The Effects of Prize Structures on Innovative Performance

AEA & CSWEP

Josh Graff Zivin, UC San Diego & NBER

Elizabeth Lyons, UC San Diego

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Innovation in Practice

Knowledge creation is fundamental for firm success and economic growth

- Aghion and Howitt (1992); Romer (1990)

Generating novel creative output is not straightforward

- Difficult for firms to be successful innovators of novel products/services
  - Azoulay et al. (2019); Krieger et al. (2018); Nanda and Rhodes-Kropf (2016)
- Theoretically optimal incentive contracts depend on innovator preferences, cost of effort, institutional environment
  - Charness and Grieco (2019); Moldovanu et al. (2012); Scotchmer (2004); Wright (1983)

Innovation in Practice: Contests

Innovation contests with financial prizes have been used extensively by firms and governments

- X-Prize, DevPost
- See Fu et al. (2012) and MacCormack et al. (2013) for more examples

Evidence that they can act as strong incentive for innovation

- Brunt et al. (2012); Kremer and Williams (2010); Moser and Nicholas (2013)

How best to structure innovation prizes in practice is an empirical question

- Williams (2012)

Innovation Contests: Empirical Evidence

Studies of how economically important historical contests offered by governments, monarchs affected subsequent innovative output

- Contests increased innovative activity (Moser and Nicholas, 2013; Brunt et al., 2012)

Experimental studies of modern innovation contests analyze how size and composition of competitor pool impacts effort and outcomes on relatively well defined tasks

- Increased competition reduces effort, increases the likelihood of very novel solutions (Boudreau et al., 2011; Gross, 2016)

In this Paper: Innovation Contest Prize Structure

Does innovation contest prize structure affect innovative performance?

- Compare two commonly used prize structures:
  - Winner-takes-all
  - Prizes for top ten performers, declining in amount

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  - Standard deviation of expected returns vary

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- Hold expected financial return to participation constant
  - Same number of participants per arm
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  - Standard deviation of expected returns vary
- Causal evidence from important field setting
  - Contest hosted by large biotech firm, high profile judges
  - Large amount of money available for complete product
  - Randomized prize structure assignment

In this Paper: Innovation Contest Prize Structure

Winner-takes-all and Top10 prize structures differ in risk of participation

- WTA has higher standard deviation of expected returns, encourages more risk taking
- Higher risk of effort may also deter participation

Thus, we expect

- More novel innovations submitted to the WTA arm
- Fewer submissions made to the WTA arm
- Theoretically ambiguous how other performance dimensions will be impacted

Research Setting: Innovation Contest

Innovation contest run with Thermo Fisher Scientific's R&D office in Baja California, Mexico

- Part of their effort to grow the STEM labor force in the region
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Promoted by TF within company, industry newsletters, college campuses, email blasts for 45 days

- Total prize money per arm (15K USD), general innovation problem topic, contest dates, sign-up instructions, judge panel, UCSD research disclosure

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Problem, evaluation criteria, and prize structure revealed at contest start

- **Problem:** *Mexico has many small health care providers and research and clinical laboratories that, on their own, cannot afford expensive equipment that would allow them to provide the highest quality care possible. We believe that the proliferation of digital and cloud technologies can help to solve this problem. We are asking you to show us how you think these technologies can be used to support access to high-quality medical equipment even for these small health care providers and labs.*

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- 54 hours between problem reveal and contest deadline

Research Setting: Innovation Contest

Designed to be as consistent with similar innovation contests as possible

- High profile judges
- Associated with organizations known for being innovative (TF and UCSD)
- Submissions through world's largest Hackathon host platform
- Advertised through most common industry list serves, newsletters
- Allow for self-selection into teams/individual (Chen and Gong, 2018)

Importantly, all of these factors are the same for all participants

Research Setting: Experiment Design

Randomize those who sign-up by deadline into two prize structures, stratified by teams/individuals:

- **WTA:** \$15K to best project within contest arm
- **TOP10:** \$15K divided among top 10 within contest arm
  - \$6K, \$3K, \$1.5K, \$900, and \$600 each to places 5-10

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Informed participants of both structures, randomization

- Could not credibly ban communication among participants
- Framed as a positive - now competing with half the pool for the same amount of money
- No evidence of displeasure/anger over prize structure assignment

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Submissions pooled across arms, randomly assigned to 3 judges

- 6 judges total from TF, Teradata, CS Professors

Data: Innovative Performance

Output Quantity: Whether or not participant submitted project for consideration by judges

Output Quality:

- Overall Ranking: Average of judge rankings across five categories
  - Functionality, user friendliness, scope of use cases, degree to which it addresses innovation challenge, novelty relative to existing products in market
- Novelty Ranking: Average of judge rankings on novelty relative to existing products in market

Heterogeneous Treatment Effects:

Teams vs Individuals

Data: Participant Characteristics

	TOP10	**WTA**	p-value of diff
Student	0.412	0.500	0.298
	(0.059)	(0.060)	
Employed	0.444	0.366	0.347
	(0.059)	(0.058)	
Female Participant/	0.212	0.242	0.681
Group Member	(0.051)	(0.053)	
Age Range	1.846	1.773	0.607
	(0.109)	(0.091)	
Highest Level of Education	3.697	3.694	0.989
	(0.107)	(0.138)	
Signed Up as Team	0.288	0.303	0.850
	(0.056)	(0.057)	
Any Prior Contest Experience	0.378	0.333	0.589
	(0.060)	(0.058)	
Number of Unique Areas of	3.000	2.848	0.672
Relevant Expertise	(0.259)	(0.245)	
Risk Preferences	2.886	2.851	0.875
(Average within Teams)	(0.153)	(0.165)	
Observations	66	66	

Main Results: Outcomes by Prize Structure

Panel A: Mean Comparisons

	TOP10	WTA	p-value of diff
Submitted a Project	0.303	0.333	0.711
	(0.057)	(0.058)	
Overall Rank	2.428	2.7842	0.227
	(0.211)	(0.150)	
Novelty Rank	2.608	3.208	0.042**
	(0.230)	(0.175)	

Panel B: Regression Analyses

	Submitted Project	Overall Rank	Novelty Rank
WTA Contest	0.031	0.274	0.689**
	(0.076)	(0.315)	(0.327)
Observations	132	42	42
R-squared	0.212	0.212	0.294
Mean dep var	0.318	2.592	2.923

Main Results: Other Outcomes & Robustness

1. No significant differences on other performance dimensions
   - Novelty benefits not coming at expense of other outcomes
2. No difference in observable extensive margin effort between prize structures
   - Registering on contest platform (DevPost), submission conditional on registering
3. Robust to controlling for judge fixed effects and participant characteristics
4. Robust to normalized scores instead of ranks
5. Post-contest survey: Over 80% in both arms prefer less risky prize structure, including eventual winners of WTA
6. No evidence that differential career concerns driving differences (students and employees perform similarly)

Heterogeneous Treatment Effects: Teams vs Individuals

	Individual	**Team**	p-value of difference
Any Prior Contest Experience	0.312	0.463	0.103
	(0.048)	(0.081)	
Unique Areas of Relevant Expertise	2.581	3.744	0.003***
	(0.182)	(0.361)	
Risk Preferences	2.892	2.811	0.744
	(0.146)	(0.150)	
N	93	39	

- Teams are formed to improve upon individual capabilities
- Formation occurs independently of prize structure assignment
- Turned out that winning teams all split prize money equally

Heterogeneous Treatment Effects: Teams vs Individuals

	Individual Mean Difference WTA - TOP10	**Team** Mean Difference WTA - TOP10	Diff-n-Diff p-value
Submitted Project	-0.060	0.226	0.103
	(0.084)	(0.157)	
N	93	39	
Overall Rank	0.079	0.389	0.542
	(0.444)	(0.298)	
Novelty Rank	0.391	0.659*	0.619
	(0.458)	(0.377)	
N	19	23	

Summary

Causal evidence from firm sponsored innovation contest

- Winner-takes-all prize structure generates more novel output than lower risk prize structure
  - Supports theoretical evidence on rank-order tournaments and problem uncertainty (Lazear and Rosen, 1981)
- Riskier prize structure did not reduce output
  - Contrary to existing evidence (Fang et al., 2020)
  - Riskier prize increased output among teams
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Conclusion

- Structure of rewards for innovation impacts innovative output even when holding total rewards, competition, and initial participant pool constant

- High risk reward structure inspires the risk-taking required for innovation novelty without compromising output levels
  - May depend on sufficiently large expected return to participation as in our setting
  - How impact of risk-sharing agreements depend on length of contract or riskiness of task demands further exploration

Other Outcomes by Prize Structure

	Multiple Prizes	One Prize	p-value of difference
Functionality Rank	3.300	3.428	0.646
	(0.231)	(0.160)	
User Experience Rank	2.808	3.015	0.436
	(0.205)	(0.168)	
Wide Scope of Use Cases Rank	2.975	3.212	0.375
	(0.215)	(0.159)	
Solves Contest Problem Rank	2.617	3.011	0.214
	0.247	0.196	