2}\beta_{\max}\delta v, \end{cases}$$

where $\beta_{\max} \equiv \max\left\{\beta_1, \beta_2\right\}$ *and* $\hat{\beta}_{\max} \equiv \max\left\{\hat{\beta}_1, \hat{\beta}_2\right\}$.

5 Conclusion

Contrary to a common conjecture that competition mitigates procrastination problems, I show that the introduction of competition may delay the completion of their tasks. Moreover, the result holds even when there is only one worker is partially naive about his self-control problem. This result suggests that procrastination and the degree of naivete are important factors that determine organizational performance. Moreover, it suggests that paternalistic policies ought to be carefully designed and implemented.

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