A Structural Analysis of Disappointment Aversion in a Real Effort Competition

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Warwick, April 2010

Introduction

- Are agents disappointment averse when they compete?
  - Are they loss averse around choice-acclimating expectations-based reference points?
  - How strong is disappointment aversion on average?
  - How does disappointment aversion vary across agents?
- Use theory to derive testable predictions arising from disappointment aversion
- Design novel computerized real effort task
- Provide evidence from laboratory experiment that agents are significantly disappointment averse in a sequential-move real effort tournament
  - Reduced form analysis
  - Structural estimation using Method of Simulated Moments

Outline of Talk

1. Theory: Sequential tournament
2. Related literature
3. Description of the real effort task
4. Experimental design
5. Econometric results
6. Theory: Simultaneous tournament
7. Conclusion

Sequential Tournament

- Two agents compete for prize of monetary value v
- Sequentially choose effort e_i
- Winning probabilities linear functions of difference in efforts
  - $P_i = \frac{e_i - e_j + \gamma}{2\gamma}$
- Second Mover observes First Mover's effort e_1 before choosing her own effort e_2
- Analyze only Second Movers

No Disappointment Aversion

- Suppose U_2 separable into utility from money and cost of effort
- $U_2 = u_2(y_2) - C_2(e_2)$
- $EU_2 = \left(\frac{e_2 - e_1 + \gamma}{2\gamma}\right)[u_2(v) - u_2(0)] + u_2(0) - C_2(e_2)$
- **RESULT 1:** e_2^* ***does not depend on*** e_1
- Specification nests loss aversion around fixed reference points
- ... even if reference point given by a prior expectation
- Also nests inequity aversion over monetary payoffs

Disappointment Aversion

- Endogenous reference point given by expected monetary payoff
  - $r_2 = vP_2(e_1, e_2)$
  - Reference point adjusts to e_1 and e_2
  - Choice-acclimating
  - Second Mover anticipates impact of effort on her reference point

- Disappointment aversion modeled as loss aversion around this endogenous reference point
  - If win, $U_2 = v + g_2.(v - r_2) - C_2(e_2)$
  - If lose, $U_2 = 0 + l_2.(0 - r_2) - C_2(e_2)$
  - Strength of disappointment aversion measured by $\lambda_2 \equiv l_2 - g_2 > 0$

- **RESULT 2: e_2^* is always weakly decreasing in e_1**

- Discouragement effect
- The negative reaction becomes stronger when the prize is higher

Why Discouragement?

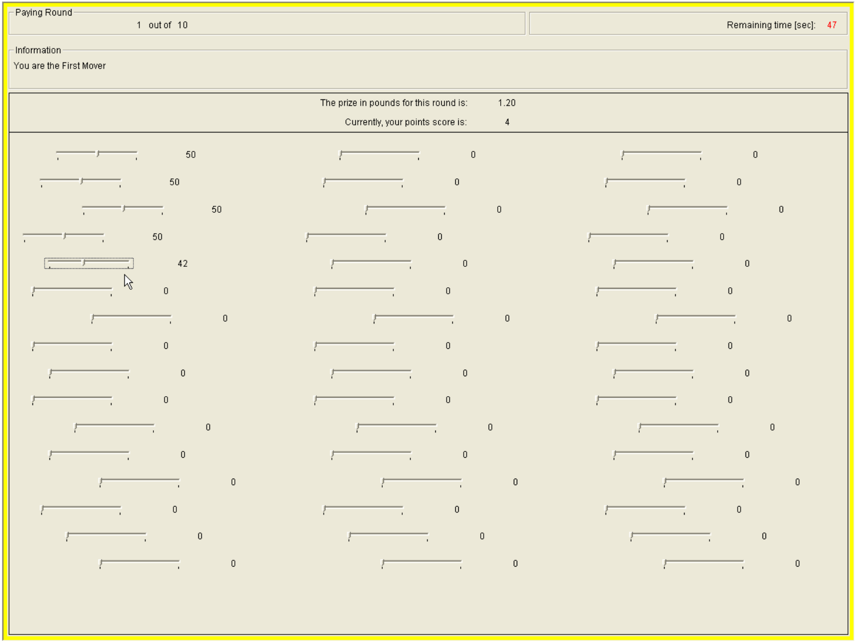
- $EU_2 = vP_2 - \lambda_2 vP_2(1 - P_2) - C_2(e_2)$
- Disappointment averse Second Mover dislikes variance in her monetary payoff
  - As losses relative to expected payoff loom larger than gains
  - With risk aversion alone, variance not relevant
- Variance is concave in P_2, and hence in e_2
  - And maximized when $P_2 = \frac{1}{2}$
- If e_1 goes up, P_2 goes down for given e_2
- So Second Mover has lower marginal incentive to exert effort
  - As variance increases faster in e_2 (to the left of $P_2 = \frac{1}{2}$)
  - Or falls less fast in e_2 (to the right of $P_2 = \frac{1}{2}$)

Related Literature

- Loss aversion with fixed reference point
  - Kahneman & Tversky (79)
- Theory with endogenous reference points
  - Bell (85)
  - Loomes & Sugden (86)
  - Koszegi & Rabin (07)
  - Gill & Stone (forthcoming)
- Empirical tests of endogenous reference points
  - Loomes & Sugden (87)
  - Abeler et al. (forthcoming)
- Response to feedback in tournaments
  - Berger & Pope (09)

The Novel Real Effort Task

- Description
  - Subject has 2 mns to move as many sliders as wants to exactly 50
  - Screen displays 48 sliders
  - Each slider starts at 0 and can be moved as far as 100
- Advantages
  - Identical across repetitions
  - Finely gradated measure of performance within short time scale
- Thus we can use repeated observations to
  - Control for persistent unobserved heterogeneity
  - Estimate distribution of costs and preferences across agents


Paying Round
1 out of 10
Remaining time [sec]: 47
Information
You are the First Mover
The prize in pounds for this round is: 1.20
Currently, your points score is: 4
50 0 0
50 0 0
50 0 0
50 0 0
42 0 0
0 0 0
0 0 0
0 0 0
0 0 0
0 0 0
0 0 0
0 0 0
0 0 0
0 0 0
0 0 0
0 0 0

Experimental Design

- 120 subjects
- 10 paying rounds
- Prize for each pair in each round random from £0.10 to £3.90
- “No contagion” rematching rule
- Remain a First Mover or Second Mover throughout
- Second Mover sees First Mover’s score before starting task
- Linear probability of winning function with $\gamma = 50$
  - Chance of winning up by 1 percentage point for every increase of 1 in the difference between points scores
- Summary screen at end of each round
  - See both points scores, probability of winning and who won

Reduced Form Analysis

	Preferred Sample 59 Second Movers		Full Sample 60 Second Movers	
	Coefficient	z value (p value)	Coefficient	z value (p value)
First Mover effort	0.044	0.898 (0.369)	0.047	0.963 (0.336)
Prize	1.639***	2.724 (0.006)	1.655***	2.794 (0.005)
Prize×First Mover effort	−0.049**	−2.083 (0.037)	−0.050**	−2.179 (0.029)
Intercept	19.777***	14.126 (0.000)	19.392***	13.400 (0.000)

- Use a linear random effects panel data regression
- First Mover effort interacted with prize has significant negative effect on Second Mover effort at 5% level
- Effect of e_1 on e_2 significant at 1% level for $v > £2.70$
- For highest prize, 40 slider increase in First Mover effort reduces Second Mover effort by 6 sliders

Structural Analysis

- Use structural analysis to estimate directly the distribution of λ_2 and the cost of effort function C_2
  - λ_2 allowed to vary across subjects
  - Specification of C_2 allows learning and persistent unobserved cost heterogeneity
- Method of Simulated Moments
  - Choose parameters to match various moments observed in the experimental data to the same moments in a number of simulated data sets
  - Can accommodate various sources of unobservables
  - We estimate 17 parameters based on 38 moments (means, variances, covariances)

Structural Model

- Behavioral preferences $\lambda_{2,n}$
  - $\lambda_{2,n} \sim N(\widetilde{\lambda}_2, \sigma_\lambda^2)$
  - $\lambda_{2,n}$ varies across subjects but is constant over time for a given subject
- Cost function
  - $C_{2,n,r}(e_{2,n,r}) = be_{2,n,r} + \frac{1}{2}c_{n,r}e_{2,n,r}^2$
  - $c_{n,r} = \kappa + \delta_r + \mu_n + \pi_{n,r}$
  - δ_r is a set of time dummies - capture learning
  - $\mu_n \sim W(\phi_\mu, \varphi_\mu)$ is Weibull distributed unobserved subject specific heterogeneity
  - $\pi_{n,r} \sim W(\phi_\pi, \varphi_\pi)$ is a Weibull distributed subject and time specific shock
  - All unobservables independent over subjects, $\pi_{n,r}$ independent over time

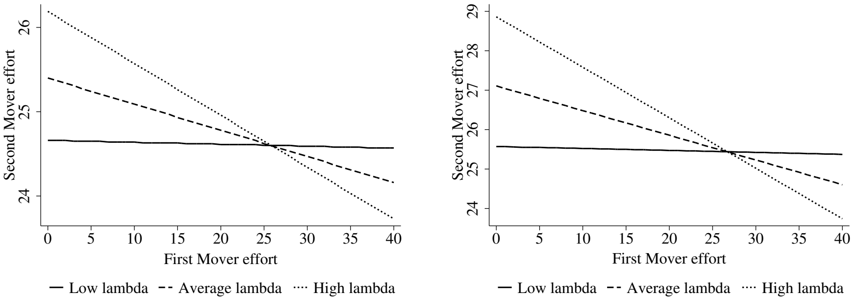
Results

- Estimate of average λ_2 significantly different from zero (at 1% level) for all specifications
  - $\widetilde{\lambda}_2 = 1.73$ in preferred specification
- Estimate of variance σ_λ^2 also significantly different from zero
  - $\lambda_{2,n} > 3.3$ for 20% of individuals
  - $\lambda_{2,n} < 0.2$ for 20% of individuals
- Significant learning effects
- Significant transitory and permanent variation in Second Movers' cost of effort
  - Persistent differences more important than transitory differences

[!h]

	Preferred Specification		Non-Quadratic Cost of Effort	
	Estimate	SE	Estimate	SE
$\widetilde{\lambda}_2$	1.729***	0.532	1.758***	0.640
σ_λ	1.823***	0.556	1.868***	0.634
b	-0.538***	0.036	-0.407***	0.018
κ	1.946***	0.103	2.063***	0.135
σ_μ	0.516***	0.062	0.902***	0.151
σ_π	0.346***	0.127	0.716***	0.204
α	-	-	-	-
ψ	-	-	2.534***	0.128
de_2/de_1(v=£0.10, low $\lambda_{2,n}$)	-0.000	0.001	-0.000	0.001
de_2/de_1(v=£2, average $\lambda_{2,n}$)	-0.030***	0.011	-0.028**	0.013
de_2/de_1(v=£3.90, high $\lambda_{2,n}$)	-0.127***	0.026	-0.107***	0.034
OI test	25.555 [0.224]		13.435 [0.858]	
	Own-Choice-Acclimating Reference Point ($g_2 = 0$)		Own-Choice-Acclimat Reference Point ($g_2 =$	
	Estimate	SE	Estimate	SE
$\widetilde{\lambda}_2$	2.070***	0.426	1.909***	0.664
σ_λ	1.476**	0.643	1.201**	0.534

Reaction Functions



(a) Prize = £2 (b) Prize = £3.90

- Low λ_2 - 20th percentile
- High λ_2 - 80th percentile
- Negative slopes significant at 1% level for average and high λ_2

Own-Choice-Acclimatization

- Discouragement effect also consistent with reference point which
  - Adjusts to rival's effort (e_1)
  - But **not** to own effort (e_2)
- Suppose that
  - $r_2 = \alpha v P_2(e_1, e_2) + (1-\alpha) v P_2(e_1, \bar{e}_2)$
  - where $\bar{e}_2$ is fixed
  - e.g., a prior expectation of own effort
- Estimating structural model with more general reference point
  - $\alpha \simeq 1$
  - $\widetilde{\lambda}_2$ estimate does not move much
  - The different reference points have different implications for how the slope of the reaction function responds to the prize

Simultaneous Effort Choices: Model

- What if agents choose effort levels simultaneously?
  - “Fairness and desert in tournaments”
  - Forthcoming in GEB, with Rebecca Stone

- $P_i(e_i, e_j) = Q(e_i - e_j + k)$
- $k \geq 0$ represents agent i’s ‘advantage’
- $C_i(e_i) = C_j(e_j)$ and $\lambda_i = \lambda_j = \lambda$
- Restrict attention to pure strategies

- Interpret endogenous reference points as arising from meritocratic notion of desert
  - Deserve more the harder I’ve worked relative to rival

Simultaneous Effort Choices: Results

- 1. In standard model ($\lambda = 0$), unique and symmetric NE
  - Even when $k > 0$ so one agent is advantaged
- 2. When $\lambda > 0$ but small and $k = 0$ the equilibrium is unchanged
- 3. When $\lambda > 0$ but not too small and $k = 0$
  - Symmetric equilibrium disappears
  - Asymmetric equilibria exist in which one agent works hard and the other slacks off completely
- 4. When $\lambda > 0$ and $k > 0$, advantaged agent tends to work harder
  - Matches experimental findings
- Apply our findings to employer's choice of relative performance incentive scheme

Conclusions

- Evidence that agents are significantly disappointment averse
  - and that disappointment aversion varies significantly across agents
- More evidence for loss aversion
  - But around an endogenous reference point
  - Rather than the status quo
  - Or some expectation fixed ex ante
- Address two important questions in literature on reference-dependent preferences
- 1. What constitutes agents' reference points (when they compete)?
  - Endogenous expectations
- 2. How quickly do these reference points adjust?
  - Reference points are instantaneously choice-acclimating