

An Economic Model of the Planning Fallacy

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Introduction: The planning fallacy

The planning fallacy of Kahneman & Tversky (1979b)

- 1 Biased beliefs:**
People tend to underestimate the amount of time it will take them to complete a task
- 2 Distorted effort:**
People tend to smooth their work effort poorly over time, missing deadlines or doing most of the work at the end

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Introduction: Experimental evidence

Buehler, Griffin & Ross (1994) (Study 2)

Experimental evidence. . .

- Experimental procedure
 - 100+ undergraduate psych majors
 - two tasks they expect to complete in the next week
 - predict completion time and confidence in prediction
 - half told study about accuracy of prediction
- Findings

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Measure	Academic	Nonacademic
Predicted days	5.8	5.0
Actual days	10.7	9.2
Difference	-4.9	-4.2
Absolute difference	5.6	5.8
Subjects completed in predicted time (%)	37.1	42.5
<i>R</i> : Predicted and actual days	.36	.48

Reported 74/70 percent certain to finish on time

Introduction: Experimental evidence

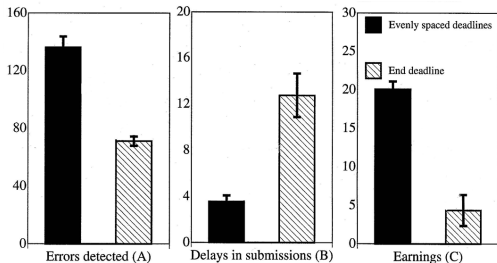
Ariely & Wertenbroch (2002) (Study 2)

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 - three proofreading exercises due at end of three weeks
 - subjects paid both for quality of work and finishing on time
 - random half assigned deadlines of one exercise/week
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People with deadline smoothed work better, detected more errors, and earned more – performed better!

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situational

- Qualitatively test theory using extant experimental findings
- Focus on beliefs as well as behavior

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Our theory: Two main elements

1 **Felicity at $t = 1$: $u(w_1) + \hat{E}_1[u(w_2)]$**

- ◇ People care about utility flow today and
- ◇ expected utility flows in the future (*anticipatory utility*)
- ⇒ **happier if believe little total work required**

2 **No split personality**

- ◇ Distorted beliefs distort actions: people are expected utility maximizers with subjective beliefs
- ⇒ **smooth work better over time if more rational**

⇒ **Trade-off: optimism about work vs poor temporal smoothing**

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Summary of results

- 1 **Optimal** to exhibit some Planning Fallacy
 - Endogenous optimism and overconfidence
 - Undue delay in task completion
- 2 With deadlines, optimal beliefs are **time inconsistent**
 - Prior to starting work, more realistic (understand future behavior)
 - Set intermediate deadline that will bind
 - Start work, meet intermediate deadline, optimistic about future work
- 3 **Test** with evidence from extant experiments by psychologists:
 - Predictions biased but *correlated* w/ actual completion time
 - Reasonably robust to framing, absent if task not unpleasant (in-lab)
 - Misplanning increases with incentives for *speed* of completion and decreases with incentives for *accuracy* of prediction
 - people optimally *self-impose* binding deadlines that *improve performance*, but not as strict as complete smoothing

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Related literatures

- 1 Psychological literature
 - Kahneman & Tversky (1982): distrib. information ignored
 - Trope & Liberman (2003): construal level theory
 - Incorrect memory (and unawareness)
 - General optimism: e.g. Armor & Taylor (1998)
- 2 Economic models of belief biases: “Optimal Expectations”
- 3 Economic models of procrastination
 - Strotz, Laibson, Gul & Pesendorfer, Benabou & Tirole, O’Donoghue & Rabin, etc.

Outline

- 1 Introduction
- 2 Related Literature
- 3 Model setup
- 4 The planning fallacy
 - Experimental evidence
- 5 Intermediate deadlines
 - Experimental evidence
- 6 Conclusion

The environment given beliefs

- Two periods $t = 1, 2$
- Total work to be done: $\eta_1 + \eta_2 \leq w_1 + w_2$
- η_t realized in t ; η_1 and $\frac{\eta_2}{\eta_1}$ i.i.d.; $E[\eta_2|\eta_1] = \eta_1$, $\text{Var}[\eta_t] = \sigma_t^2 > 0$
- Intermediate deadline: $w_1 \geq \phi\eta_1$
- Person believes $\hat{E}[\]$ before observing η_1 and $\hat{E}_1[\]$ after
- Do not require $\hat{E}[\] = E[\]$ or $\hat{E}[\eta_2|\eta_1] = \hat{E}_1[\eta_2|\eta_1]$

Model setup: felicity

Person's objective

Immediately prior to period 1: choose deadline, ϕ

While working in period 1: choose work w_1

While working in period 2: choose work w_2

To maximize felicity:	$t = 1$	$t = 2$
Felicity prior to period 1, $\hat{E}[V_1]$	$\hat{E}[u(w_1) +$	$u(w_2)]$
Felicity in period 1, $\hat{E}_1[V_1]$	$u(w_1)$	$\hat{E}_1[u(w_2)]$
Felicity in period 2, V_2	$\delta u(w_1)$	$u(w_2)$

where $u(w) = -\frac{1}{2}w^2$ and subject to meeting any deadline and completing the task at the end of period 2

Model setup: Behavior given beliefs

Work given beliefs

Lemma: Given $\phi = 0$, people smooth work:

$$w_1^* = \frac{1}{2} \left(\eta_1 + \hat{E}_1[\eta_2|\eta_1] \right)$$

$$w_2^* = \frac{1}{2} \left(\eta_1 + \hat{E}_1[\eta_2|\eta_1] \right) + \left(\eta_2 - \hat{E}_1[\eta_2|\eta_1] \right)$$

So a person with rational beliefs chooses

$$w_1^{RE} = \frac{1}{2} \left(\eta_1 + E[\eta_2|\eta_1] \right)$$

$$w_2^{RE} = \frac{1}{2} \left(\eta_1 + E[\eta_2|\eta_1] \right) + \left(\eta_2 - E[\eta_2|\eta_1] \right)$$

If $w_1^* < \phi\eta_1$ then $w_1^* = \phi\eta_1$

Deadline given beliefs

- Immediately prior to starting work, person understands his future behavior
- If he thinks he will do enough work in period 1, he sets a non-binding deadline
- If he thinks he will do 'too little' work in period 1, if $\hat{E}[\eta_2|\eta_1] > \hat{E}_1[\eta_2|\eta_1]$ then he sets a binding deadline

Model setup: Well-being

Average/expected felicity across periods

Well-being: $\mathcal{W} = \frac{1}{2}E \left[\hat{E}_1[V_1|\eta_1] + \hat{E}_2[V_2|\eta_1, \eta_2] \right] = \frac{1}{2}E[\hat{E}_1[V_1] + V_2]$

- Well-being with $\delta = 1$ is 'preference consistent':

$$\begin{aligned}\mathcal{W} &= \frac{1}{2}E \left[u(w_1) + \hat{E}_1[u(w_2)|\eta_1] + u(w_1) + E[u(w_2)|\eta_1] \right] \\ &= E[V_1] = E[V_2] \text{ if } \hat{E}_1 = E\end{aligned}$$

- Well-being with $\delta = 0$:

$$\mathcal{W} = \frac{1}{2}E \left[u(w_1) + \hat{E}_1[u(w_2)|\eta_1] + E[u(w_2)|\eta_1] \right]$$

Model setup: Optimal beliefs

Optimal beliefs are the set of probability distributions defined on the support of the objective distributions that maximize well-being

$$\mathcal{W} := \frac{1}{2} E \left[\hat{E}_1 [V_1] + V_2 \right]$$

given that actions are optimally chosen given beliefs subject to resource constraints.

The planning fallacy without deadines

The benefits of a little planning fallacy

Set η_1 to be nonstochastic

Proposition 2: A small degree of optimism increases a person's well-being and decreases work in the first period:

$$\frac{d\mathcal{W}}{d\hat{E}_1[\eta_2]} \Big|_{\hat{E}_1[\eta_2]=E_1[\eta_2]} < 0$$

$$\frac{dw_1^*}{d\hat{E}_1[\eta_2]} \Big|_{\hat{E}_1[\eta_2]=E_1[\eta_2]} > 0$$

The planning fallacy without deadines

Proposition 3: The planning fallacy is optimal. The agent with optimal beliefs exhibits the planning fallacy:

- $\hat{E}_1^{**} [\eta_2] = \frac{1-\delta}{3+\delta} \eta_1 < E_1 [\eta_2]$
- $w_1^{**} = \frac{2}{3+\delta} \eta_1 < w^{RE}$

Consistent with Kahneman and Tversky (1979b):

*The context of planning provides many examples in which the distribution of outcomes in past experience is ignored. Scientists and writers, for example, are notoriously **prone to underestimate the time required to complete a project**, even when they have considerable experience of past failures to live up to planned schedules.*

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Proposition 4: Overconfidence

- 1 A small decrease in the perceived uncertainty about future work increases a person's well-being: $\frac{dW}{d\hat{Var}_1[\eta_2]} \Big|_{\hat{Var}_1[\eta_2]=Var_1[\eta_2]} < 0$;
- 2 A person's well-being is maximized by the belief that he knows what work level will be required: $\hat{Var}_1^{**}[\eta_2] = 0 < Var_1[\eta_2]$

Consistent with Kahneman and Tversky (1979b):

The planning fallacy is a consequence of the tendency to neglect distributional data and to adopt what may be termed an internal approach to prediction, in which one focuses on the constituents of the specific problem rather than on the distributional outcomes in similar cases.

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Comparative statics

Proposition: The planning fallacy becomes worse:

- the more the agent cares about the past (the higher δ), because memory of little work lasts
- the lower the elasticity of intertemporal substitution (the larger the linear term in quadratic utility), because poor smoothing is less costly
- the less impatient the agent, because lower impatience lowers importance of anticipatory utility

Experimental evidence I

Biased forecasts are informative

Proposition 6: Predicted completion times are correlated with actual completion times across experiments and people

Example: Buehler, Griffin & Ross (1994)

- *Study 1:* when complete undergraduate thesis;
Correlation of predicted and actual days: 0.77
- *Study 2:* as in slide 4, primed with studying accuracy;
Correlation: 0.77 (academic) 0.45 (nonacademic)
- *Study 3:* school project expected done in 2 weeks, add think-aloud procedure; correlation: 0.81
- *Study 4:* computer assignment, recall past experiences and describe scenario for completion - -no bias and correlation 0.75!

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Framing often fails to eliminate misplanning

The following fail to eliminate:

- repeated tasks vs. new tasks (many)
- list relevant past experiences (Hinds 99)(asks for completion time)
- decomposing the task (Byram 97(1))
- list possible surprises (Byram 97(1), Hinds 99)
- anchoring/adjustment/multiple scenarios (Byram 97(1,2), Newby-Clark et al. 00, BGR 94, but Connolly-Dean 97)
- no cultural effect (Japan, Canada vs. US) (BG 04)

The following do eliminate:

- list past experiences and ask how long to complete if typical of past and describe plausible scenario for completion (Buhler et al. 94(5))
- form concrete and detailed plans for completion (by reducing actual time) (Koole-Spijker 00)

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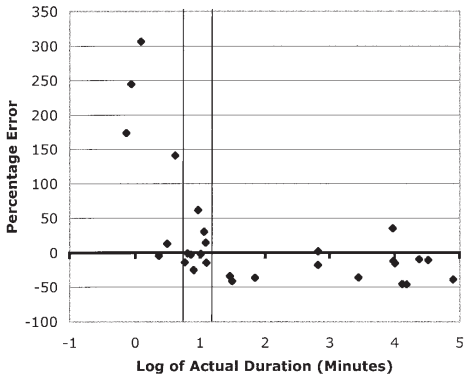
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Laboratory experiments vs. real-world experiments

Percentage Error as a Function of Task Duration



source: Roy, Christenfeld & McKenzie (2005)

Laboratory experiments vs. real-world experiments

Why be optimistic about finishing quickly if have to sit in lab? E.g. experiments about anagrams, origami, etc.

Byram (1997): short lab experiment with unpleasant task and can leave when done

- Build computer stand, each subject tested individually
- Average predicted time: 48.2 minutes
- Average actual time: 76.1 minutes

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Incentives for speed: Model

Setup:

$$\begin{aligned}\hat{E}_1[V_1] &= u(w_1) + \hat{E}_1[u(w_2) + P - cw_2] \\ V_2 &= \delta u(w_1) + u(w_2) + P - cw_2\end{aligned}$$

Behavior given beliefs: $w_1^* = (1/2)(\eta_1 + \hat{E}_1[\eta_2] + c)$

Proposition 7: Incentives for speed increase the planning fallacy:

$$\frac{d\hat{E}_1^{**}[\eta_2]}{dc} \leq 0 \text{ and } \frac{dw_1^{RE}}{dc} \geq \frac{dw_1^{**}}{dc} > 0$$

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Incentives for speed: Evidence part 1

Byram (1997) (Experiment 5)

- Experimental procedure
 - look at folding instructions for origami
 - make median time prediction then fold origami
 - random half of sample given \$4 for as fast as top 25% of comparison group; \$2 for top 50%; \$1 for top 75%
 - control group given \$3
- Findings

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Experiment 5: Predicted and Actual Times by Condition (in Minutes)

Condition	Prediction	Actual
No incentives ($n = 34$)		
<i>M</i>	10.1	9.8
<i>Mdn</i>	7.8	8.8
<i>SE</i>	1.1	0.9
Incentives ($n = 32$)		
<i>M</i>	6.7	9.8
<i>Mdn</i>	5.0	7.8
<i>SE</i>	0.7	1.2
Overall average		
<i>M</i>	8.5	9.8
<i>Mdn</i>	6.5	8.3
<i>SE</i>	0.7	0.7

Incentives for speed: Evidence part 2 *Buehler, Griffin & MacDonald (1997)* (Study 1)

- Experimental procedure: filing of taxes
 - tax refund: overoptimistic when to file
 - tax liability: insignificantly overoptimistic

Experimental evidence I

Incentives for accurate prediction: Model

Setup:

$$\begin{aligned}\hat{E}_1[V_1] &= u(w_1) + \hat{E}_1[u(w_2) - c(\hat{\mu} - \eta)^2] \\ V_2 &= \delta u(w_1) + u(w_2) - c(\hat{\mu} - \eta)^2\end{aligned}$$

Proposition 8: Incentives for accuracy of prediction decrease the planning fallacy

$$\frac{d\hat{E}_1^{**}[\eta_2]}{dc} \geq 0, \text{ and } \frac{dw_1^{**}}{dc} \geq \frac{dw_1^{RE}}{dc} = 0$$

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 - 60 undergraduates given practice anagram puzzles
 - Then two trials, puzzles typically took 5 to 7 minutes
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 - Expected completion in 4.1 min without accuracy incentive
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Model summary

General model with deadlines: Recall: η_1 stochastic, $E[\eta_1|\eta_2] = \eta_1$

- Period 2: complete work
- Period 1: choose w_1 to maximize $\hat{E}_1[V_1]$ subject to $w_1 \geq \phi\eta_1$ given understanding of $w_2^{**}(\eta_2|\eta_1)$
- Prior to starting work:
 - choose ϕ to max $\hat{E}_0[V_1]$ given understanding of $w_1^{**}(\eta_1)$ and $w_2^{**}(\eta_2|\eta_1)$ or
 - outside observer sets ϕ to maximize expected 'performance' defined as better smoothing, $-\frac{1}{2}E[w_1^2 + w_2^2]$
- Beliefs maximize well-being

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Intermediate deadlines

Proposition 5: Self-imposed and externally-imposed deadlines

- 1 With no deadline ($\phi = 0$), the person is optimistic, is overconfident, and postpones work in period 1
- 2 With a self-imposed deadline, the person initially believes $\frac{\hat{E}^{**}[\hat{E}^{**}[\eta_2|\eta_1]\eta_1]}{\hat{E}^{**}[\eta_1\eta_1]} = \frac{3-\delta}{3+\delta}$, imposes a binding deadline, and is more optimistic and postpones less work in period 1 than in case (i)
- 3 With an externally-imposed deadline, the deadline is stricter than in case (ii), the person is equally optimistic in period 1, but he does not postpone work
- 4 Self-imposed deadlines improve task performance, but do not maximize task performance unless $\delta = 0$

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- 3 With an externally-imposed deadline, the deadline is stricter than in case (ii), the person is equally optimistic in period 1, but he does not postpone work
- 4 Self-imposed deadlines improve task performance, but do not maximize task performance unless $\delta = 0$

Intermediate deadlines

Proposition 5: Self-imposed and externally-imposed deadlines

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Intermediate deadlines

Proposition 5:

		<i>subjective beliefs</i>				<i>objective beliefs</i>	
		<i>(i) no deadline</i>	<i>(ii) self imposed</i>	<i>(iii) externally imposed</i>	<i>self imposed</i>		
<i>deadline</i>	ϕ	0	<	$\frac{3}{3+\delta}$	\leq	1	$[0, 1]$
<i>period 1 beliefs</i>	$\hat{E}_1^{**}[\eta_2 \eta_1]$	$\frac{1-\delta}{3+\delta}\eta_1$	>	0	=	0	η_1
	$\hat{Var}_1^{**}[\eta_2 \eta_1]$	0	=	0	=	0	$Var_1[\eta_2]$
<i>work</i>	w_1^{**}	$\frac{2}{3+\delta}\eta_1$	<	$\frac{3}{3+\delta}\eta_1$	\leq	η_1	η_1

Intermediate deadlines: Models of procrastination

- 1 Sophisticated hyperbolic discounting or Gul-Pesendorfer
 - Delay due to preferences
 - Reduces wellbeing
 - Self-control problem is situational
 - Commitment device eliminates procrastination
 - Person makes correct predictions
- 2 Naive hyperbolic discounting
 - Delay due to preference inconsistency and belief biases
 - Reduces wellbeing
 - Self-control problem not situational (misunderstood completely)
 - Commitment device eliminates procrastination
 - Person makes exogenous incorrect predictions
- 3 In our model:
 - Delay due to arbitrarily small temporal belief inconsistency
 - Increases wellbeing
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Experimental evidence II

Ariely & Wertenbroch (2002)

- 3 term papers (study 1) or 3 proofreading exercises (study 2) over three weeks
- All 3 due by end, but for 1 and 2, people (or class) randomly assigned to:
 - equally-spaced deadlines
 - self-imposed deadlines
 - no deadline (proofreading only)
- Graded assignments or paid for proofreading quality and penalized for missing deadlines
- Interpret model as two projects, with work η_1 and η_2 , and $E[\eta_2|\eta_1] = \eta_1$, ϕ is fraction of total project halfway instead of when complete given fraction

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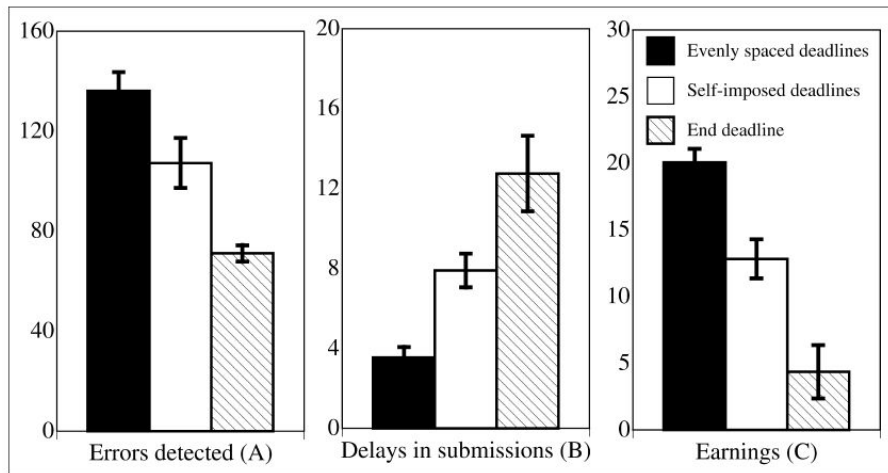


Fig. 2. Mean errors detected (a), delays in submissions (b), and earnings (c) in Study 2, compared across the three conditions (error bars are based on standard errors). Delays are measured in days, earnings in dollars.

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- People on average choose binding deadline
- Chosen deadlines less than equally-spaced, $\phi^{**} < 1$
- Self-imposed deadlines improved performance
- Equally-spaced deadlines improved performance more

Also: Grove & Wasserman (2006)

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Conclusion

- **Optimal** to exhibit some Planning Fallacy
 - Optimism and Overconfidence
 - Self-impose deadlines from belief inconsistency
- Planning fallacy in model is **situational** as in reality:
 - Predictions biased but *correlated* w/ actual completion time
 - Increases with incentives for *speed* of completion.
 - Decreases with incentives for *accuracy* of prediction.
- Matches experimental evidence on **deadlines**:
 - people optimally *self-impose* binding deadline
 - self-imposed deadlines *improve performance*
 - externally-imposed deadlines increase performance more