PRINCETON UNIVERSITY

BENDHEIM CENTER for FINANCE

Webinar: Encouraging the development and manufacturing of vaccines and diagnostics

WITH MICHAEL KREMER

HARVARD UNIVERSITY

Friday, May 1, 12:30 PM ET

Pre-Registration Required

BENDHEIM CENTER for FINANCE | Griswold Center | Public Policy & Finance | PRINCETON ECONOMICS

Intro: MARKUS BRUNNERMEIER Twitter: @MarkusEconomist

PRINCETON UNIVERSITY

BENDHEIM CENTER for FINANCE

Markus' intro

- Previous/future webinars
  - Joseph Stiglitz: Evaluating US Response
  - Dani Rodrik: Future of Globalization
- Speakers

Website: http://**bcf.Princeton.edu**

Vaccine/Tests & Externalities

- Get vaccinated
  - Tradeoff: avoid getting sick vs. -ve side effects

    +

    don't infect others
    (+ve externality)

- Internalize externality
  - Command & control
  - Permit not to be vaccinated (tradable?)
  - Pigouvian Tax/subsidy

Vaccine/Tests & Externalities

- Get vaccinated
  - Tradeoff: avoid getting sick vs. -ve side effects
    - high
    - low

    \+

    don't infect others (+ve externality)
    - high
    - low

Introducing heterogeneity (in side effects + externalities)

- Internalize externality
  - Command & control
  - Permit not to be vaccinated (tradable?)
  - Pigouvian Tax/subsidy

Moral question/Fairness:
Should rich people
Be allowed to buy their way out?

Production: Vaccines/Diagnostic

- Externality: Reduced demand ⇒ Reduced Supply

- Intervention:
  - Command & Control
  - Subsidize
  - X-Prize

+ uncertain investment (risk premia due to fin. frictions)

➡ Advanced Market Commitments
  - https://www.who.int/immunization/newsroom/amcs/en/

Background: All-pay auction

- Prize $100
  - For highest bidder
- Bid & pay $x

- Suppose 4 bidders:
  - You: $50 Others' bids: $98, $80, $40
    - You bid next: $99

POLL01: Yes or No

Background: All-pay auction

- Prize $100
  - For highest bidder
- Bid & pay $x

- Suppose 4 bidders:
  - You: $50 Others' bids: $98, $80, $40
    - You bid next: $99 POLL01: Yes or No
  - You $99 Others' bids: $100, $80, $40
    - You bid next $101 POLL02: Yes or No

Background: All-pay auction

- Prize $100
  - For highest bidder
- Bid & pay $x

- Suppose 4 bidders:
  - You: $50 Others' bids: $98, $80, $40
    - You bid next: $99 POLL01: Yes or No
  - You $99 Others' bids: $100, $80, $40
    - You bid next $101 POLL02: Yes or No
  - You $102 Others' bids: $101, ….

Escalation Game

Vaccine-X-Prize

- Prize $100 — $100M for vaccine discovery
  - For highest bidder
- Bid & pay $x — $xM in R&D expenditures

- Suppose 4 bidders: — 4 pharmaceutical companies
  - You: $50 — Others' bids: $98, $80, $40
    - You bid next: $99 — POLL01: Yes or No
  - You $99 — Others' bids: $100, $80, $40
    - You bid next $101 — POLL02: Yes or No
  - What if social pressure doesn't allow Pharma companies not to be part of the R&D race?

(Dynamic) Mechanism Design

- How long to stay in the R&D race for a new vaccine? (roll out a diagnostic test)

- Timing games
  - "War of attrition" — Bulow & Klemperer, …
  - with R&D spillovers — Reiganum, …
  - With co-opetition
    Clock games — with Abreu, Morgan
  - …

+ many other relevant aspects

Patent buy-outs

- Michael Kremers' 1998 paper
  PATENT BUYOUTS: A MECHANISM FOR ENCOURAGING INNOVATION
- Eliminates monopoly distortion
- Eases adoption and follow-up research
- At what price?
- *Notice similarity to Michael's webinar title!*

PRINCETON UNIVERSITY

BENDHEIM CENTER for FINANCE

Webinar: Encouraging the development and manufacturing of vaccines and diagnostics

WITH MICHAEL KREMER

HARVARD UNIVERSITY

Friday, May 1, 12:30 PM ET

Pre-Registration Required

BENDHEIM CENTER for FINANCE | Griswold Center | Public Policy & Finance | PRINCETON ECONOMICS

Intro: MARKUS BRUNNERMEIER Twitter: @MarkusEconomist

FINANCING A COVID-19 VACCINE

Susan Athey, Stanford

Arthur Baker, Harvard

Owen Barder, Precision Agriculture for Development

Juan Camillo Castillo, Stanford

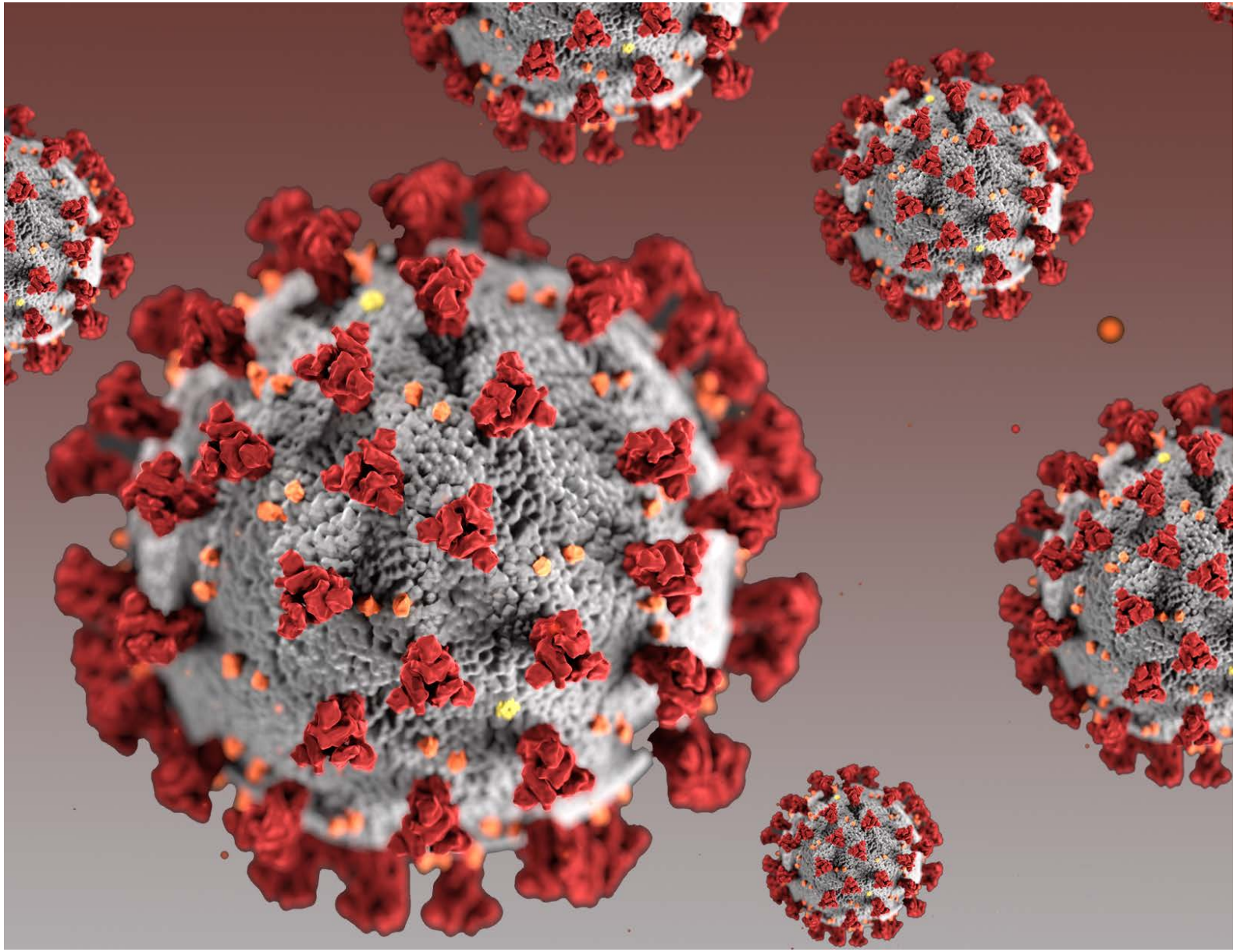
Michael Kremer, Harvard

Jean Lee, World Bank

Jonathan Levin, Stanford

Christopher Snyder, Dartmouth

Alex Tabarrok, George Mason



IMF estimates $9 trillion loss due to COVID-19 over two years

Suggests ~$375B gain from accelerating development of effective vaccine by one month

Normal vaccine timeline:

- At least 3-4 years from initial testing to commercial use
- Capacity installation only after trials (at least 6 months)
- Firms build limited capacity to serve high income market initially, long delays before roll out to LMICs.

IS IT WORTH BUILDING LARGE-SCALE CAPACITY IN PARALLEL WITH TRIALS?

- Private incentives to accelerate vaccine development may not correspond with social benefit
  - Disease externalities; spillover economic benefits from reduced social distancing, government buyers
  - Installing large capacity may put pressure on prices in high-income countries
- Back of the envelope calculation:
  - Costs of “wasted” capacity vs. benefits of accelerating vaccine?
  - If positive, how many vaccines worth large-scale accelerated investment?

BACK OF THE ENVELOPE CALCULATIONS

- Collect data on vaccine candidates by stage of development, technological approach
- Estimate chance of success for each, based on historical record, adjustments for production difficulty given accelerated timeline, expert input
- Incorporate correlated risks (by platform)
- Will refine approach over time
- Estimate that 14 candidates necessary for 90% chance at least one vaccine available within 18 months
- Implies lots of “wasted” capacity

CALCULATING THE OPTIMAL NUMBER OF VACCINE CANDIDATES

Marginal benefit:

- Marginal increase in probability of vaccine development * $375 billion per month * 6 months advance in vaccine development
- Discounted by 50 percent chance that drug developed that averts 50 percent of COVID-19 costs

Marginal cost:

- $1 per annual unit of capacity (takes into account capacity fungibility)
- Consider case of 6B annual capacity, so can vaccinate 1.5B people within three months.
  - Rough estimate of vulnerable + health workers

Social optimum:

- Equate marginal cost and benefit if invest in 15 vaccines
- Total social benefit ($1.59 trillion) >> total social cost ($90 billion)

STRUCTURING FUNDING

- **Consider a model in which mass of firms have private information that** low chance of producing vaccine rapidly

- Suppose impossible to perfectly audit costs
  - Particularly in context of multi-product firms, repurposing facilities

- Suggests that may be appropriate to cap reimbursement of capacity expenditures. Consider 80% cap.

PROPOSED FUNDING STRUCTURE

- Provide direct finance to cover 80% of the cost of manufacturing capacity
- Firms are required to cover 20% of capacity cost, so they have skin in the game
- Around $72.5bn for 15 vaccine candidates.
- In return firms agree to provide an option to purchase
  - Two-part pricing to reward firm, while generating static efficiency
- Set “pull” funding to make marginal firm willing to participate.

CALCULATING REQUIRED PULL FUNDING

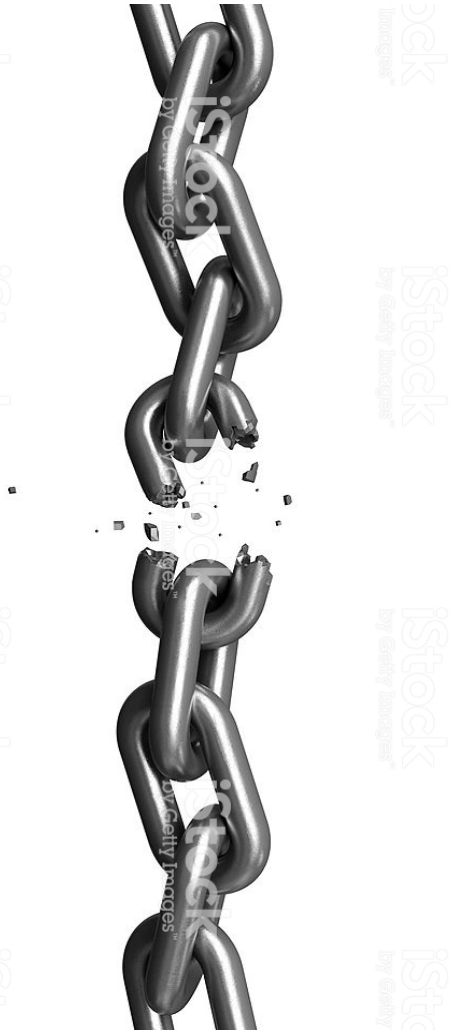
- Cost for firm to install manufacturing capacity = $1.2bn (20% cost share).
- Production cost borne by firm (if sole successful vaccine) = $4.5bn ($1 per person, 4.5bn people).
- Probability of success for marginal (15^{th}) candidate = 11%
- Probability of getting funding for marginal candidate = 33%
- Firm indifferent whether to invest when pull funding is $39.5bn
- To adjust for risk, incentivize speed, set the price per dose at $35 for the first bn, $5 for the subsequent 3.5bn. Total pull funding of $52.5bn

PULL FUNDING

- $52.5 billion in bonus if vaccines available within 18 months
- Price structure: $35 for the first 1bn, $5 each for subsequent 3.5bn
- If multiple vaccines developed, governments have authority to choose which product or products to purchase.
- Top up vs. price: firm participation constraint

SUPPLY CHAINS: FOR WANT OF A VIAL, THE VACCINE MAY BE LOST.

- The supply chain for vaccines will be under pressure. Glass vials may be a bottleneck.
- Consider İnvesting in production of key inputs?



COULD INTERNATIONAL COOPERATION BE INCENTIVE COMPATIBLE?

- Consider partnership in which each member contributes 0.15% of 2018 GDP ($125bn)
  - World Bank loans for developing countries. IDA? Forgivable if no vaccine?
- Enough capacity would be built to serve all members' vulnerable population within 3 months, entire population within one year
- Members get first access to vaccine
- Non-members are not subject to price cap
- If a critical mass of countries join, in each country's national interest to join:
  - Avoid risk that own candidates fail
  - The returns of early vaccination for vulnerable populations are very large.
  - Compatible with extra financing for domestic candidates.
- Arguably incentive compatible early, but not later

LIGHT COOPERATION?

- Deals with foreign firms to finance extra capacity in advance, in order to diversify their portfolio
- Agreement on non-exclusivity?
- Informal coordination on supply chains?

INNOVATIONS TO SPEED VACCINE TRIALS?

- Early revelation of clinical trial data to guide manufacturing decisions
- Testing multiple vaccines together?
- Adaptive trials
- Challenge trials

END

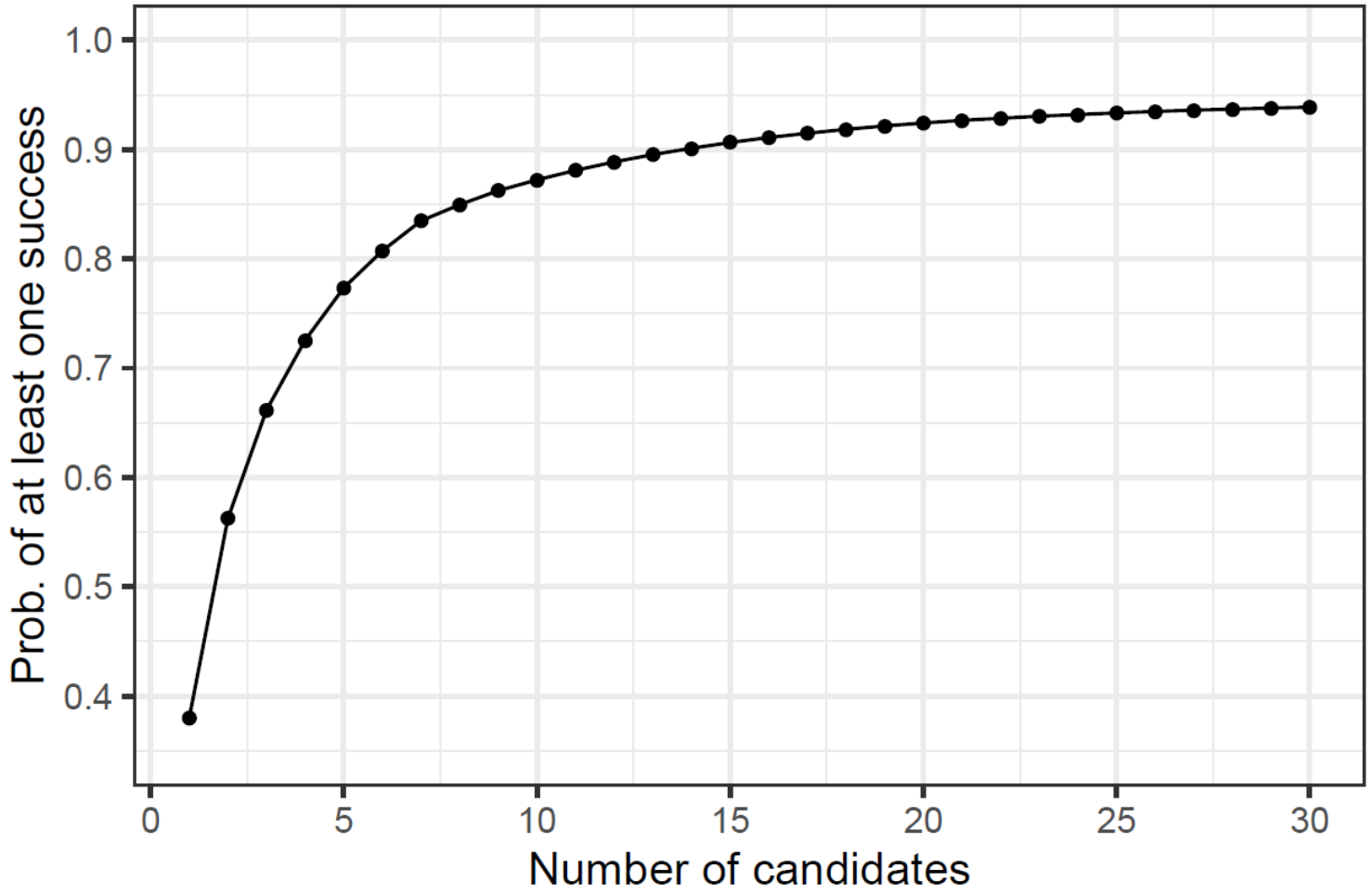
FIRMS CAPTURE A SMALL FRACTION OF SOCIAL RETURNS FROM ADVANCING A VACCINE

- Will argue large socSpeeding up a vaccine requires installing large scale production capacity.
- Installing capacity is expensive. Firms could serve the same population over a longer period with less capacity.
- Firms must install capacity in advance in order to produce as soon as a vaccine is ready. Firms bear risk, but benefit is to the whole of society.
- Static distortions: firms might price out countries which value vaccine above marginal cost.
- If firms produce a very high volume of vaccine they may worry they will need to sell to LICs at lower rates which might undermine their price margins in HICs.

THE CASE FOR GOING BIG: CAPACITY

- **Firms lack incentives to build/repurpose the socially efficient capacity**, If firms produce a very high volume of vaccine they may worry they will need to sell to LICs at lower rates which might undermine their price margins in HICs.

VACCINE SUCCESS PROBABILITIES



Probabilities includes estimates of correlation of risks across candidates within a platform. Data on vaccine candidates from WHO.

INSURANCE

- Weitzman (2012) has emphasized the importance of limiting global carbon emissions as a kind of insurance to limit tail risks. The same issue of tail risk arises with COVID-19 but over a matter of months and years rather than over many decades.
- Will a treatment make a vaccine less necessary (we assume a 50% probability of reducing value of vaccine by 50%).
- Could COVID-19 dissipate due to weather, beneficial mutation, herd immunity or other factor?
- Could COVID-19 return in the fall in a second wave, as did Spanish flu, worse than the first wave?
- Could detrimental mutations make COVID-19 worse?
- Could COVID-19 turn into an endemic disease requiring annual vaccination?
- Many unknowns and many unknown unknowns.
- The risks justify significant investment even if fortune favors us.

CALCULATING THE OPTIMAL LEVEL OF INVESTMENT

To calculate optimal level of investment, find:

1. N vaccine candidates at which marginal cost = marginal benefit.
2. Push funding required of 500m per month capacity for N vaccine candidates.
3. Pull funding required to induce Nth candidate to participate.

CALCULATING THE OPTIMAL NUMBER OF VACCINE CANDIDATES

HOW DOES THIS FIT WITH MONDAY'S PLEDGING CONFERENCE?

- Donors are seeking to raise $8bn in funding for **vaccines, therapeutics and diagnostics**. Far too low.
- This has mainly been thought of as a developing country initiative. It is in the interest of developed countries to join and make this much bigger
- A vaccine could easily cost $500 per person (it would be highly cost-effective at that price if it enabled reopening the economy)
- If the UK bought the vaccine for 50% of the population that would cost UK £10bn. USA might well spend 10 times that.
- Spending some of that money now to help ensure there is sufficient supply would bring a vaccine sooner.

QUANTIFY AND REFINE

- Our approach is to find a quantitative estimate, and refine over time.
- These numbers are not set in stone.

CALCULATING REQUIRED PULL FUNDING

The marginal firm is indifferent about participating where expected cost = expected benefit

- The marginal firm's expected cost is:

$$0.2\ (probability\ of\ success) +\ (probability\ of\ getting\ funding) * (production\ cost)$$

- The marginal firm's expected benefit is

$$(probability\ of\ success) * (probability\ of\ getting\ funding) * (pull\ funding\ value)$$