Designing Scientific Grants

Christoph Carnehl Marco Ottaviani Justus Preusser (Bocconi University)

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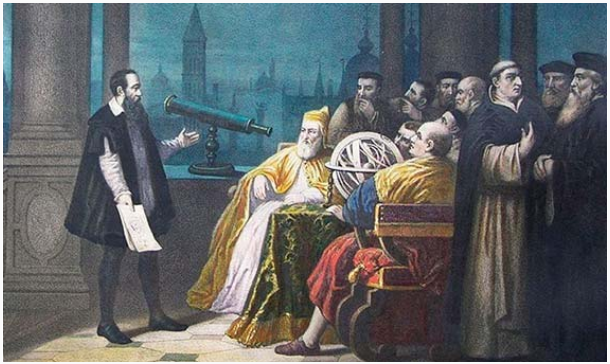
Economic Analyses of Science, Oxford University, 20 May 2024

Historical Roots of Grantmaking: Patronage, Science, and Entrepreneurship



- Galileo presents his telescope to Venice's Senate in August 1609

Galileo’s Letter to the Doge of Venice

Most Serene Prince,
Galileo Galilei most humbly prostrates himself before Your Highness, watching carefully, and with all spirit of willingness, not only to satisfy what concerns the reading of mathematics in the study of Padua, but to write of having decided to present to Your Highness a **telescope that will be a great help in maritime and land enterprises**.

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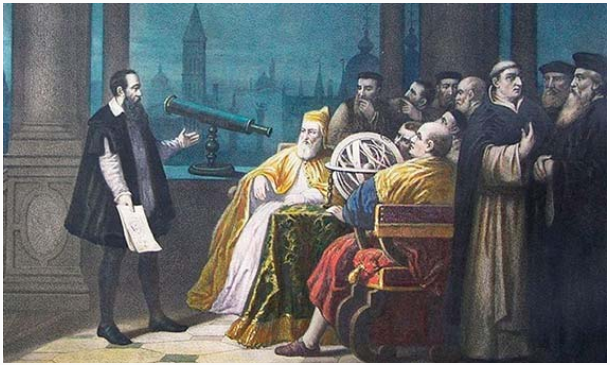
Historical Roots of Grantmaking: Patronage, Science, and Entrepreneurship



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  ". . . many discoveries and such as perhaps no other prince can match"

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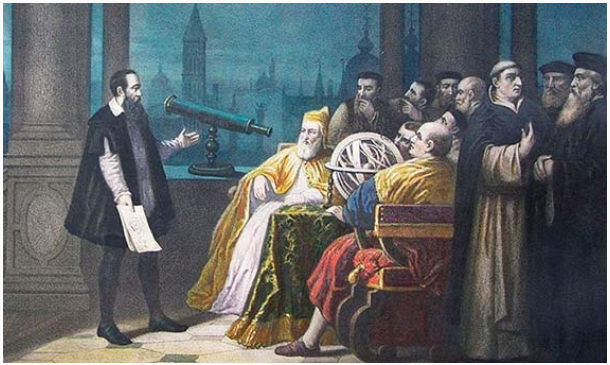

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  ". . . many discoveries and such as perhaps no other prince can match"

- Cosimo granted Galileo full teaching buyout @ University of Pisa

Science Funding

Traditional markets induce inefficient investment in research

- Nelson (1959), Arrow (1962), Jones and Summers (2021), ...

Widespread agreement **that** research should be funded

- NSF and NIH with annual budget of around USD 58 billion
- Horizon Europe with budget EUR 95.5 billion for 2021-2027

Less obvious **how** to fund; various coexisting instruments

- Prizes, patents, grants, ...

Why Fund Research with Grants?

Grants can be a desirable funding instrument if:

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    - Ex-post limitations in access to findings (e.g. through patents) undesirable

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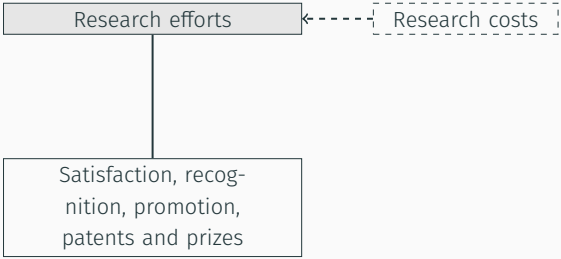
3. Final research outcomes are highly uncertain
   - Prize requirements cannot be precisely specified ex ante
4. Researchers are financially constrained
   - Patents and prizes deliver resources after research

Overview of Our Perspective


Research efforts
Research costs
Satisfaction, recog-
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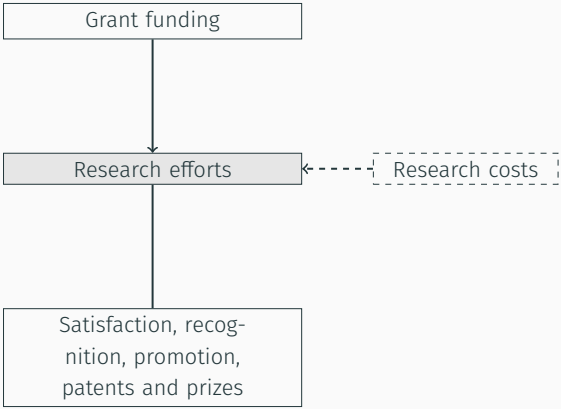
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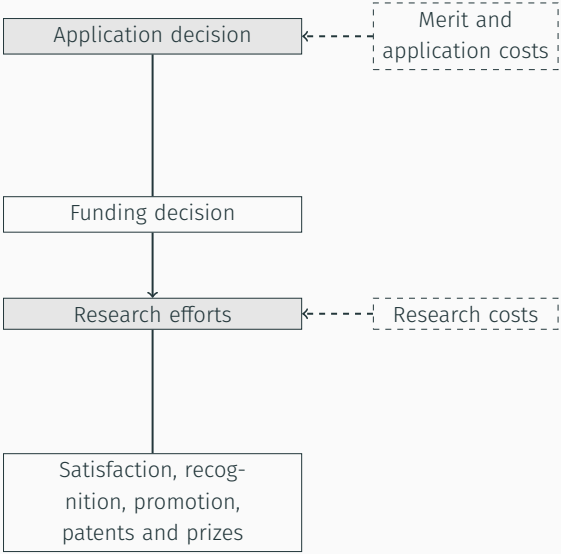
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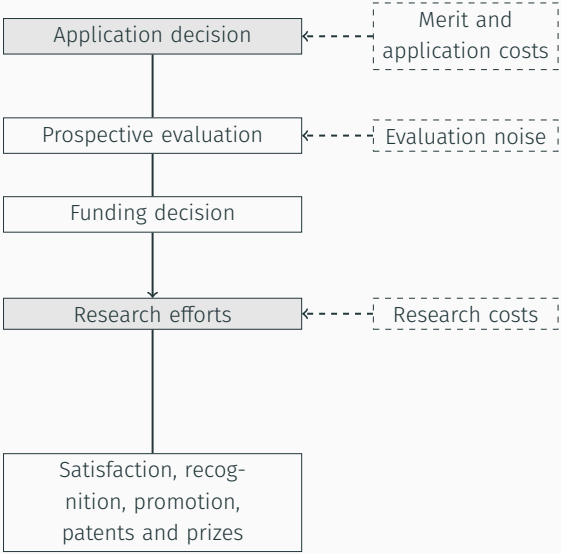
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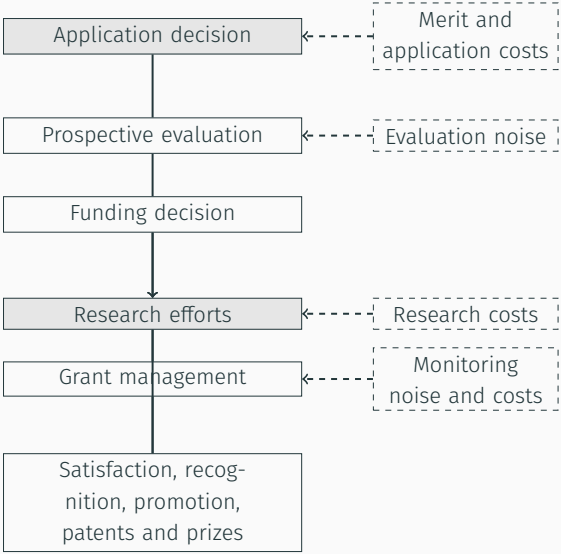
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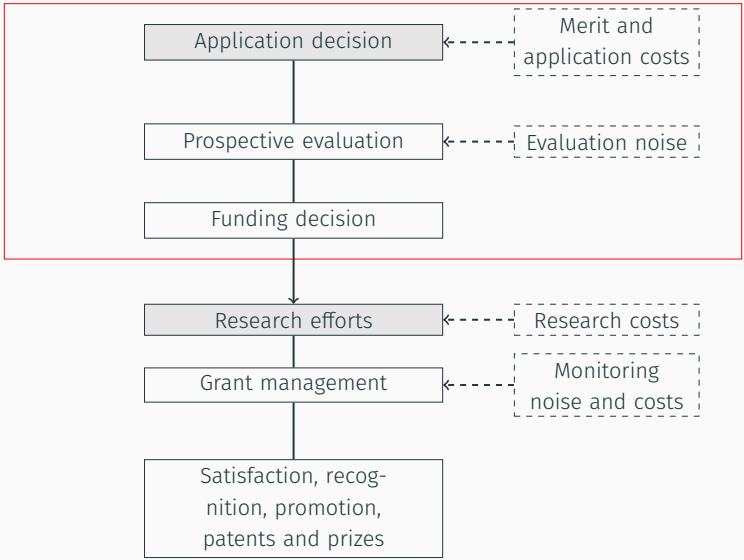
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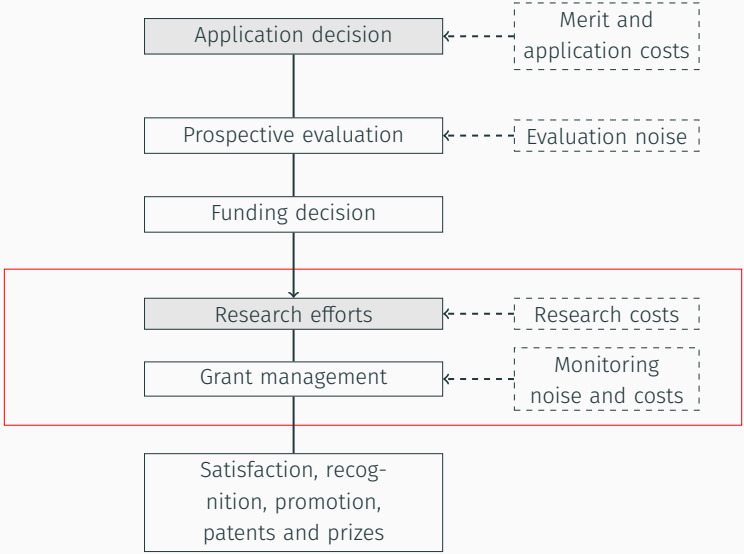
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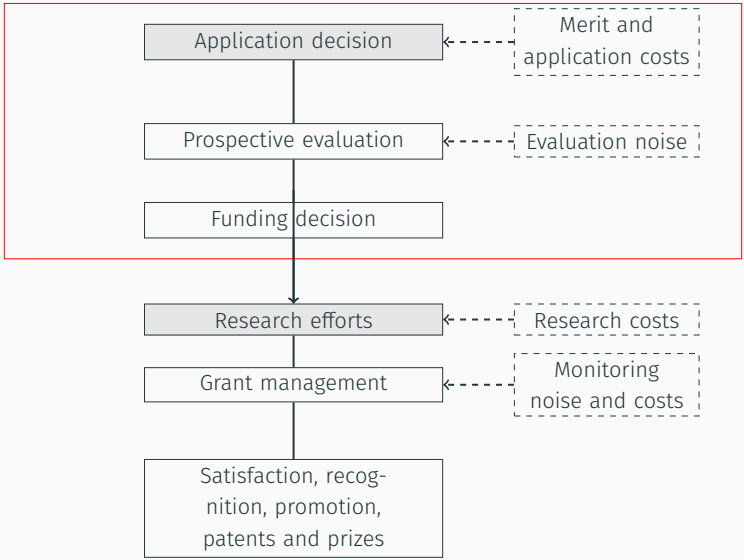
Our Approach to Grant Funding

Interpret these problems as asymmetric information problems:

1. Researchers have more precise information about merit than funder
   → hidden information
2. Researchers take actions that are not directly observed
   → hidden action

Insights from information economics and mechanism design about grant funding

The Funding Process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Grantmaking, Adda & Ottaviani (2024)

Researchers with heterogeneous merit

Funder wants to fund highest-merit researchers, but:

- funder observes noisy signal about merit (e.g., a panel evaluation), and
- funder has limited budget

Timing:

1. Researchers, knowing their merit, apply at a cost
2. Funder observes signals and decides who receives funding

Funding and Application Decision

Supply: Funder awards grant to applicants evaluated sufficiently positively

- Better evaluation $\Rightarrow$ higher expected merit
- Funder funds best-evaluated-applicants until budget exhausted.

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Demand: Researchers apply only if merit is sufficiently high

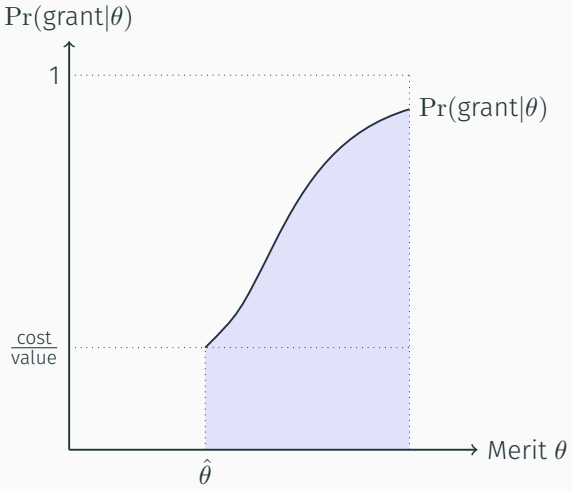
- Higher-merit researchers expect better evaluation $\Rightarrow$ higher grant probability
- Only sufficiently high-merit researchers find application costs worthwhile

Equilibrium

Demand: for marginal applicant $\hat{\theta}$,

$$\Pr(\text{grant}|\hat{\theta}) = \frac{\text{cost}}{\text{value}}$$

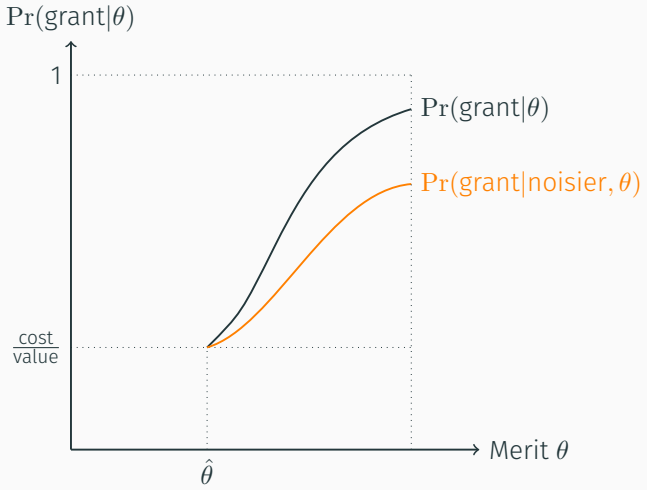
Supply: Budget B equals total $\Pr(\text{grant}|\theta)$ for inframarginal $\theta \geqslant \hat{\theta}$



What if Evaluation Becomes Noisier?

Less meritocratic evaluation

Applicants' grant probability ↓



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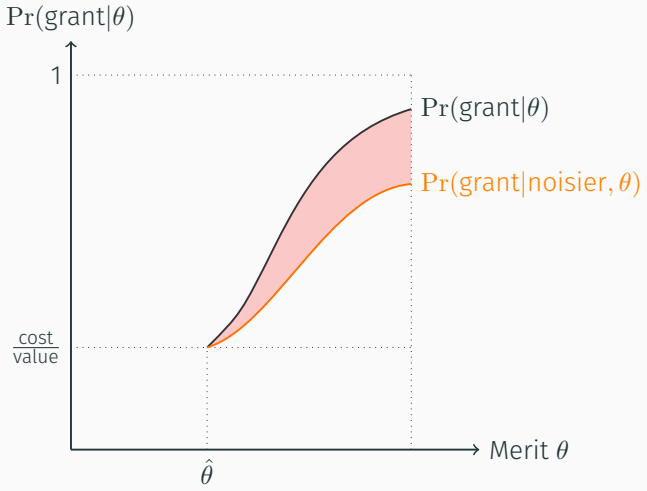
Expected grants below budget



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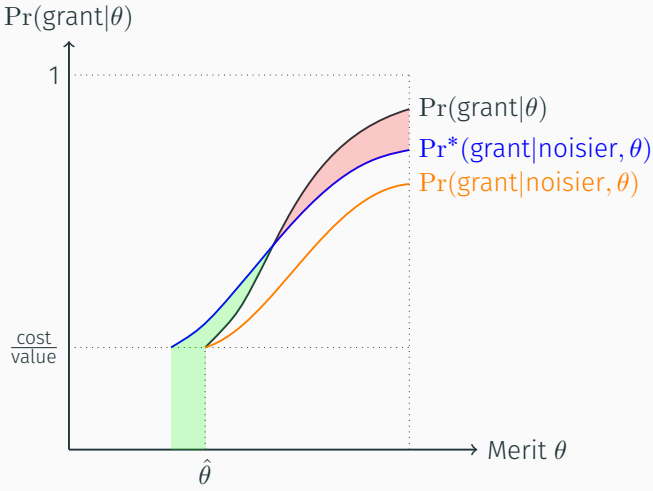

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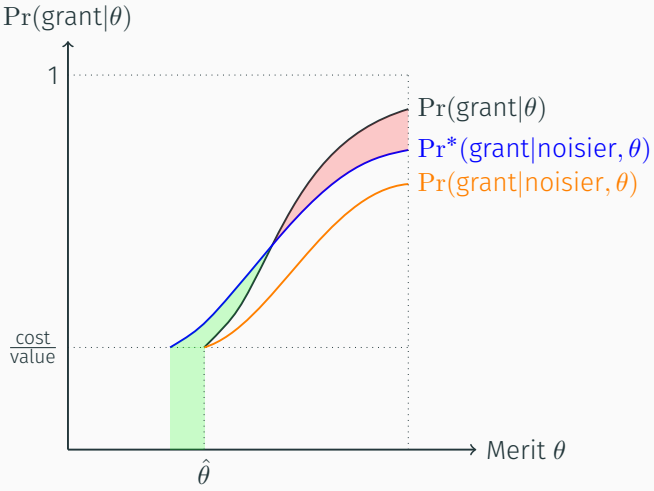
More applications, lower merit



Budget Allocation Across Fields

Many large institutions allocate budgets across fields based on applications

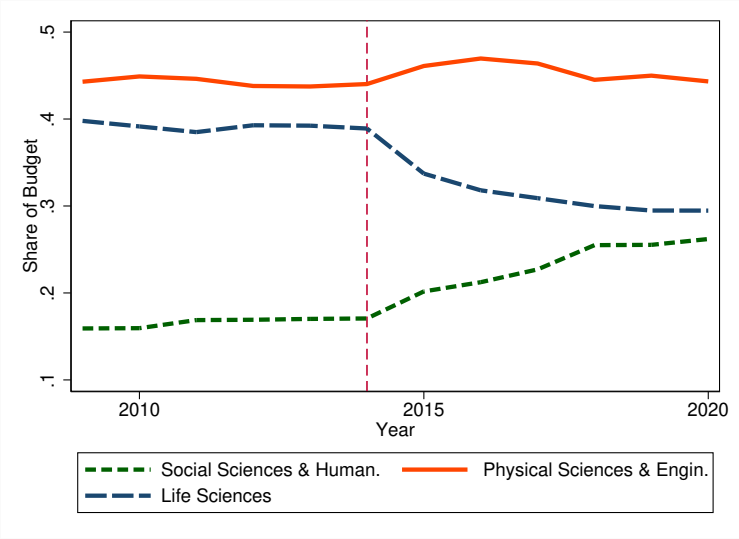
- For example, NIH and ERC use proportional budget allocation rules

What happens if budget is allocated across fields proportionally to applications?

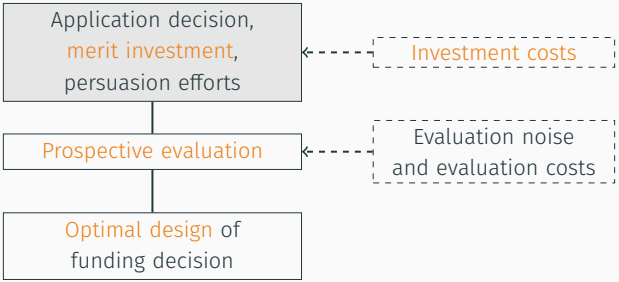
1. Noisy fields receive more applications than precise fields
2. Budget of noisy fields increases, budget of precise fields declines
3. Noisy fields receive more applications, precise fields fewer

Note. A field with perfect evaluation receives zero applications!

ERC Budget Across Time



More on the Funding Process — Investment in Merit


Application decision, merit investment, persuasion efforts
Investment costs
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Optimal design of funding decision

Investment Incentives

Beyond the application decision, researchers spend considerable time crafting proposals

- Hippel and Hippel (2015): 116 hours per grant application (survey of astronomers)
- Myers (2024): Professors spend 15% of time preparing grant application (avg. across all fields, survey at major US institutions)

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Effort could be productive or purely persuasive, and certainly costly

Here: How should proposals be evaluated to induce socially efficient effort?

Optimal Evaluation Noise

Ongoing work with Justus Preusser, related to Morgan et al. (2022)

Unit mass of ex-ante identical researchers

- Benefit v from winning grant
- Cost $c(e)$ for exerting effort e

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Grantmaker with mass $B < 1$ of grants

- Obtains e for funding each reseacher with effort e
- Observes noisy signal $e + \sigma\varepsilon$, where $\sigma > 0$
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Which noise level σ maximizes equilibrium welfare?

Optimal Evaluation Noise

Morgan et al. (2022): Noise level σ induces equilibrium such that

- Researchers that participate exert same effort $e_\sigma > 0$
- Some fraction $\alpha(e_\sigma)$ participate
- Remaining fraction $1 - \alpha(e_\sigma)$ do not participate, effort 0

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Impact of noise σ?

- e_σ strictly decreasing in σ
- participation rate $\alpha(e_\sigma)$ weakly increasing in σ

$\rightarrow$ let's identify choice of σ with choice of e.

Participation

Suppose share $\alpha(e)$ participate and symmetrically exert effort e:

$\rightarrow$ each expects to win w.p. $\frac{B}{\alpha(e)}$

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Participation

Suppose share $\alpha(e)$ participate and symmetrically exert effort e:

$\rightarrow$ each expects to win w.p. $\frac{B}{\alpha(e)} \rightarrow$ utility from participating is $v\frac{B}{\alpha(e)} - c(e) \rightarrow$ utility from not participating is 0

Thus:

$$\alpha(e) = \begin{cases} 1 & \text{if } c(e) \leqslant vB \\ \frac{vB}{c(e)} & \text{if } c(e) > vB \end{cases}$$

Optimal Evaluation Noise

Equilibrium welfare:

$$\underbrace{eB}_{\text{funder's payoff}} + \underbrace{vB - \alpha(e)c(e)}_{\text{researchers' rent}}$$

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By contrast, at first-best solution only B researchers should participate:

$$\max_e eB + vB - Bc(e)$$

and should exert effort such that $c'(e) = 1$

Optimal Evaluation Noise

Two candidate levels e for maximizing equilibrium welfare:

NOISY $\rightarrow$ full participation. e such that $c'(e) = B$ and $c(e) \leqslant vB$

- All researchers participate and exert effort e that maximizes researchers' rent conditional on full participation
- Inefficiencies:
  $\rightarrow$ Effort is too low compared to first best
  $\rightarrow$ participation too high relative to first-best

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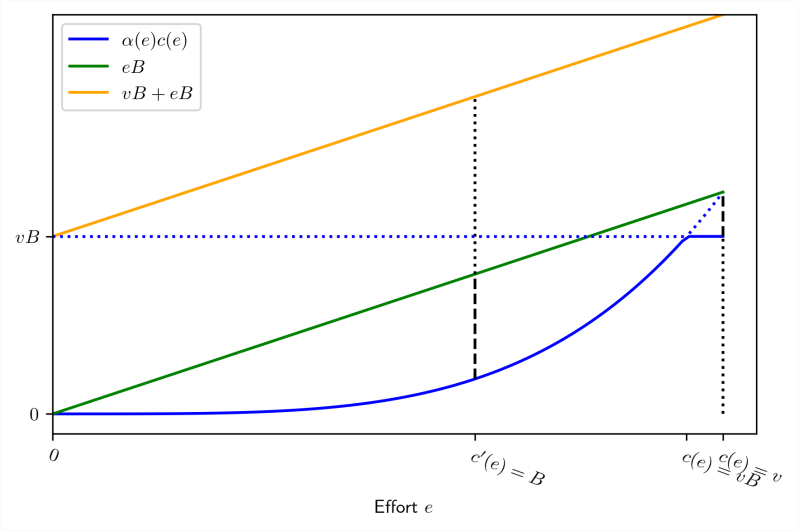
  → participation too high relative to first-best

NOISELESS → extreme effort. e such that $Bc(e) = vB$

- Efficient share B of researchers participate
- Inefficiency: Effort is so high as to deter higher participation
  → researcher rent is dissipated

Noisy evaluation optimal



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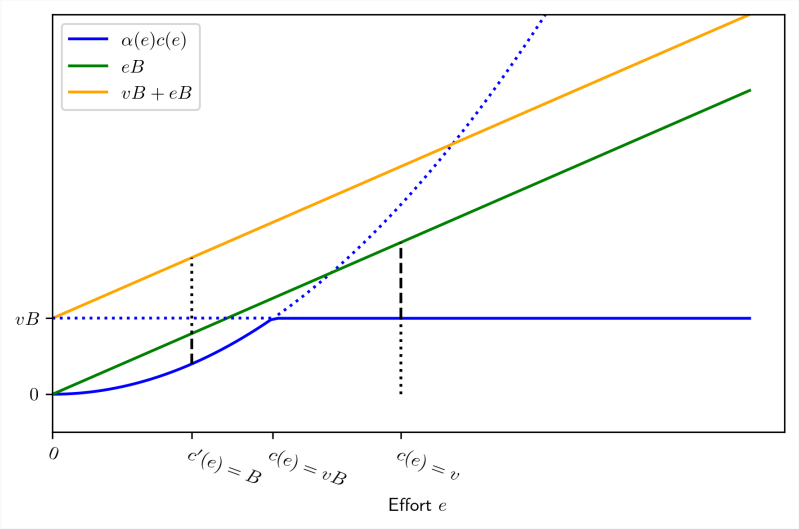

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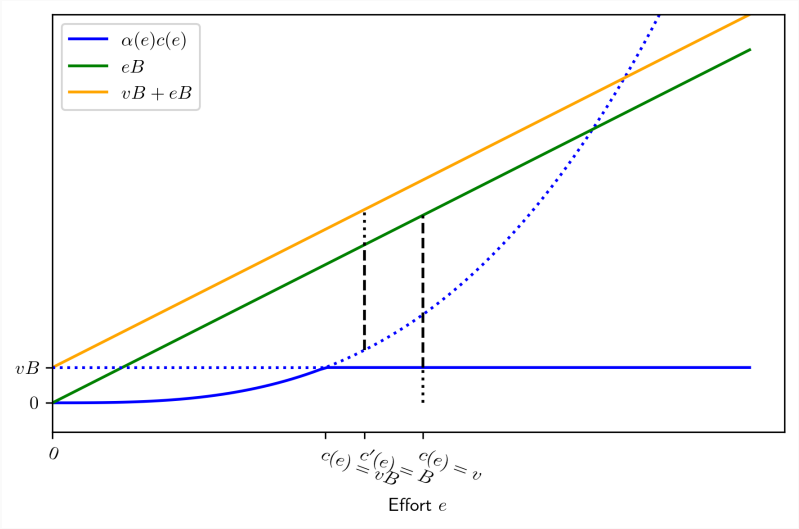


Comparison with Contest Literature

We considered equilibrium welfare:

$$\underbrace{eB}_{\text{funder's payoff}} + \underbrace{vB - \alpha(e)c(e)}_{\text{researchers' payoffs}}$$

Objective in Morgan et al. (2022) as in contest literature

$$\text{total effort of participants} \quad \alpha(e)e$$

However, if unfunded researchers cannot conduct research, their effort is wasted...

Noise that Maximizes Total Effort in Equilibrium

$$\alpha(e)e = \begin{cases} e, & \text{if } c(e) \leqslant vB, \\ \frac{e}{c(e)}vB, & \text{if } c(e) \geqslant vB. \end{cases}$$

Convex costs $c \Rightarrow \frac{e}{c(e)}$ decreasing

$\Rightarrow$ optimal effort is s.t. $c(e) = vB$

Intuition:

- If $c(e) \geqslant vB$, effort e of participants deters new participants via effort costs
- Convex $c \Rightarrow$ small increase in effort deters many researchers
  $\Rightarrow$ overall effort decreases in e if $c(e) \geqslant vB$

Optimal Mechanisms with Investment

Model of Augias and Perez-Richet (2023):

- Heterogeneous researchers, distinguished by initial merit
- Researcher can exert effort to improve merit
- Final merit observable

Optimal rule for maximizing final merit of funded (if type density decreases):

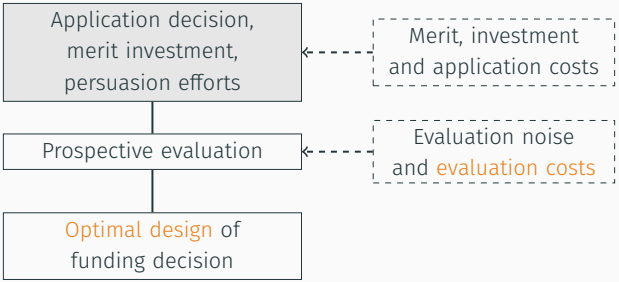
Fund w.p. 1 if final merit above certain threshold; else, don't fund

Implementation via noisy evaluation:

- If final merit above threshold, signal perfectly reveals merit
- Else, signal only reveals that merit below threshold

Evaluation Costs

The Allocation Process — Further Topics



Costly Evaluation

So far: funders can evaluate applicants at zero cost

One could think evaluation costs are additional source of inefficiency and noise

- How can funders balance costs with allocative efficiency?
- How do costs lead to noise in funding decision?

Costly Evaluation

Model of Ben-Porath et al. (2014).

- One grant, n applicants
- Applicants only care about own funding prob.
- Each applicant i has privately known merit θ_i
- Merit iid. across applicants
- Grantmaker's value of funding applicant i is θ_i
- Grantmaker can verify individual merits by paying cost $c > 0$ (costly panel evaluation)

Mechanisms

A mechanism specifies verification and funding decision as function of reports and, possibly, verified merit

Examples of mechanisms:

- Grantmaker verifies no applicant, grant allocated completely at random
- Grantmaker verifies all applicants and allocates to best

How to balance allocative efficiency with costs?

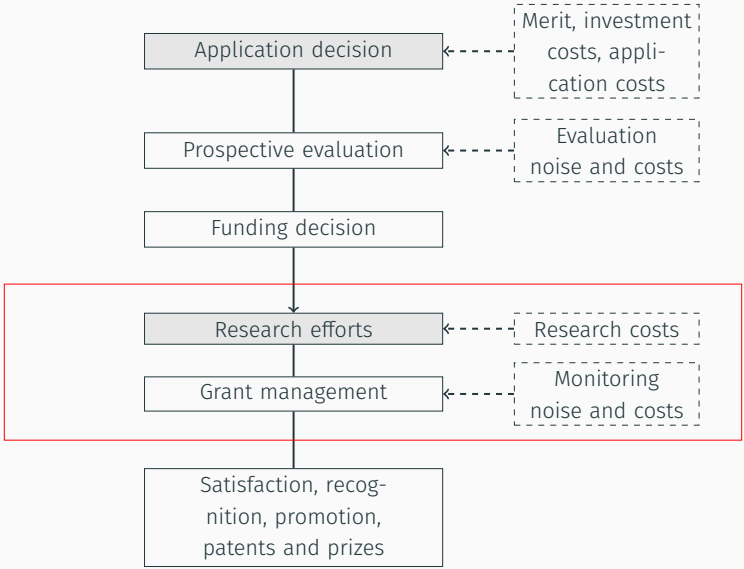
Optimal Mechanism

Optimal mechanism:

- Grantmaker announces threshold t^*, applicants report private merits
- If all report below t^*, grantmaker chooses winner uniformly at random
- Otherwise, highest report verified and funded if truthful
- Untruthful verified reports never funded

Grantmaker could allocate to highest merit w.p. 1, but this is too costly

Retrospective evaluation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Grant Management as Hidden Action Problem

After receiving grant, researcher chooses how to use funds

Potential conflict of interest between researcher and funder

- Privately optimal action; e.g., travel to conferences
- Socially optimal action; e.g., work on proposed agenda

Conflict arises if:

$$\text{private benefit} \succ_{\text{Researcher}} \text{social benefit}$$

and

$$\text{private benefit} \prec_{\text{Funder}} \text{social benefit}$$

How can funder align incentives of researcher with funder's incentives?

How Can Funder Align Incentives of Researcher?

Suppose funder has signal about researcher's choice; e.g. lack of publications

Funder can introduce tools to affect grantee's incentives; e.g., by

- (temporary) exclusion from future grant calls (Maurer & Scotchmer, 2004)
- splitting grant into stages

If well-designed, grantee's incentives align with funder's preferences:

$$\text{private benefit} - \text{punishment} \prec_{\text{Researcher}} \text{social benefit}$$

and

$$\text{private benefit} \prec_{\text{Funder}} \text{social benefit}$$

Concluding remarks

Randomness as Overarching Theme

Randomness, in various forms, is prevalent at many stages

- Evaluation noise shapes self-selection into application, investment incentives
- Evaluation costs add more randomness to allocation
- Noise when monitoring effort of funded researchers

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Randomness may be beneficial or detrimental, e.g.

- random allocation allows economizing on evaluation costs ...
- ... but may interfere with application/investment incentives

Open Questions

Many other interesting issues:

- How to deter wasteful persuasion effort?
- How to steer direction of research?

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- How to deter wasteful persuasion effort?
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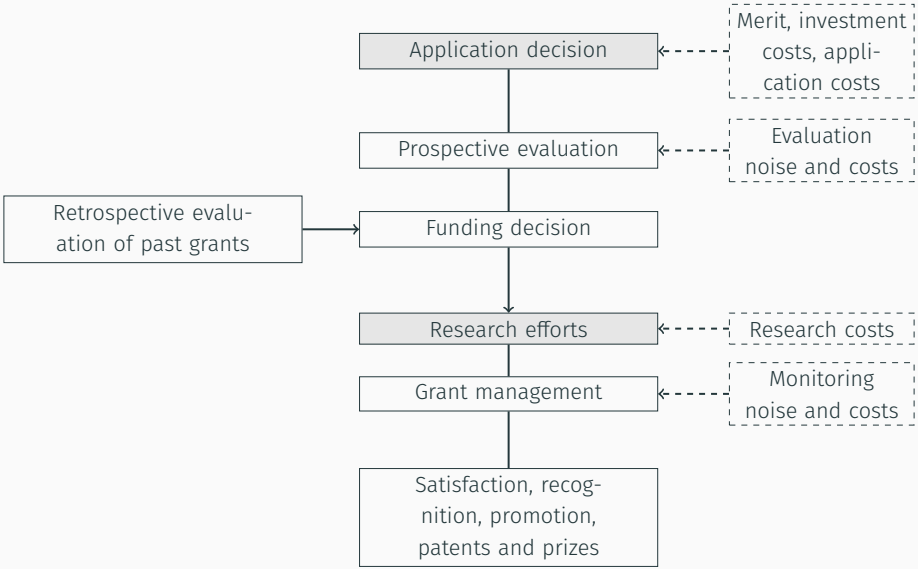
Challenges:

- Combination of retrospective evaluation with prospective evaluation?
- Most theoretical work not tailored to grant allocation— missing key details?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Appendix

Costly Evaluation

Costly Evaluation

Single-agent version of Ben-Porath et al. (2014)

- One applicant with privately known merit $t \in [-1, 1]$
- Grantmaker's belief about t is given by cdf. F
- Grantmaker enjoys payoff t when funding applicant, 0 otherwise
- Suppose $\mathbb{E}_{t \sim F}[t] \leqslant 0 \Rightarrow$ a-priori, grantmaker would not fund applicant
- Grantmaker can verify t by paying cost $c > 0$ (costly panel evaluation)
- Applicant only cares about funding prob.

Mechanisms

Mechanism specifies verification and funding prob depending on reports and verified merit

Timing:

1. Applicant chooses report $\hat{t}$
2. Grantmaker verifies applicant w.p. $v(\hat{t})$
   - if report $\hat{t}$ matches verified merit t, funding prob. is 1
   - if report $\hat{t}$ does not match verified merit t, funding prob. is 0
3. If applicant is not verified, funding prob. is $q(\hat{t})$

Mechanism is truthful if truthful report is optimal for applicant

Grantmaker finds it optimal to use truthful mechanism

Truthful Reports

Expected funding prob. if applicant has merit t and reports truthfully:

$$p(t) = v(t) \cdot 1 + (1 - v(t)) \cdot q(t)$$

Mechanism is truthful if and only if for all $t, \hat{t}$,

$$p(\hat{t}) \geqslant p(t) - v(t)$$

In words:

- If applicant with merit $\hat{t}$ misreports t, applicant wins with same prob. $p(t)$ as t-merit applicant...
- except if grantmaker verifies report, and then applicant loses funding ($-v(t)$)

Optimal mechanism

Equivalently, mechanism is truthful if and only if

$$v(t) \geqslant p(t) - \underbrace{\inf_{\hat{t}} p(\hat{t})}_{=\underline{p}}$$

Grantmaker's utility:

$$\mathbb{E}_{t\sim F}\left[p(t)t - v(t)c\right]$$

Subject to truthfulness, $v(t)$ is set as small possible:

$$\mathbb{E}_{t\sim F}\left[p(t)t - (p(t) - \underline{p})c\right] = \mathbb{E}_{t\sim F}\left[(p(t) - \underline{p})(t - c) + \underline{p}t\right]$$

Intuition: If grantmaker raises $p(t)$ above $\underline{p}$, report t must be verified $\Rightarrow$ effective payoff is $t - c$

Optimal Mechanism

$$\mathbb{E}_{t\sim F}\left[(p(t)-\underline{p})(t-c)+\underline{p}t\right]$$

Optimal mechanism: $\underline{p}=0$, and $p(t)=\mathbf{1}(t\geqslant c)$

- Grantmaker funds (and verifies) applicants with merit above c
- Others are unfunded

Note: If merit is between 0 and c, grantmaker would like to fund, but does not do so in optimal mechanism