GLOBAL ENVIRONMENTAL RISK –
ECONOMIC OBSERVATIONS ON PANDEMICS

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BACKGROUND

endogenous risk

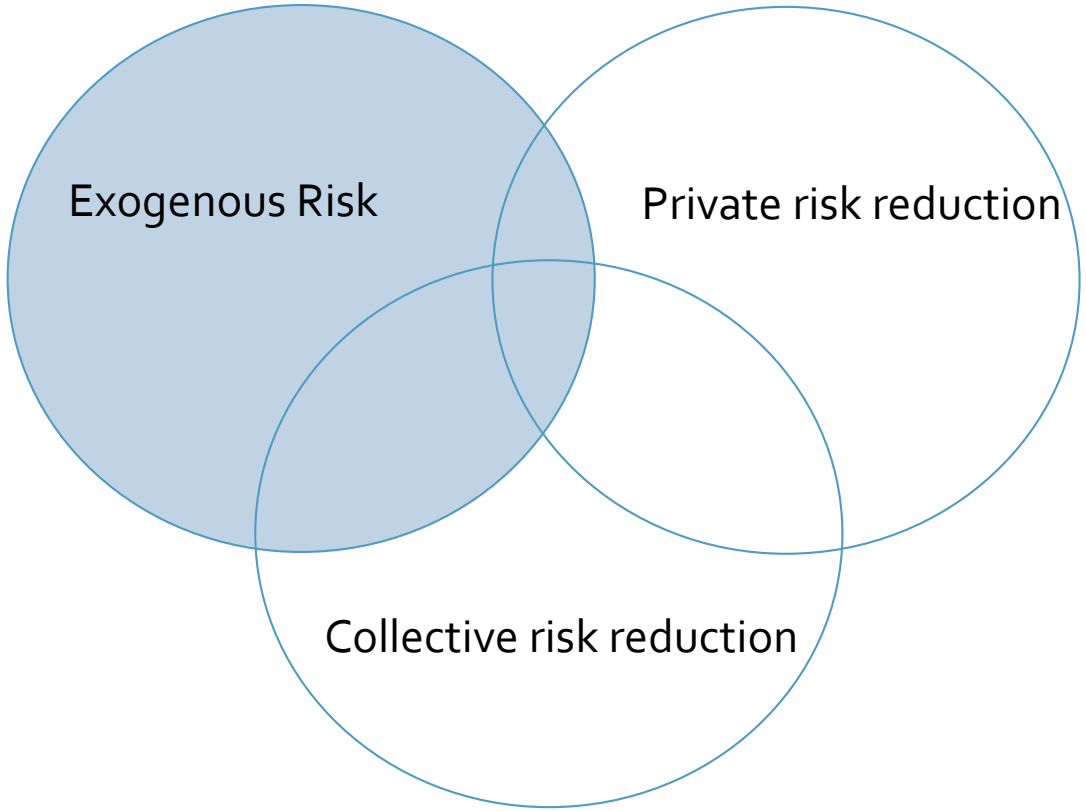
Two perspectives:

- Protect us from X
- Protect Y from us

A MINDSET

- PROSPERITY
- FAILURE
- RISK
- CONFLICT
- COOPERATION
- CONTROL
- VALUATION

ENDOGENOUS RISK



INVESTING TO REDUCE RISKS TO HEALTH: HUMAN & ENVIRONMENTAL

- ENVIRONMENTAL POLICY AS A LOTTERY
- LOW PROBABILITY – HIGH SEVERITY EVENTS
- MAKE THE ODDS MORE LIKELY GOOD THINGS HAPPEN AND BAD THINGS DO NOT
- SELF-PROTECTION & SELF-INSURANCE
- MITIGATION & ADAPTATION
- PREVENTION & CONTROL & ERADICATION
- AVERTING BEHAVIOR & DEFENSIVE ACTIONS

Endogenous risk

- People have preferences over lotteries over outcomes
- Self-protection – reduce chance of bad state
- Self-insurance – reduce severity of bad state
- Privately invest to make it more likely good things happen and bad things do not
- Static and dynamic

Self-protection

- $EU = p(z)u(w-z) + (1 – p(z))v(w – d – z)$

- $p'[u – v] – [pu' + (1 – p)v'] = 0$

Extensions based on behavioral factors

- $F(p'[u – v] – [pu' + (1 – p)v']) + E = 0$

My take on this pandemic story

- States on Nature
  - Peaceful Kingdom (ex ante)
  - 9 Circles of Hell (ex post)
  - Guardian angel keeps the two apart
- BUT when choices have consequences
  - New lotteries emerge
  - Odds of Introduction & establishment
- 9 Circles of Hell bleed into the Peaceful Kingdom

Static version

$$EU = \Phi(z)u(w - z - N) + (1 - \Phi(z))[\Psi(N)u(w - z - N) + (1 - \Psi(N)v(w - d(N) - z - N)]$$

- $\Phi(z)$ – probability of no introduction
- $\Psi(N)$ – probability of no establishment

THREE QUESTIONS FOR PANDEMICS:

Q1: Valuing risk reductions?

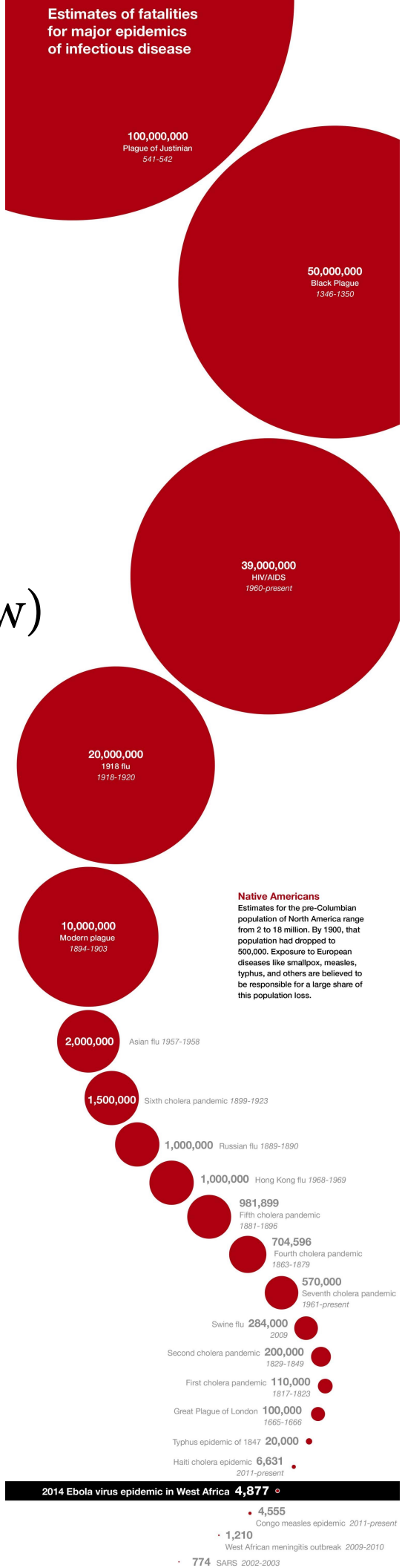
Q2: Investing in prevention stock vs flow?

Q3: Mechanism design and R&D Incentives?

Plague of Justinian 100m (541-542)

Black Plague 50m (1346-1350)

AIDS 30m (1960-now)



QUESTION 1:
VALUING RISK REDUCTION?

Valuing a pandemic:
Exploring trade-offs in rational risk reduction

J Pike, D Aadland, WK Viscusi, & P Daszak

- Emerging infectious diseases are on the rise, increasing the risk of a pandemic
- HOW does US public think about pandemic risks given competing risks?
- Homeland Security Report—USA is unprepared

- A National survey to elicit the opportunity cost based on two measures:
  - (1) risk-risk tradeoffs between pandemics and environmental/ terrorist events (Viscusi et al.)
  - (2) risk policy effectiveness based on number of lives saved per dollar expenditure (Cameron and James)

Example of RISK-RISK

Suppose you can vote for one of two policies that cost the same amount but reduce different kinds of risks.

Policy #1 prevents 50 deaths caused by an environmental disaster.
Policy #2 prevents 100 deaths caused by a pandemic outbreak.

Which of the two policies would you prefer?

_____environmental disaster policy

_____pandemic outbreak policy

Policy #1 prevents 250 deaths caused by a terrorist attack.
Policy #2 prevents 25 deaths caused by a pandemic outbreak.

Which of the two policies would you prefer?

_____terrorist attack policy

_____pandemic outbreak policy

FIGURE 3
Minimum Lives Saved (LVS) question

Suppose a pandemic outbreak from diseased animals will reach the US in the next 15 years. The pandemic could be mild, medium, or severe, in terms of predicted deaths. Predicted US deaths for a mild pandemic are 22,000 more deaths in a year, for a medium pandemic are over 200,000 more deaths in a year, and for a severe pandemic are over one million more deaths in a year.

Suppose a US/global policy exists to reduce the probability of a pandemic outbreak from interactions with diseased animals; this policy would prevent _____ expected US deaths. This policy would cost your household $5 more each year. If you vote in favor of this policy it implies taking money away from other programs to reduce terrorism, flu, traffic accidents, cancer, and heart disease. Would you vote in favor of this policy?

_____yes _____no

3 results

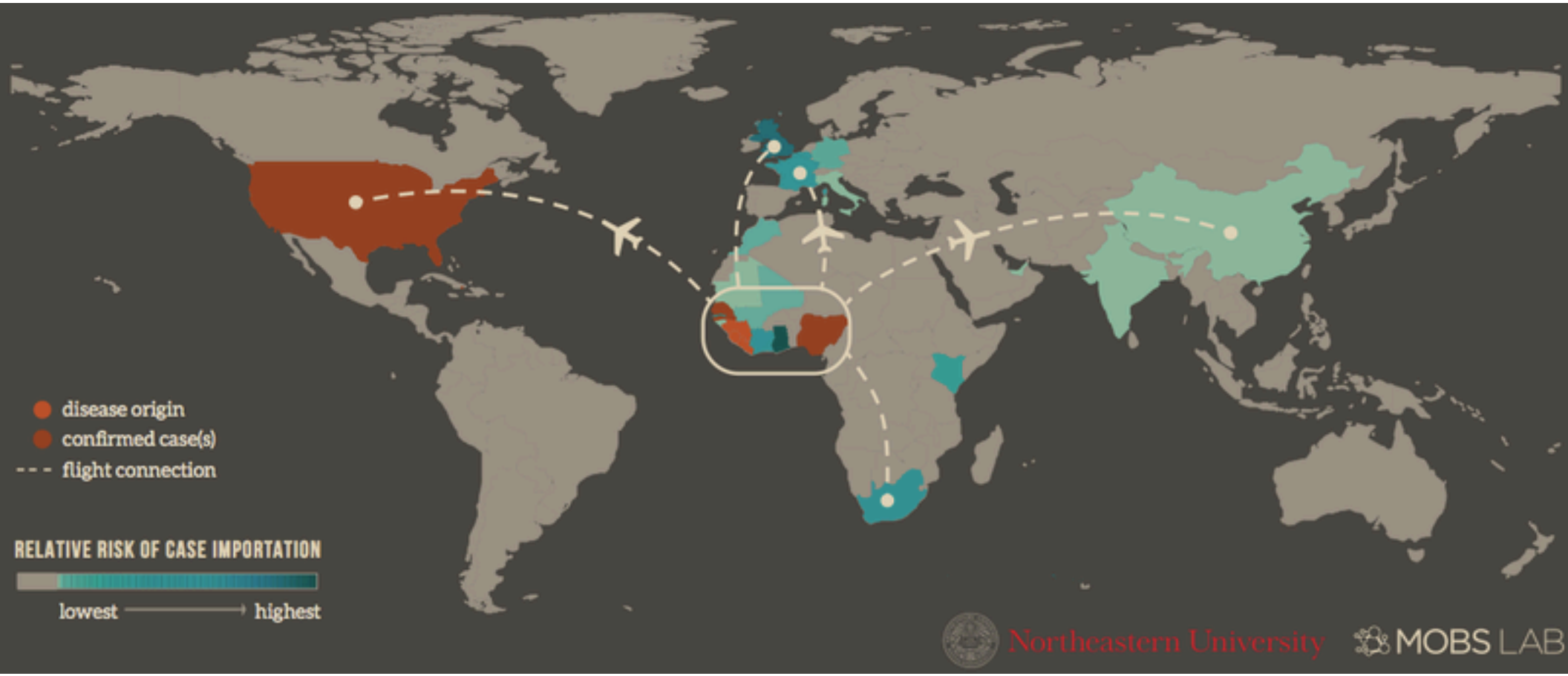
- National US web-based panel, we find:
- First, preventing deaths from environmental disaster or terrorist is ~3.5 times more valuable than pandemic risks.
- A life saved should be a life saved…
- …BUT US citizens did NOT quantify unfamiliar risks posed by pandemic outbreaks
- Implied VSL is ~$1.7m

- Second, their behavior still seem predictable.
- People view pandemic risks on par if:
  - Educated about risks
  - Experienced a catastrophe
  - More vulnerable to a catastrophe
  - Geographical closer to *a prior* catastrophe

- Third, average US citizen needed nearly 500,000 saved lives for a $5/year contribution to a pandemic risk policy
- Does not contradict idea that USA is unprepared for pandemic

Revisiting preferences after 2014 Ebola Scare

- Survey 1 – July 2013
- Ebola Scare – 2014
- Survey 2 – Jan 2015


disease origin
confirmed case(s)
flight connection
RELATIVE RISK OF CASE IMPORTATION
lowest
highest
Northeastern University
MOBS LAB

Re-ran the Survey after Ebola scare

- Wake up to Reality
- NOW: 1:2.5 risk tradeoffs vs 3.5:1
- NOW: $16m VSL vs $1.7m VSL
- Complacency vanished
- But will new vigilance dissipate?

Preparing for the Next Outbreak

Public Views on Global Infectious Diseases and Health Security

July 2015

WORLD BANK GROUP

A global survey: 4,000 interviews in five key developed countries

- Survey of publics & opinion elites in 5 key developed countries
- France, Germany, Japan, UK, US
- Web survey, conducted June 15-24, 2015
- Total of 4,000 interviews
- 600 interviews with general public in each country
- Additional 172-200 “extra” interviews in each with “opinion elites”
  - Defined as university diploma + closely follow global news
  - Total of 2,052 interviews with opinion elites

Key findings: high concern; low confidence; support for investment

1. In wake of Ebola crisis, high concern about global health & disease outbreaks

2. Most not convinced global community or own country prepared to respond

3. Majorities support investment in developing countries to protect own health

QUESTION 2:
INVESTING IN PROTECTION STOCKS?

How should the US Government allocate

$6.18 billion to stop Ebola?

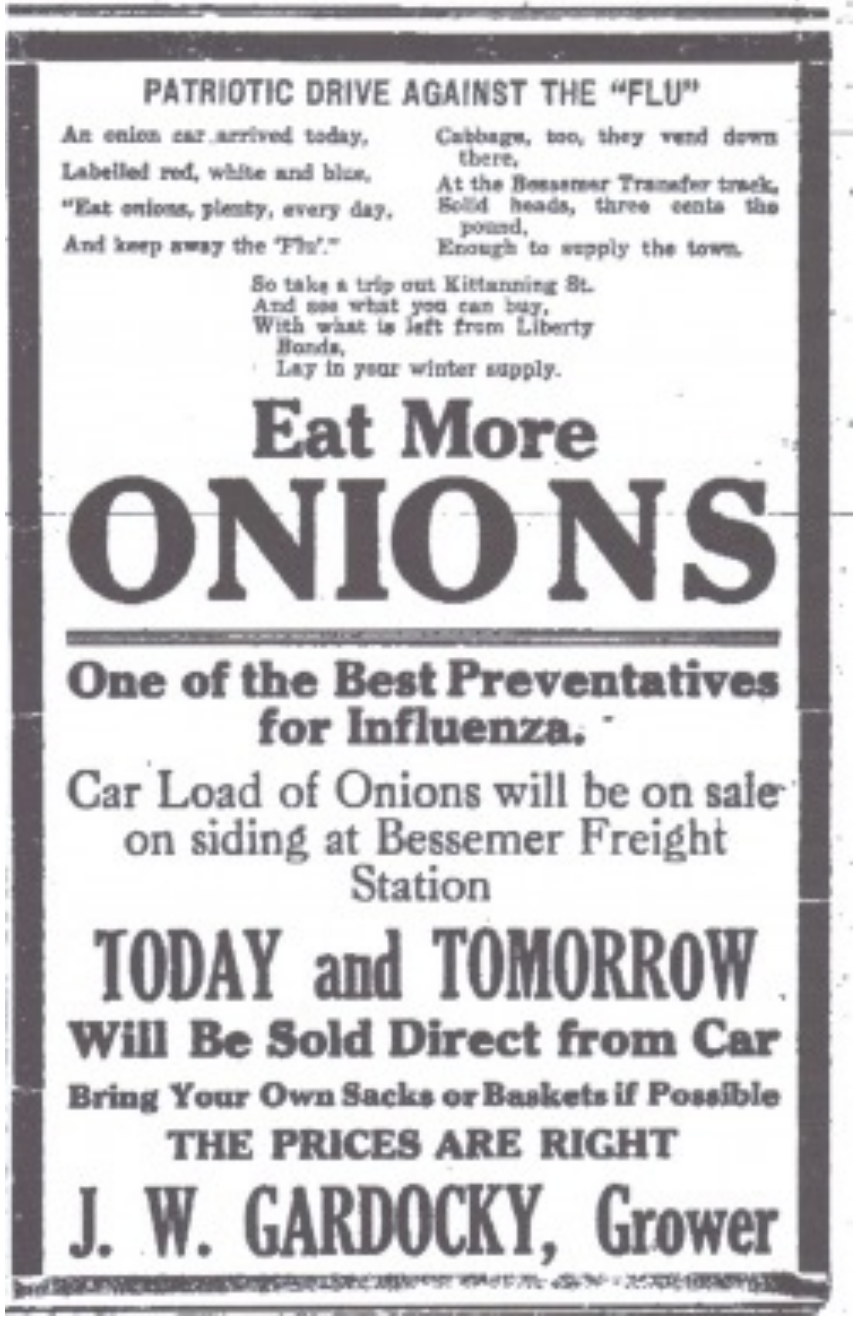
K Berry, C Allen, R. Horan, J Shogren, P Daszak, & D Finnoff

Motivation

- President Obama asking Congress for $6b for Ebola
- How to spend this $6b?
- Lack of clarity between
  - immediate response
  - contingency funding
  - capacity building

Model

- Endogenous risk in dynamic setting
- Poisson event models - Polasky et al. Tsur & Zemel
- Increasing background risks- Tsur & Withagen



PATRIOTIC DRIVE AGAINST THE "FLU"

An onion car arrived today,
Labelled red, white and blue,
"Eat onions, plenty, every day,
And keep away the 'Flu'."

Cabbage, too, they vend down there,
At the Bessemer Transfer track,
Solid heads, three cents the pound,
Enough to supply the town.

So take a trip out Kittanning St.
And see what you can buy,
With what is left from Liberty Bonds,
Lay in your winter supply.

Eat More

ONIONS

One of the Best Preventatives for Influenza.

Car Load of Onions will be on sale on siding at Bessemer Freight Station

TODAY and TOMORROW

Will Be Sold Direct from Car

Bring Your Own Sacks or Baskets if Possible

THE PRICES ARE RIGHT

J. W. GARDOCKY, Grower

- ASSUMPTIONS
- Influenza arrives by a plane and spreads rapidly, causing large morbidity/mortality and lost productivity.

- Outbreaks: small, localized, & burn out.
- Disease is present - outbreak that becomes a pandemic may have occurred before the "event" itself occurs.
- Event means the disease reaches the urban area which creates a pandemic

The conditional current value Hamiltonian is

$$H = -n - wu - C(N) - JX\psi(N, b, u) + \rho_1(n - \delta N) + \rho_2\psi(N, b, u) + \lambda\sigma(b) \quad (4)$$

Investments in prevention capital, n, have a unit cost of one and flows of prevention effort, u, have a unit cost of w.

Prevention capital includes a flow of costs to operate the existing stock, $C(N)$ beyond depreciation expenses.

Conditional costate variable for prevention capital is ρ_1, the conditional costate variable for the cumulative hazard is ρ_2, and λ is the conditional costate variable for the exogenous background probability

Modeling issues

- Poisson model - uncertainty restricted to the timing of the event
- Magnitude can be treated as the known expected value of a system after outbreak.
- Focus on ex-ante mitigation via Stock and Flow of prevention

- KEY RESULT:
- Spend the $6b on stock of prevention within the region of origin
  - Immediately investment in a stock
  - Support stock with a flow to maintain capacity building against pandemic re-emergence.

- NUMERICAL EXAMPLE:
- A capital stock of $970 million yielded expected savings of $10.3 billion.
- A flow of investment equal to ~$50 million annually required to maintain this stock at the steady state.

Prevention Stock

Risk

Investment in stock maintenance

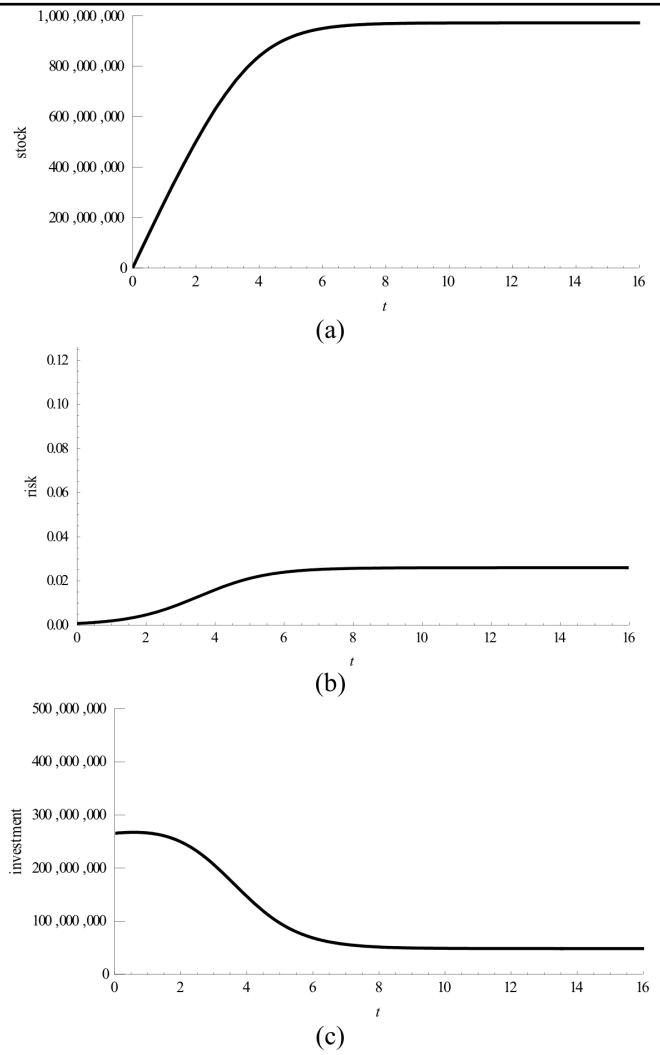


Fig. S3

The above figures are calibrated to when it takes $5 billion to make the risk of an outbreak negligible, with a 2.6% risk of an outbreak. The outbreak would cause damages of $32.6 billion. In Fig. S3a the stock of prevention capital increases from nothing to $500 thousand in one large impulse investment while risk is negligible, and then large investments in the stock cause it to rise to $970 million as the risk, shown in Fig. S3b increases from .2% to 2.6%. As the stock increases investment in prevention decreases from $265 million to roughly $48.6 million, the amount needed to replace capital as it depreciates. The expected savings from optimally controlling the system increase as the risk increases from $10.3 billion to $4.5 billion.

- Capacity building is more effective than development of pathogen-specific vaccines is counter-intuitive
- If risk decreases (technology, infrastructure), cut investments to let stock naturally depreciate.
- Results represent a lower bound – do not reflect positive spillover effects from healthcare on development outcomes.

- Raises NEW POLICY QUESTION:
- Should the West & East treat Ebola and other EIDs as a self-interested development strategy?
- – not just an emergency medical response issue
- A “standing FOREIGN army” for Ebola prevention?

QUESTION 3:
MECHANISM DESIGN & R&D FOR VACCINES

Mechanism Design with Push-Pull Subsidies

J Pike, J Shogren & K van't Veld

Push vs Pull Subsidies - which public strategy will better promote private investment in vaccine R&D?

Push strategy - Supply-side - a subsidy per unit costs to develop vaccine

Pull strategy - Demand -side - guaranteed purchase of vaccine

Two cases to consider

1. Govt can capture all rents from firms

First best - no difference in Push vs Pull

2. Govt cannot capture rents

First best - ambiguous which strategy generates more effort

Depends on relative convexity of probability of success and costs of

Next steps in theory:
- understand convexity of probabilities and costs
- consider asymmetric information on:

cost containment
reputation as good citizen
social norms as good citizen

Final Observations

- Pandemics
  - Pre-Ebola: USA underestimate pandemic risks << Terrorism risk
  - Post-Ebola: Risk = risk
- US should Invest in STOCK of prevention in source country
- Push vs Pull R&D subsidies?
-
- Sovereign Wealth Funds?
  - Skoll Global Threats Fund
  - Pandemic Emergency Financing (PEF) – World Bank, IMF, WHO, UN, G20
  - WY Wildlife & Natural Resource Trust