Proportional rewards in agriculture and nutrition: Contest designs with many winners

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Why consider proportional rewards?

- Prize competitions typically focus on top performers, in rank order
  - Aim is high-powered incentive (Lazear & Rosen in AER, 1981)
  - "And the winner is…" (McKinsey & Co., 2009)
  - Lack of incentive for lower-ranked workers may worsen outcomes (Brown in JPE, 2011)
- Other competitions reward everyone, in proportion to success
  - "Proportional rewards" is used here to mean that contestants win varying shares of the total reward
  - Examples include portfolio weights in financial markets; bonus pools and ownership shares within firms
  - Like a royalty or commission, but in sponsored contests the total reward is usually fixed
- When might proportionality be useful for contest design?
  - Contest must have a measurable outcome
  - Funder must value all achievements, not just best
    - For proportionality, need a cardinal metric (e.g. quantity or value)
    - Can convert ordinal rank to cardinal percentiles (Barlevy & Neal, AER 2012)
- Why so much focus on top performers?
  - Contests leverage the signaling value of information about success
  - Stories about individual winners are more compelling than stories about data

    …but cultural norms may be shifting back towards interest in the whole population

Evidence on proportional rewards versus winner-take-all prizes

- Lab experiments with students at Purdue

  Cason, T.N., Masters, W.A. and Sheremeta, R.M., 2010. Entry into winner-take-all and proportional-prize contests: An experimental study. *Journal of Public Economics*, *94*(9-10), pp.604-611.
  (Solving math problems -- real effort, with unobservable skill)

  Cason, T.N., Masters, W.A. and Sheremeta, R.M., 2018. Winner-take-all and proportional-prize contests: theory and experimental results. *Journal of Economic Behavior & Organization,* in press.
  (Investing cash to win rewards -- chosen effort, with unique Nash equilibrium)

- Field trials with childcare workers in India

  Singh, P. and Masters, W.A., 2017. Impact of caregiver incentives on child health: Evidence from an experiment with Anganwadi workers in India. *Journal of Health Economics*, *55*, pp.219-231.
  (Benchmarking performance pay versus unconditional bonus)

  Singh, P. and Masters, W.A., 2018. Performance bonuses in the public sector: Winner-take-all prizes versus proportional payments to reduce child malnutrition in India. *J. of Development Econ.,* in press.
  (Direct comparison of proportional versus winner-take-all contest)

- Experience with AgResults
- Conclusion and a suggestion

A lab experiment with real effort:
Can proportional rewards attract more entrants, and more success?

ELSEVIER

Journal of Public Economics
Volume 94, Issues 9–10, October 2010, Pages 604-611

Entry into winner-take-all and proportional-prize contests: An experimental study

Abstract

This experiment compares the performance of two contest designs: a standard winner-take-all tournament with a single fixed prize, and a novel proportional-payment design in which that same prize is divided among contestants by their share of total achievement. We find that proportional prizes elicit more entry and more total achievement than the winner-take-all tournament. The proportional-prize contest performs better by limiting the degree to which heterogeneity among contestants discourages weaker entrants, without altering the performance of stronger entrants. These findings could inform the design of contests for technological and other improvements, which are widely used by governments and philanthropic donors to elicit more effort on targeted economic and technological development activities.

Using students' performance on unfamiliar arithmetic problems, we find that initial success drove willingness to compete

To start, all subjects were paid for each solved problem then shown their score relative to others

Subjects were then offered each type of contest in random order, and chose whether to enter

The alternative to entry was continued piece rate payment, like a job

With proportional rewards, more people entered and more problems were solved by more lower-skill workers

Performance in arithmetic contests, with endogenous entry

	Total Number of Entry Observations	Total Number of Correctly Solved Problems	Total Number of Attempted Problems	Average Number of Correctly Solved Problems
Piece rate	69	661	893	9.6
Winner-take-all contests (one winner)				
Enter	85	1077	1342	12.7
Don't enter	122	1440	1796	11.8
All subjects	207	2517	3138	12.2
Proportional reward contests (share of correct answers)				
Enter	129	1509	1912	11.7
Don't enter	78	1071	1281	13.7
All subjects	207	2580	3193	12.5

More entrants

More solutions in the contest

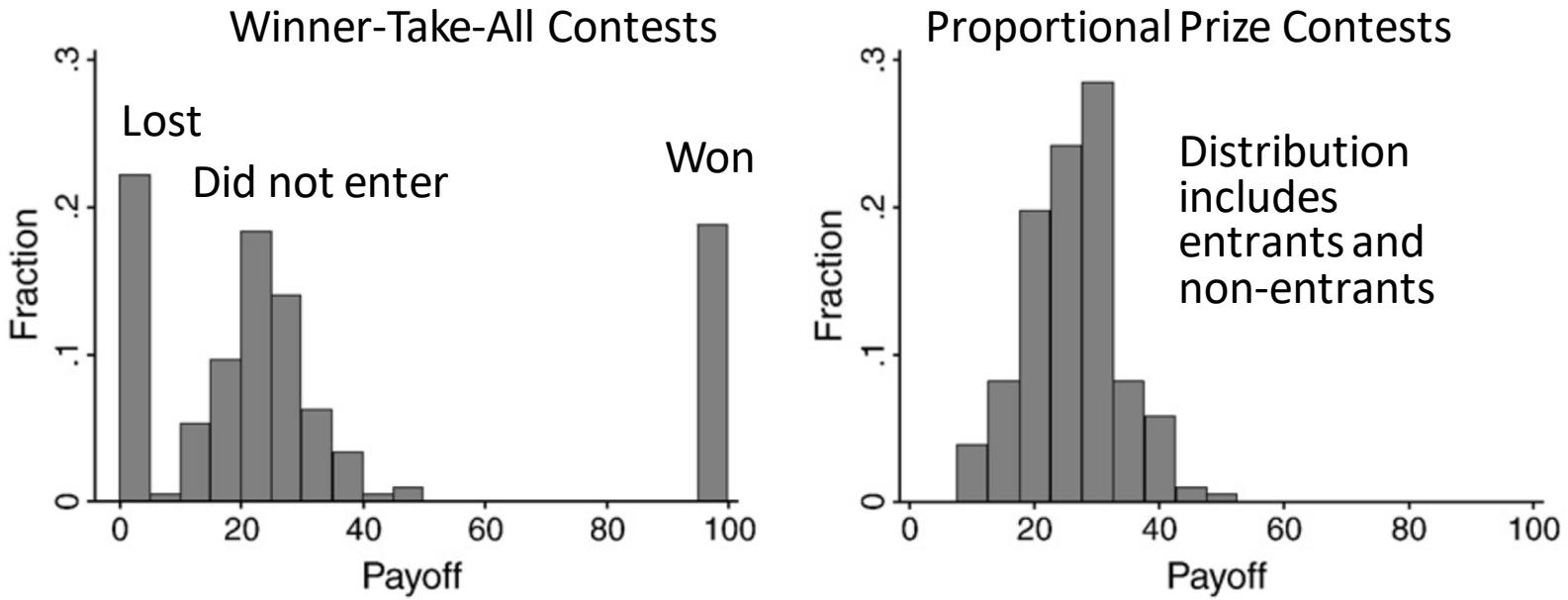
More solutions in total

Warning: With proportional rewards, the contestant pool includes more less-skilled people, facing less highly-powered incentives

Note: Results shown are for 207 contests involving 69 subjects, conducted in computer labs at Purdue University

Our lab experiment was designed to mimic real choices between earning wages and entering a contest

Offering proportional contests led to more entry and more total effort, with less inequality in payoffs



Results shown are for 207 contests involving 69 subjects

Source: Cason, T.N., Masters, W.A. and Sheremeta, R.M., 2010. Entry into winner-take-all and proportional-prize contests: An experimental study. *Journal of Public Economics*, *94*(9-10), pp.604-611

Using known cost functions to solve for equilibrium, we find that proportionality limits behavioral bias

ELSEVIER
Journal of Economic Behavior & Organization
Available online 5 February 2018
In Press, Corrected Proof

Winner-take-all and proportional-prize contests: Theory and experimental results ☆

Abstract

This study provides a unified framework to compare three canonical types of contests: winner-take-all contests won by the best performer, winner-take-all lotteries where probability of success is proportional to performance, and proportional-prize contests in which rewards are shared in proportion to performance. We derive equilibria and observe outcomes from each contest in a laboratory experiment. Equilibrium and observed efforts are highest in winner-take-all contests. Lotteries and proportional-prize contests have the same Nash equilibrium, but empirically, lotteries induce higher efforts and lower, more unequal payoffs. Behavioral deviations from theoretical benchmarks in different contests are caused by the same underlying attributes, such as risk-aversion and the utility of winning. Finally, we find that subjects exhibit consistent behavior across different types of contests, with subjects exerting higher effort in one contest also exerting higher effort in another contest.

Field trials with childcare workers in Chandigarh, India

- Aim of randomized trial was to help Indian ICDS childcare centers reduce underweight
- We used contests among caregivers in Chandigarh, offering small cash incentives for improved outcomes to reveal what actions led to observed improvements

- Trial #1: pay-for-performance vs fixed bonus
  - Control group (fixed salary only)
  - Pay-for-performance (200 Rs/child improved)
  - Fixed bonus (600 Rs to all workers)
- Trial #2: winner-take-all vs shared rewards
  - Traditional contest (one winner)
  - Proportional prizes (share of children improved)

Incentives + measurement focus workers' attention

Impact of caregiver incentives on child health: Evidence from an experiment with Anganwadi workers in India

P. Singh, W.A. Masters / Journal of Health Economics 55 (2017) 219–231

Abstract

This paper tests the effectiveness of performance pay and bonuses among government child-care workers in India. In a controlled study of 160 ICDS centers serving over 4000 children, we randomly assign workers to either fixed bonuses or payments based on the nutritional status of children in their care, and also collect data from a control group receiving only standard salaries. In all three study arms mothers receive nutrition information. We find that performance pay reduces underweight prevalence by about 5 percentage points over 3 months, and height improves by about one centimeter. Impacts on weight continue when incentives are renewed and return to parallel trends thereafter. Fixed bonuses are less expensive but lead to smaller and less precisely estimated effects than performance pay, especially for children near malnutrition thresholds. Both treatments improve worker effort and communication with mothers, who in turn feed a more calorific diet to children at home.

Proportional rewards help even weak performers do better

Performance bonuses in the public sector: Winner-take-all prizes versus proportional payments to reduce child malnutrition in India

JOURNAL OF Development ECONOMICS

Prakarsh Singh [a], William A. Masters [b,*] *In press, at doi.org/10.1016/j.jdeveco.2018.10.003*

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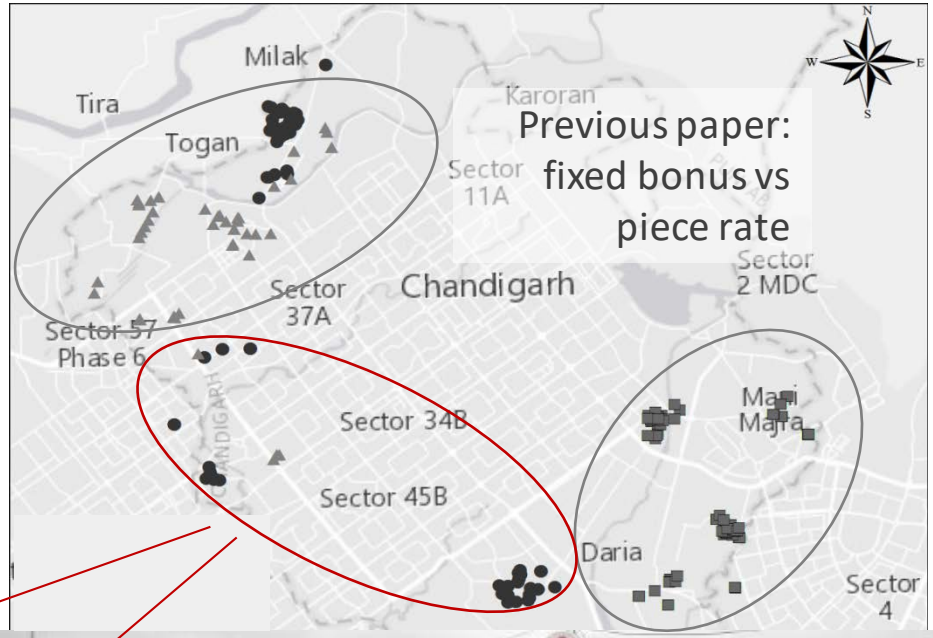
Abstract

We conduct a randomized trial to compare incentives for improved child outcomes among salaried caregivers in Chandigarh, India. A contest whose prize is divided among workers in proportion to measured gains yielded more improvement than a winner-take-all program. In our population of about 2000 children served by 85 workers, using proportional rewards led to weight-for-age malnutrition rates that were 4.3 percentage points lower at 3 months (when rewards were paid) and 5.9 points lower at 6 months (after the contest had ended), with mean weight-for-age z scores that were 0.071 higher at 3 months, and 0.095 higher at 6 months. Proportional bonuses led to larger and more sustained gains because of better performance by lower-ranked workers, whose efforts were not rewarded by a winner-take-all prize. Results are consistent with previous laboratory trials and athletic events, demonstrating the value of proportional rewards to improve development outcomes.

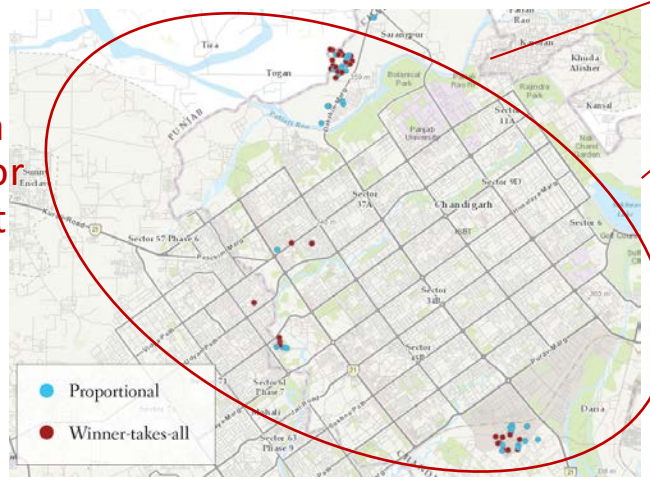
Effect of incentives depends on context

Context for these trials is Chandigarh ICDS
-- Planned city in far north India
-- Capital of both Punjab and Haryana
-- Population size < 2 million

Trials were developed with ICDS management
-- Geographically separated blocks in slum areas
-- First study compares two blocks, one as control for trends and seasonality, the other for 2 treatments
-- Contest study used different sites for 4 rounds of data collection at 3 month intervals, Oct 2014 - July 2015, with surveys of workers, children and their mothers



In the contest design study, workers were randomly assigned to a proportional-rewards or winner-take-all contest in their neighborhood



The contests in this trial were designed to meet ICDS needs

- Bonus pool in each cluster total Rs. 600 per worker (3% of monthly salary)
  - Equal expected value and timing of payment in each treatment arm
  - In the winner-take-all contest, the highest performer wins the entire bonus pool

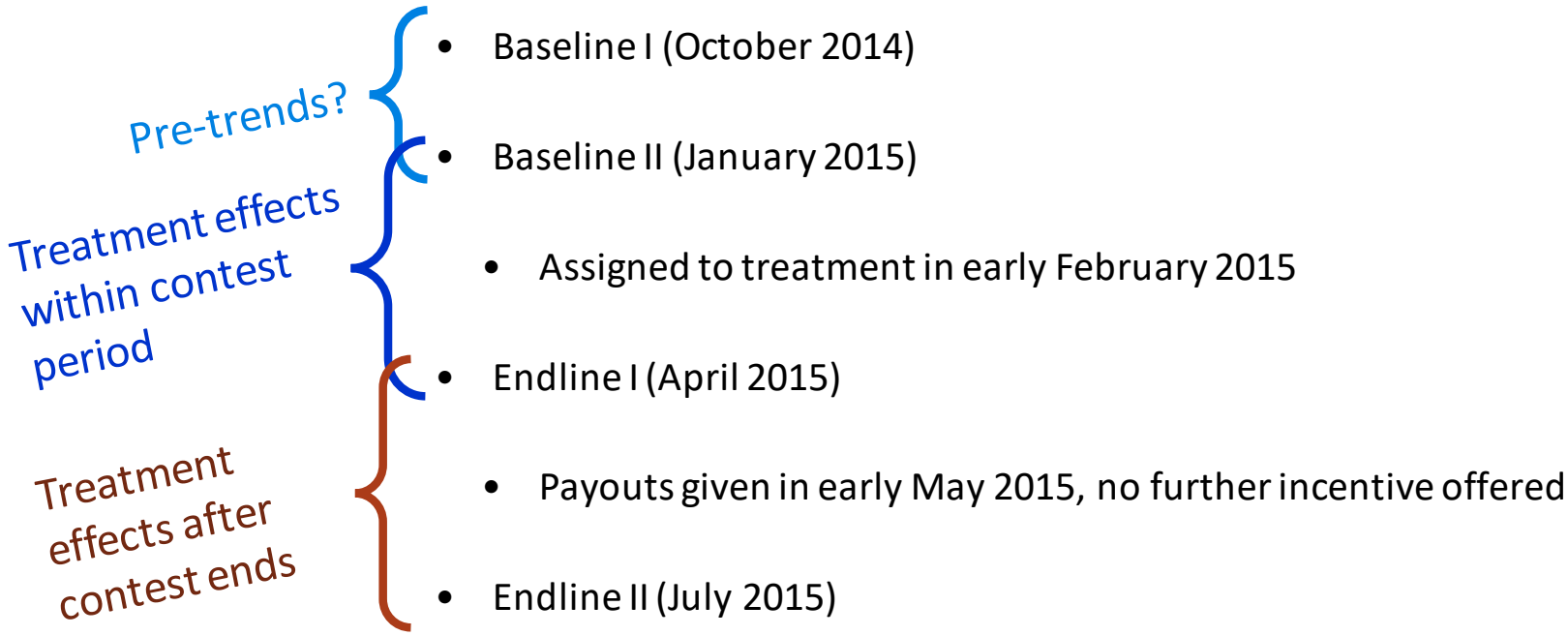
$$P_{ijk} = \begin{cases} B_k \; if \; n_i > n_j \; for \; all \; j \; in \; k \\ 0 \; if \; n_i < n_j \; for \; any \; j \; in \; k \end{cases}$$

  - In proportional rewards treatment, each successful performer wins their share of the bonus

$$P_{ijk} = \begin{cases} \dfrac{n_i B_k}{\sum_{j=1}^{N} n_j} \\ 0 \; if \; n_i < 0 \end{cases}$$

- Simple implementation: Goal cards with gains needed for each child
  - Status improvements can be from severe (WAZ<-3) to moderate (WAZ<-2) or to none
  - Status improvements exclude any cases of overweight relative to height (WHZ>+1)
  - Bonuses are net of any declines in status into moderate or severe malnutrition
  - Bonuses are additional to regular salaries, and cannot be negative

Timeline of measurement was designed to capture trends in control areas, and test for persistence of contest impacts



Malnutrition rates were reduced significantly more with proportional rewards than with a winner-take-all contest especially after the contest ended

Average treatment effects of proportional rewards (vs. winner-take-all)

	Weight (kg) (1)	WAZ score (2)	Malnutr. status (3)	Weight (kg) (4)	WAZ score (5)	Malnutr. status (6)	Weight (kg) (7)	WAZ score (8)	Malnutr. status (9)
Within the contest period (after 3 months)									
Proportional	0.0764	**0.071***	**-0.043***	0.138	0.064	-0.038	0.138	0.064	-0.037
Child and mother-level controls				X	X	X	X	X	X
Worker Controls							X	X	X
Over the longer term (after 6 months)									
Proportional	0.202	**0.095***	**-0.059****	**0.209****	**0.088***	**-0.052***	**0.200***	**0.082***	**-0.050***
Child and mother-level controls				X	X	X	X	X	X
Worker Controls							X	X	X
N	2325	2272	2272	1935	1934	1934	1935	1934	1934

Larger, more significant gains in longer run could be due to biological delays, or behavioral effect of contest on attitudes and intrinsic motivation

Dependent variables are Weight (kg), Weight-for-Age Z scores (WAZ), Malnutrition status (WAZ below -2 threshold)

Significance levels shown are * 10%, ** 5%, *** 1%.

Malnutrition rates improved more with proportional rewards especially among the lower-ranked workers

Heterogeneity in treatment effects of proportional rewards (vs. winner-take-all)

	Wfa z (1)	Weight (2)	Wfa z (3)	Weight (4)	Wfa z (5)	Weight (6)
Within the contest period (after 3 months)						
Proportional (PRP)	**0.0703***	0.076	0.0638	0.138	0.0642	0.138
Difference to Mean Payout	0.0111	0.0256	0.0181	0.0342	0.018	0.0341
Difference to Mean Payout*PRP	-0.0101	-0.0376	-0.0158	-0.0317	-0.0163	-0.0316
Child and mother-level controls			X	X	X	X
Worker Controls					X	X
N	2342	2348	1665	1665	1665	1665
Over the longer term (after 6 months)	*Largest gains were among workers with lower payouts*					
Proportional (PRP)	**0.0947***	**0.203***	**0.0880***	**0.210****	**0.0836***	**0.202****
Difference to Mean Payout	**0.0351****	**0.0403**	**0.0307****	**0.0667****	**0.0278****	**0.0610****
Difference to Mean Payout*PRP	**-0.0508*****	**-0.0935****	**-0.0447*****	**-0.0920*****	**-0.0377*****	**-0.0783*****
Child and mother-level controls			X	X	X	X
Worker Controls					X	X
N	2272	2325	1934	1935	1934	1935

Difference to mean payout coefficients are in thousands of rupees
Dependent variables are Weight (kg) or Wfa z (WAZ)
Significance levels shown are * 10%, ** 5%, *** 1%.

Conclusions from lab experiments and field trials

- Contests with known payouts and fixed timelines can elicit effort and information about what works, in a budget-friendly and administratively feasible manner
  - Bonus of ~5% of salary lowered malnutrition rates by 6% after 6 months, 4% after 3 mo.
  - Impacts were persistent, implying that additional incentives did not displace other motivations
- Using proportional rewards encourages all workers, not just top performers
  - Avoids discouragement of lower-ranked workers found in winner-take-all contests
  - We find larger gains among those with below-average initial outcomes
- Developing real-world contests relies on funder interest, suitability of the problem
  - Contest must have a measurable outcome
  - Funder must value all achievements, not just best
- Contests are best seen as complements to other mechanisms
  - Prize amounts must be sufficient to attract interest, but no larger (to limit distortion)
  - Contest focuses attention on what is measured, and reveals what works

Case study of AgResults

- AgResults.org is a multidonor initiative that designs and implements prize competitions for private sector agricultural innovations
- Launched at the G20 summit in 2012 with commitments from Australia, Canada, UK, US and the Bill & Melinda Gates Foundation, initially totaling $118 m., now $145 million
    - Each contest is a project, targeting a specific objective in a particular location
    - A **Steering Committee** of donor representatives approves each project
    - The **World Bank** serves as trustee for donors' funds and contracts with secretariat
    - **Deloitte** acts as secretariat, selecting **project managers** and implementing partners
    - **Abt Associates** acts as independent evaluator, for process and impact assessments

Source: Agresults.org, May 2019

Projects implemented by AgResults.org

Source: Agresults.org, May 2019

Summary of current status

Source: Agresults.org, May 2019

Hermetic grain storage in Kenya, 2014-18

Up to $7.75 m. for sale of insect-proof storage units sold
from May 2015 to May 2018, as a proportional reward based on storage capacity

Eastern Region: All competitors that reach the 21,000 MT sales threshold of any single storage device type that is LGB proof will share US $3,000,000, proportionally distributed based on the capacity sold to smallholder farmers.

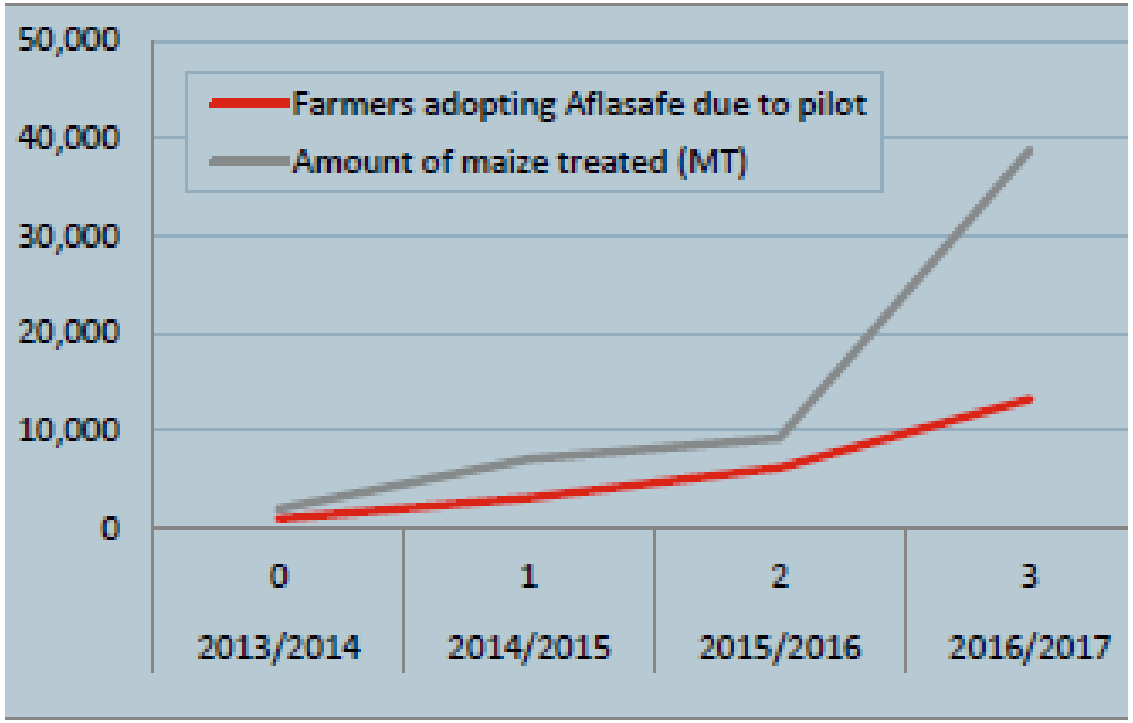
Rift Valley: The first five competitors that attain the 21,000 MT sales threshold of any single storage device type will receive a US $750,000 performance-based grant. All competitors that reach the 21,000 MT sales threshold of any single storage device type will share US $1,000,000, proportionally distributed based on the capacity sold to smallholder farmers.

- Project manager was Tanager (also manager of Zambia pilot), to promote sale of successful hermetic grain storage units
- Verification based on protection of stored grain from large grain borer (LGB) insects, inside & outside the storage unit; sales data audited by Enst and Young
- Attracted 9 competitors (7 brands of hermetic bags, one metal silo, and one plastic silo), which sold a total of 1.4 m. storage units with capacity of 413,265 mt of maize; a total of $6.25 m. in prize payments were made ($4 m. proportionally)

Source: Agresults.org; TanagerIntl.org; May 2019

Aflasafe adoption in Nigeria, 2013-2019

Up to $13 m. for sale of maize certified as treated with Aflasafe
over 3 harvest years (2015, 2016 and 2017), as premium of $18.75/mt



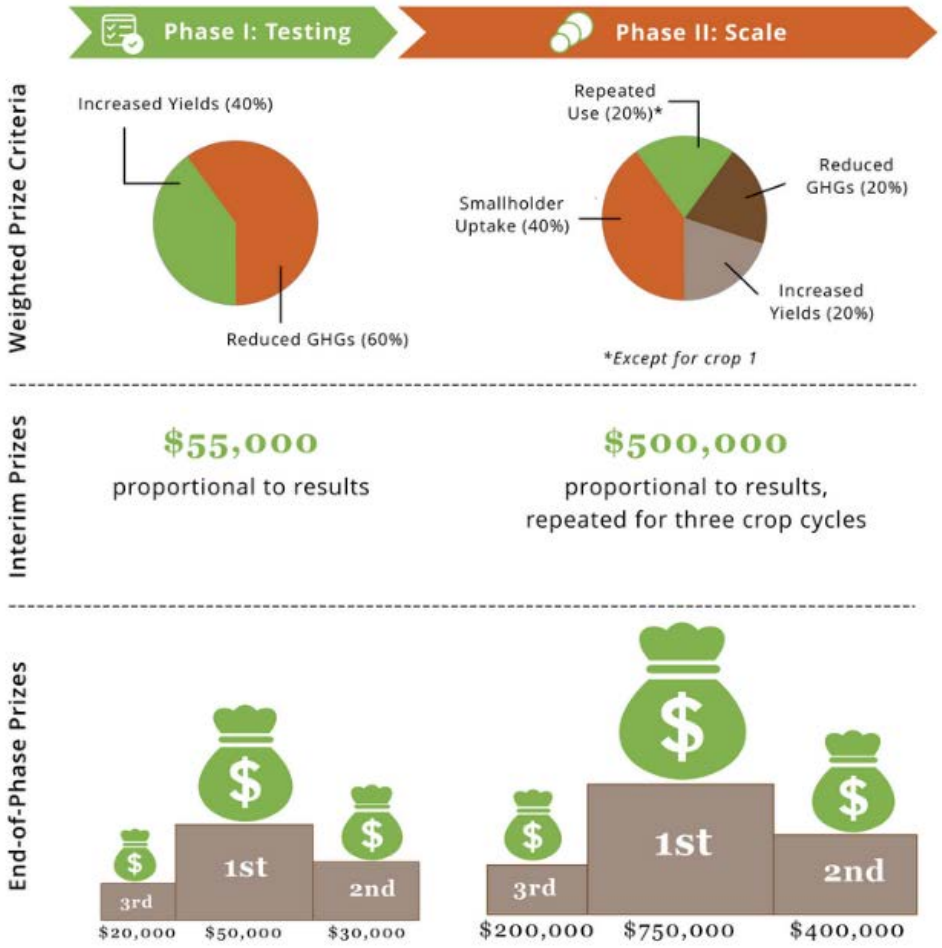
Ongoing successfully

- Project manager is IITA, developer of the Aflasafe fungus designed to outcompete toxic strains of aspergillus
- Attracted 24 seed growers, feed producers and maize traders, aggregating Aflasafe treated maize from 13,372 smallholder farmers, totaling 38,820 mt/yr after three years (0.8% of Nigerian maize supply), primarily in Kano and Kaduna states
- Cost-effectiveness estimated at $43-85 per $100 in additional farm income from sale of premium maize
- Future demand for Aflasafe-treated maize is uncertain, due to absence of other third-party quality assurance

Source: Agresults.org, May 2019; T. Narayan, D. Mainville, J. Geyer, K. Hausdorff, and D. Cooley, AgResults Impact Evaluation Report: Nigeria Aflasafe™ Challenge Project. Rockville, Maryland: Abt Associates, March 2019.

Emissions reduction in Vietnam, 2017-20

Up to $8 m. to farm input companies for low-emission rice growing systems used in Thai Binh province during 2019-20, as rank-order prizes

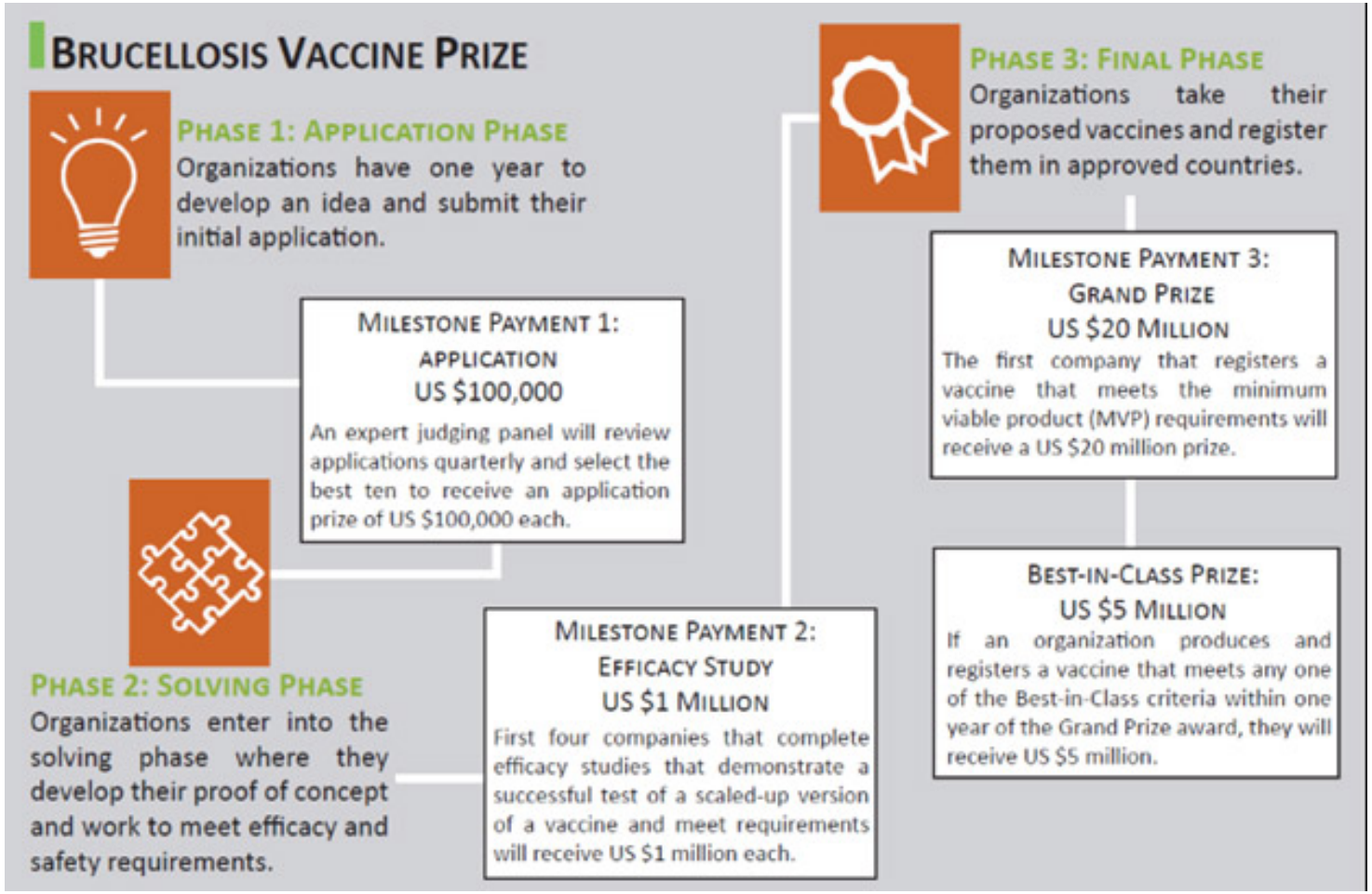


- Project manager is SNV-Vietnam, with verification by Applied Geosolutions based on field measurement and emissions modeling
- Phase I attracted 15 competitors over two growing seasons in 2017-18, from which 3 won prizes and a fourth was also retained for Phase II, for data over four growing seasons in 2019-20
- Techniques concern fertilizer use and organic amendments, residue and water management, tillage practices, and varietal choice

Source: Agresults.org, SNV.org & appliedgeosolutions.com, May 2019

Brucellosis vaccine prize (launched 2016)

Up to $30 m. for a vaccine against a strain of Brucellosis, as winner-take-all prizes



- Project manager is GALVmed, as brucellosisvaccine.org
- Created as a 10-year project; the only AgResults award for new R&D (others are to stimulate adoption)
- Milestone #1 awards made in Jan. 2018 to 3 applicants (Greenvac, Virbac, and TAMU); 7 others registered around the world

Source: Agresults.org, brucellosisvaccine.org; May 2019

Vitamin-A rich maize in Zambia, 2015-19

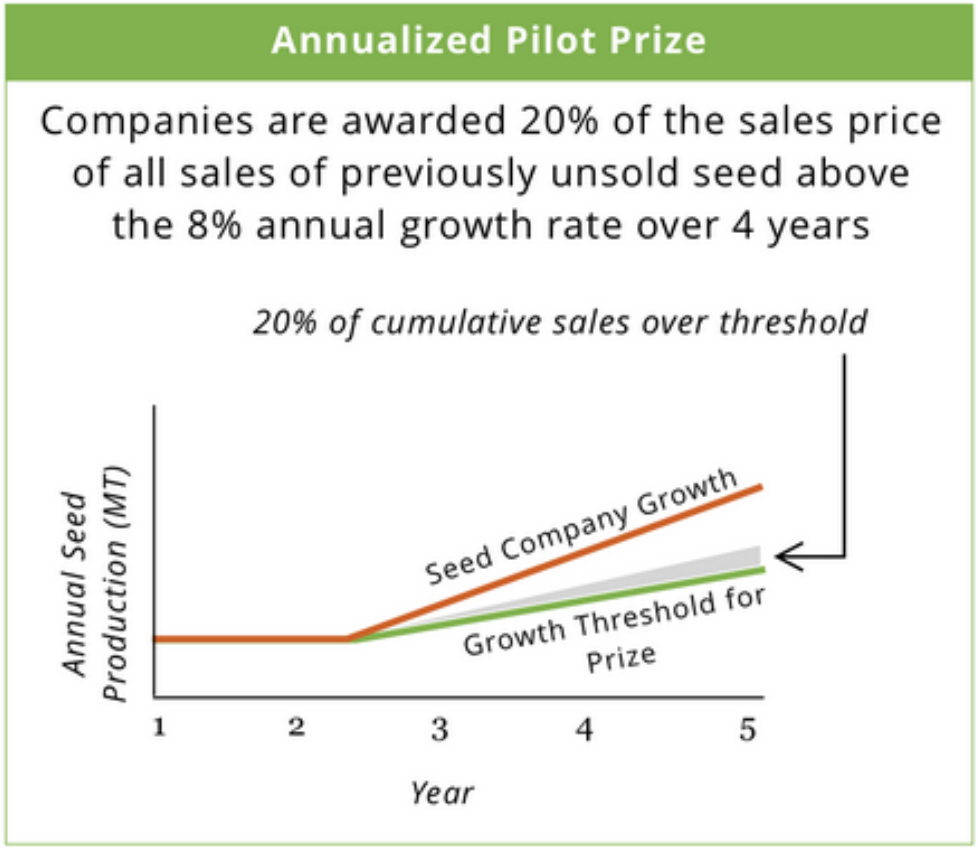
Up to $7 m. to seed companies for seed sales, and to millers for grain purchase, using a threshold prize plus a per-unit premium for each ton of seed or grain sold

- Project manager was Tanager, to promote sale of pro-vitamin A maize seed, and purchase of the grain by millers
- Project was ended early, after $605,741 in prize funds disbursed for 647 mt of maize seed sold (and no qualifying grain millers), due to disruption in the Zambia maize market and lack of demand

Source: Agresults.org, May 2019

Legume seeds in Uganda, 2015-18

A $1.5 m. project for seed companies to sell more certified legume seeds, as a premium per unit sold



- Project manager was Lutheran World Relief, with seed quality assurance by AgVerify
- Intended to be a 5-year project, terminated early due to disruption in seed demand and uncertainty about seed quality verification

Source: Agresults.org, LWR.org, AgVerify.net; May 2019

Lessons from AgResults for contest design in the real world

- **AgResults chose to pursue a few discrete projects**
  - detailed business plans for how each prize would change outcomes
  - specific technologies and geographic locations targeted for adoption and impact

  => **Are contests open to more diverse winners too difficult to communicate?**

- **AgResults chose to focus on very diverse targets**
  - Hermetic storage containers (excludable inputs, widely sold in markets)
  - Vitamin-A rich maize seeds and legume seeds (open-pollinated, difficult to sell)
  - Aflatoxin-treated maize (a credence good, requires quality assurance)
  - Low-emissions rice production (a process improvement, difficult to replicate)
  - Brucellosis vaccine (a new technology with public-good characteristics, somewhat like Advance Market Commitment for pneumococcal vaccine improvement)

  => **Are contests for more novel technologies too difficult to communicate?**

- **AgResults chose a mix of payment mechanisms**
  - five are traditional rank-order prizes or premiums per unit sold
  - one is a proportional reward ($4m. divided in proportion to improved storage capacity)

  => **Are proportional rewards relatively difficult to communicate?**

Conclusion:
Could proportional rewards be used to elicit data about success?

- For example, to spur innovation in African agriculture, could offer a modest sum (e.g. $1 m./year), to be divided in proportion to evidence of impact from adoption of new techniques in eligible areas over specified years
- Contest would reward submission of existing and new data following standardized protocols, showing:
  - quantity changes for outputs and inputs,
  - prices used to value outputs and inputs, and
  - extent of adoption relative to alternatives
- Secretariat would audit the data and compute awards
- Donors would disburse payments, highlighting the evidence for magnitude of each success
- Investors, innovators and adopters use prize information to scale up spread of winning techniques, in the private sector (if proprietary) or the public domain (if non-excludable)
- **In effect, this would be a contest for data, to reveal what works and guide investment**

Source: W.A. Masters, "Transformational incentives for innovation and aid effectiveness: Pull mechanisms, contests and prizes", pages 196-202 in R. Shah & S. Radelet, eds. *Frontiers in Development*. Washington, DC: USAID, 2012.