RSAConference2015
San Francisco | April 20-24 | Moscone Center

SESSION ID:

The Wolves of Vuln Street: The 1st System Dynamics Model of the 0day Market

Katie Moussouris
Chief Policy Officer
HackerOne
@K8em0 <— that's a zero

Michael Siegel
Principal Research Scientist
Massachusetts Institute of Technology
@MITsloan

Collaborators

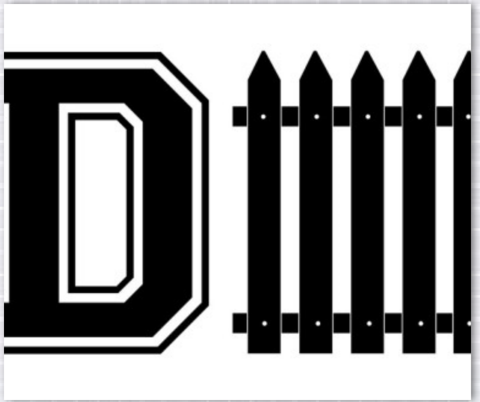
- 0day market system dynamics research funded by **Facebook**

Research Team

Dr. Michael Siegel, Principal Research Scientist, Sloan School, Massachusetts Institute of Technology
James Houghton, Sloan School, Massachusetts Institute of Technology
Dr. Ryan Ellis, Harvard Kennedy School
Collin Greene, Security Engineer, Facebook
Katie Moussouris, Chief Policy Officer, HackerOne

Why Model the 0day Market?

Myths and Markets – Money Isn't Everything



$$$

DEFENSE

$$$$$$

MIXED USE

$$$$$$$$$$$$$$$$$$$$$$$
$

OFFENSE

WANTED: Dead or Alive – Over $500,000 PAID

Microsoft's Strategic Bounty Programs:

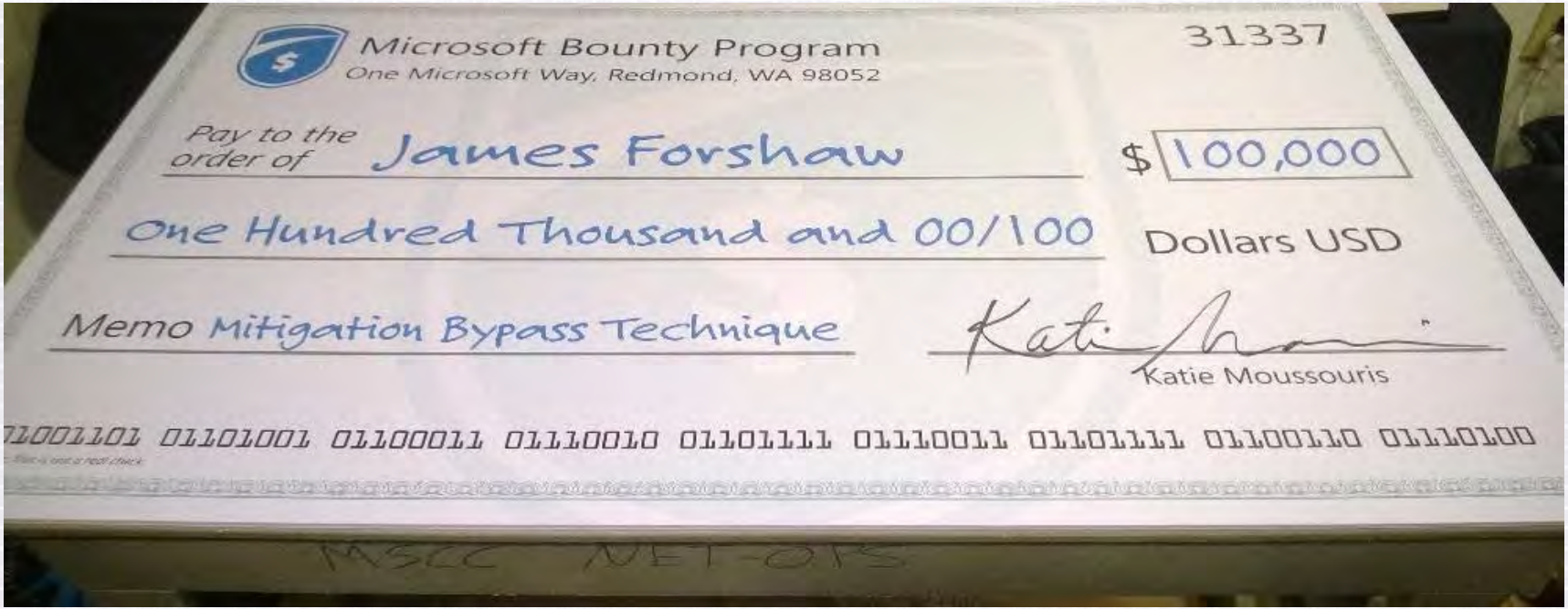
$100,000 for new techniques

$50,000 for new defenses

$11,000 for IE11 beta bugs

Mitigation Bypass Bounty: $100,000 for a Technique

James and the Giant Check

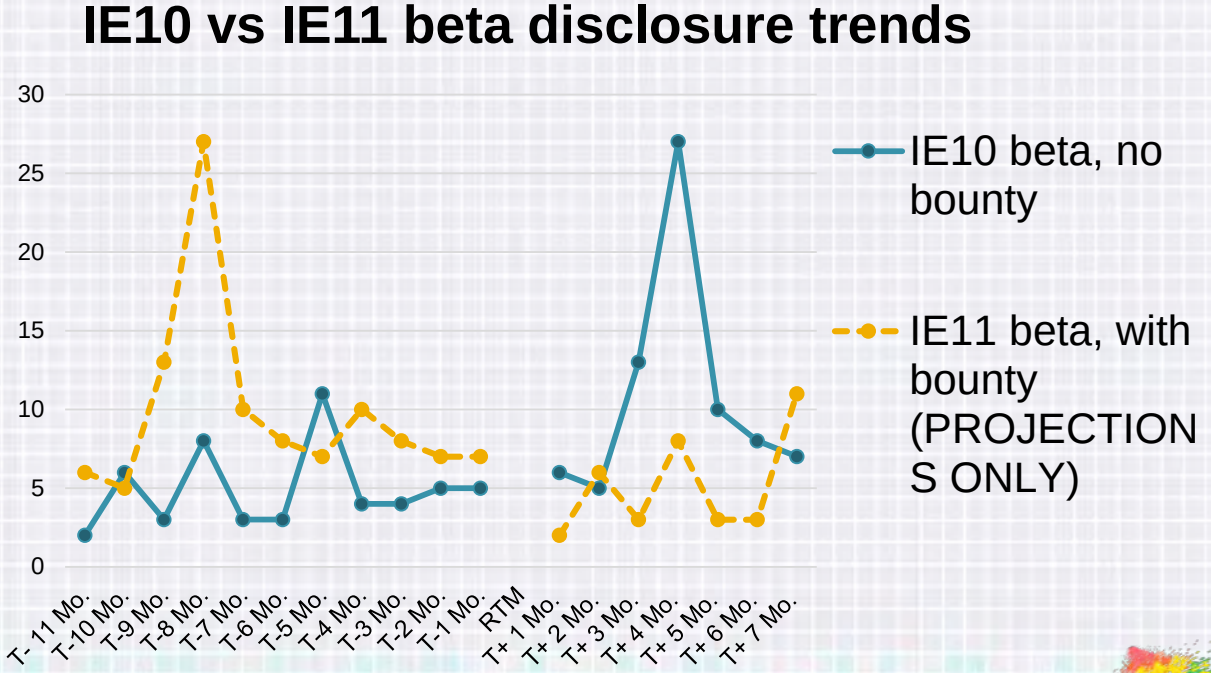


IE Preview (AKA Beta) Bug Bounty: All in the TIMING

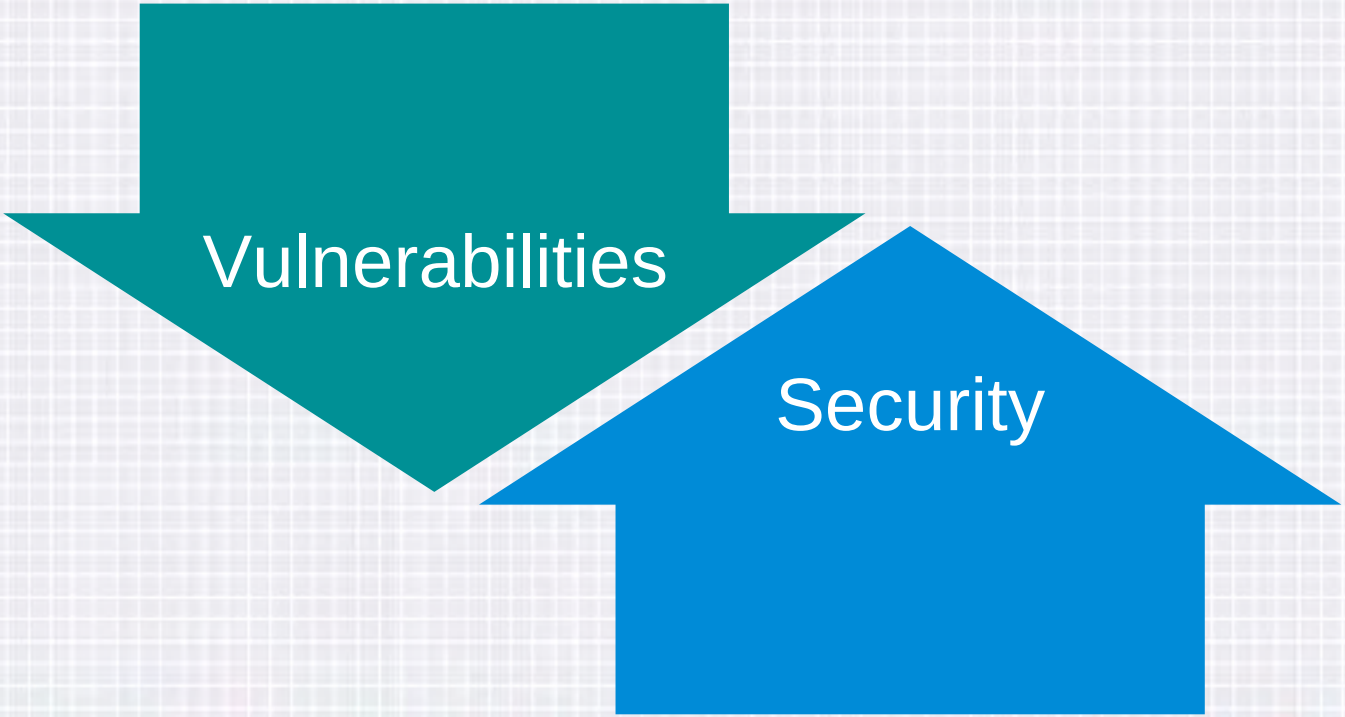
- James and the Giant Check

Marketplace Gap:
When Defense is the only game in town

Actual Results:
18 serious security holes



Vulnerabilities and Security



Vulnerabilities: All Different but Still Fruit

Creating a Vulnerability Typology

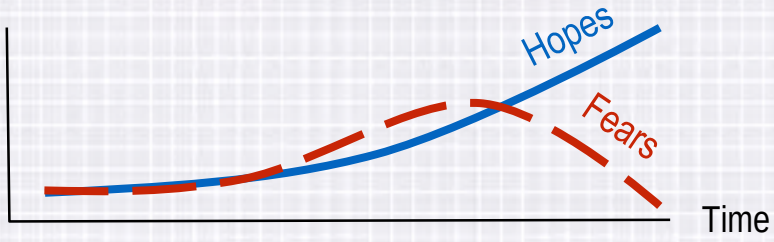
Vulnerability Characteristics	Quantity of Vulnerabilities	➢	Scarce - Numerous
	Ease of Vulnerability Discovery	➢	Easy - Difficult to Find
	Likelihood of Vulnerability Rediscovery	➢	Low - High
Patching Dynamics	Technical Difficulty of Remediation	➢	Easy - Hard to Fix
	Logistical Difficulty of Remediation	➢	Easy - Hard to Access
	Average Life of a Vulnerability	➢	Short - Long
Market Dynamics	Third Party Market for Vulnerability	➢	Offensive, Defensive, Mixed, Etc.
	Market Size	➢	Small - Large
	Bug Bounty Program	➢	Yes, No
Human Dynamics	Attackers	➢	Criminals, States, Patriots, Etc.
	Researcher Pool	➢	Small - Large
	Attacker Motivation	➢	Political, Financial, Reputational

System Dynamics Modeling

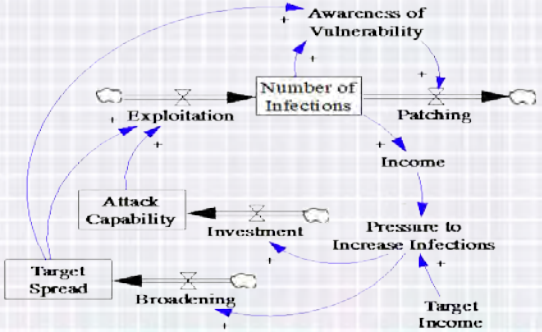
I. Models Complex Human Systems

- ✓ Process Improvement
- ✓ Market Crises
- ✓ Government Stability
- ✓ Software Development

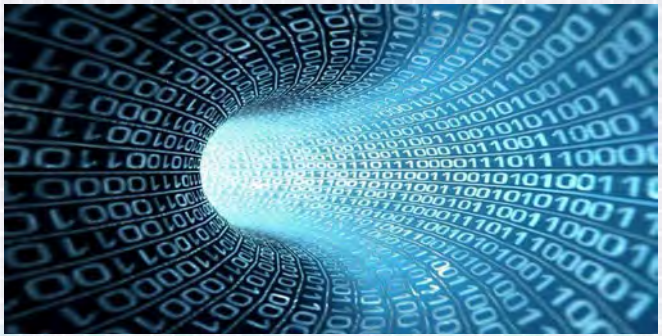
II. Simulates Dynamic, Nonlinear Behavior



III. Formalizes Connection, Causality & Feedback



IV. Gives Structure to Data

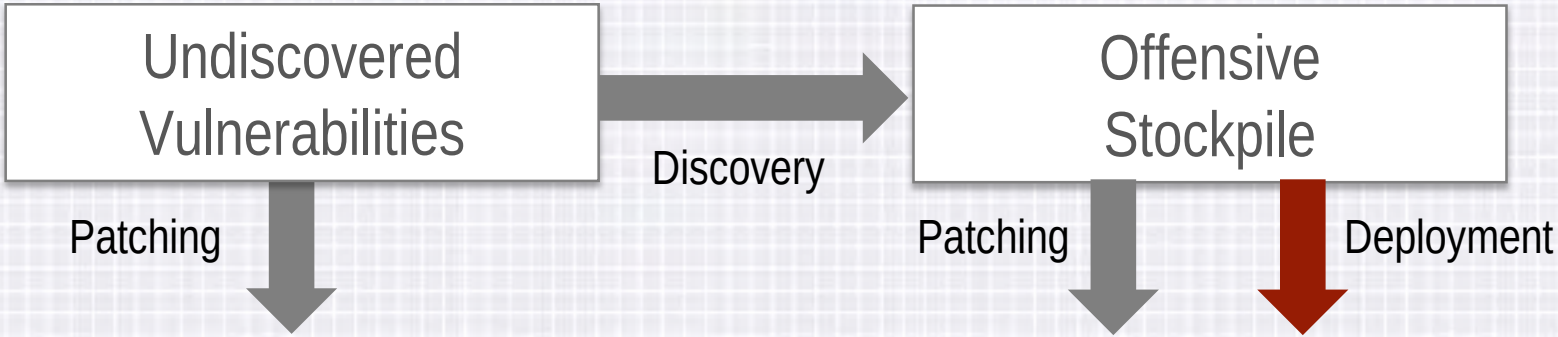


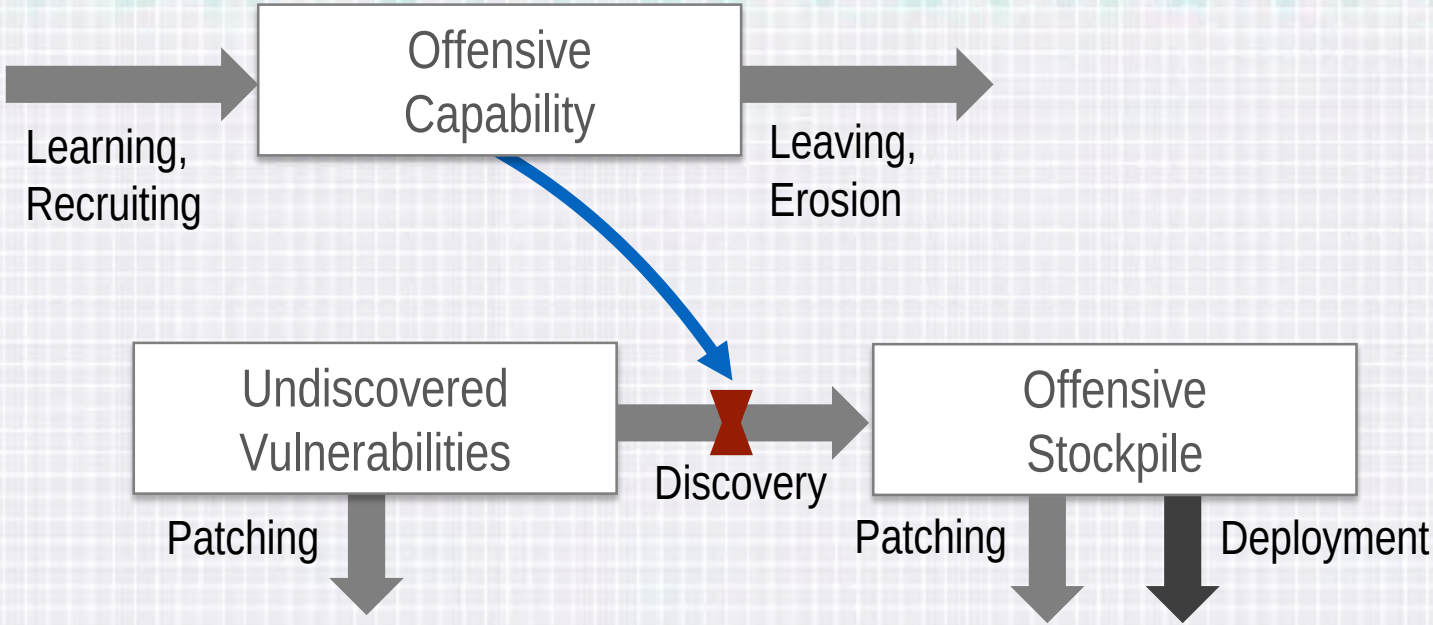
RSAConference2015

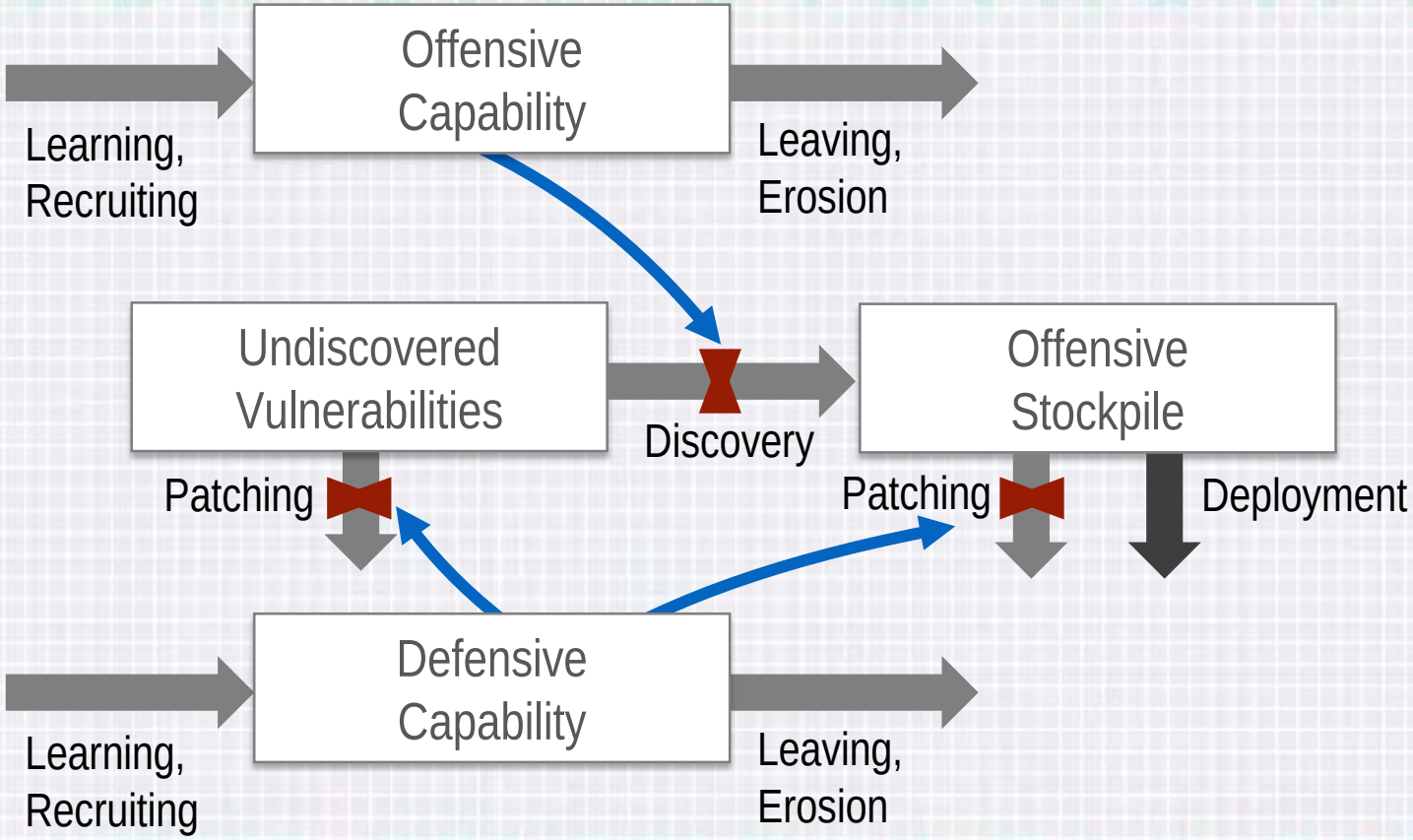
What policy levers do we have for reducing vulnerability?

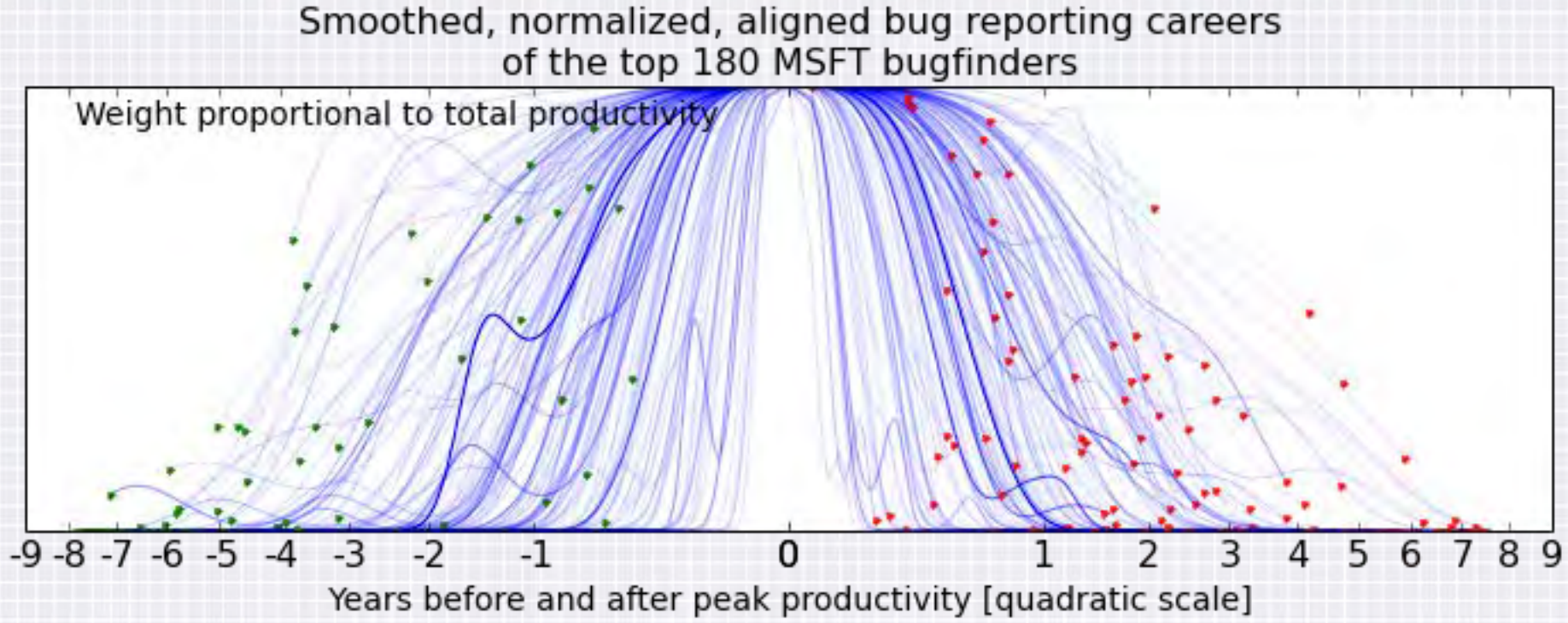
Which has the most leverage?

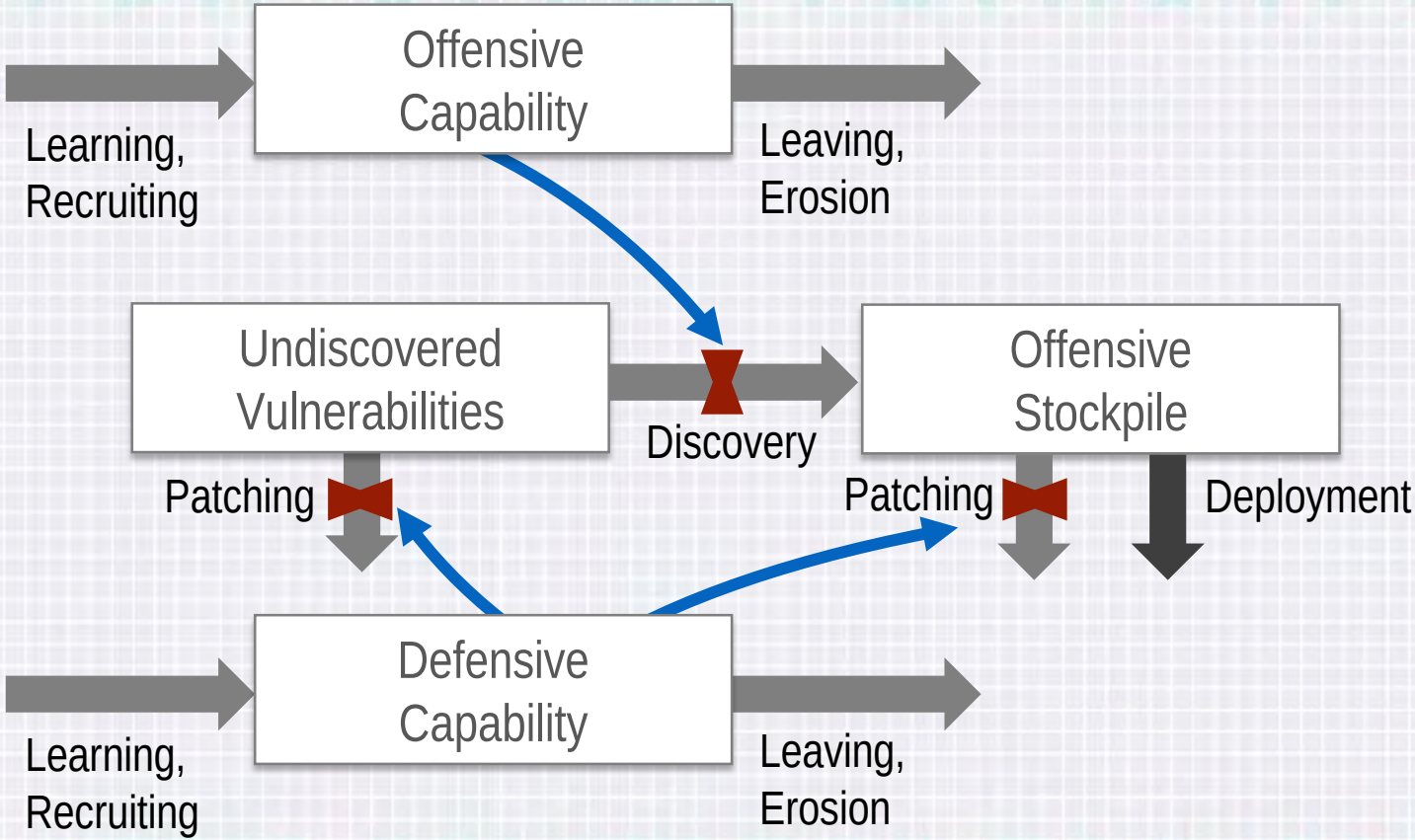

Undiscovered
Vulnerabilities
Patching

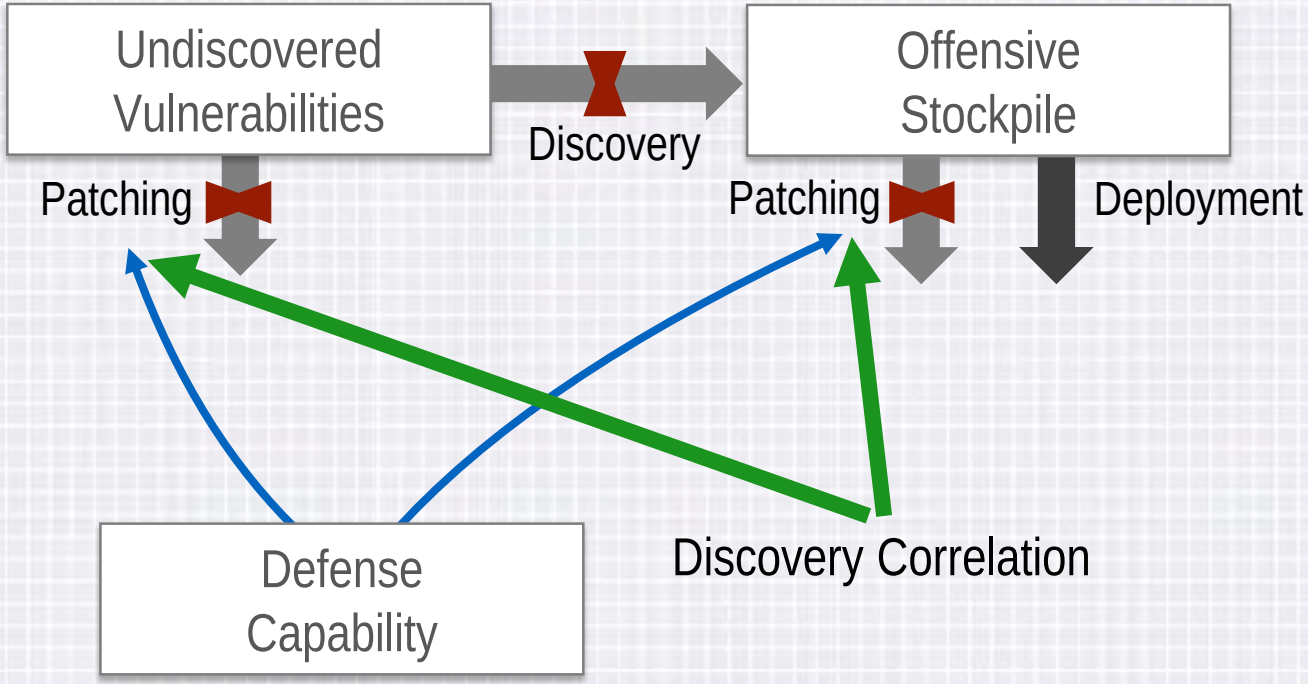

Undiscovered Vulnerabilities
Discovery
Offensive Stockpile
Patching
Patching
Deployment


Offensive Capability
Learning, Recruiting
Leaving, Erosion
Undiscovered Vulnerabilities
Discovery
Offensive Stockpile
Patching
Patching
Deployment

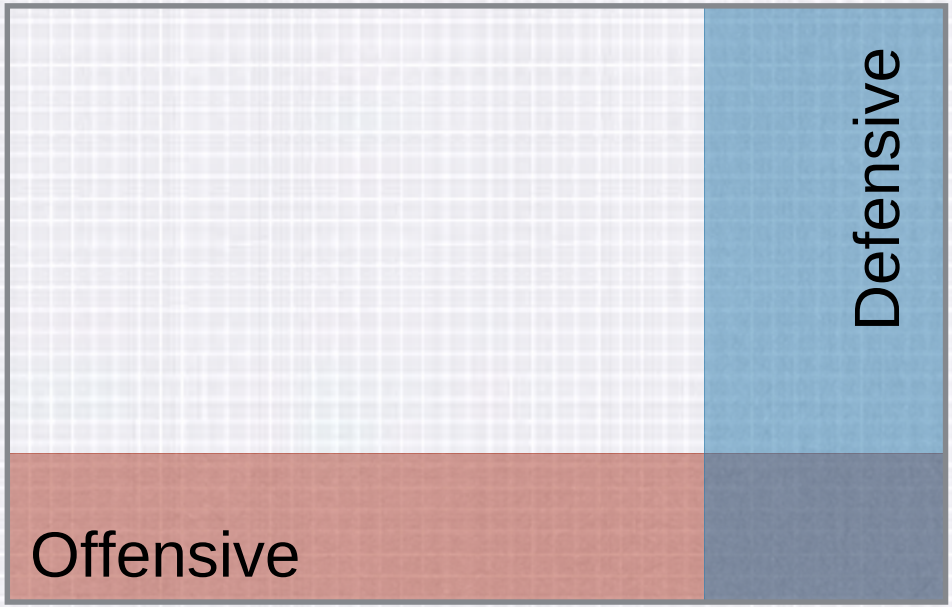

Offensive Capability
Learning, Recruiting
Leaving, Erosion
Undiscovered Vulnerabilities
Discovery
Offensive Stockpile
Patching
Patching
Deployment
Defensive Capability
Learning, Recruiting
Leaving, Erosion


Smoothed, normalized, aligned bug reporting careers
of the top 180 MSFT bugfinders
Weight proportional to total productivity
-9 -8 -7 -6 -5 -4 -3 -2 -1 0 1 2 3 4 5 6 7 8 9
Years before and after peak productivity [quadratic scale]

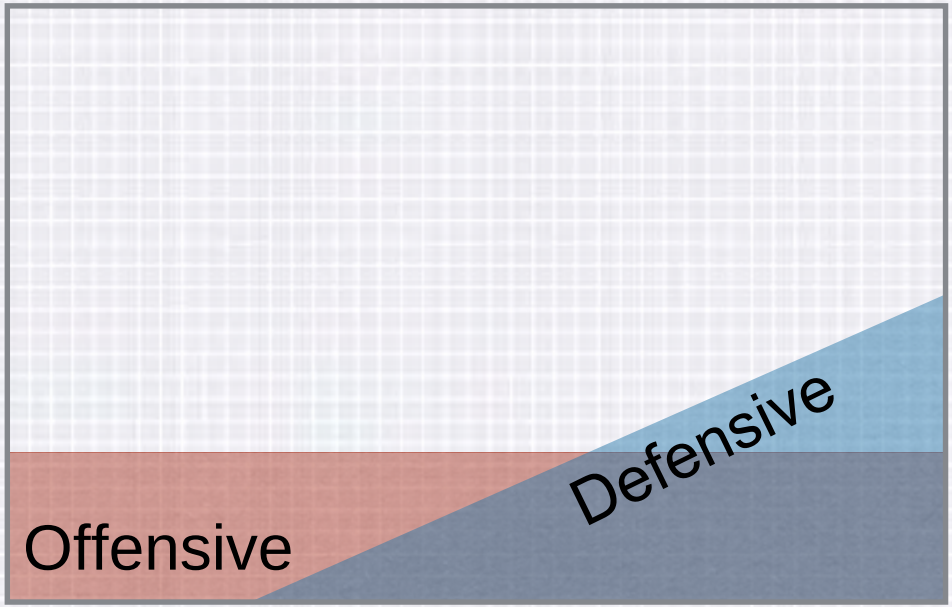

Offensive Capability
Learning, Recruiting
Leaving, Erosion
Undiscovered Vulnerabilities
Discovery
Offensive Stockpile
Patching
Patching
Deployment
Defensive Capability
Learning, Recruiting
Leaving, Erosion


Undiscovered Vulnerabilities
Discovery
Offensive Stockpile
Patching
Patching
Deployment
Defense Capability
Discovery Correlation

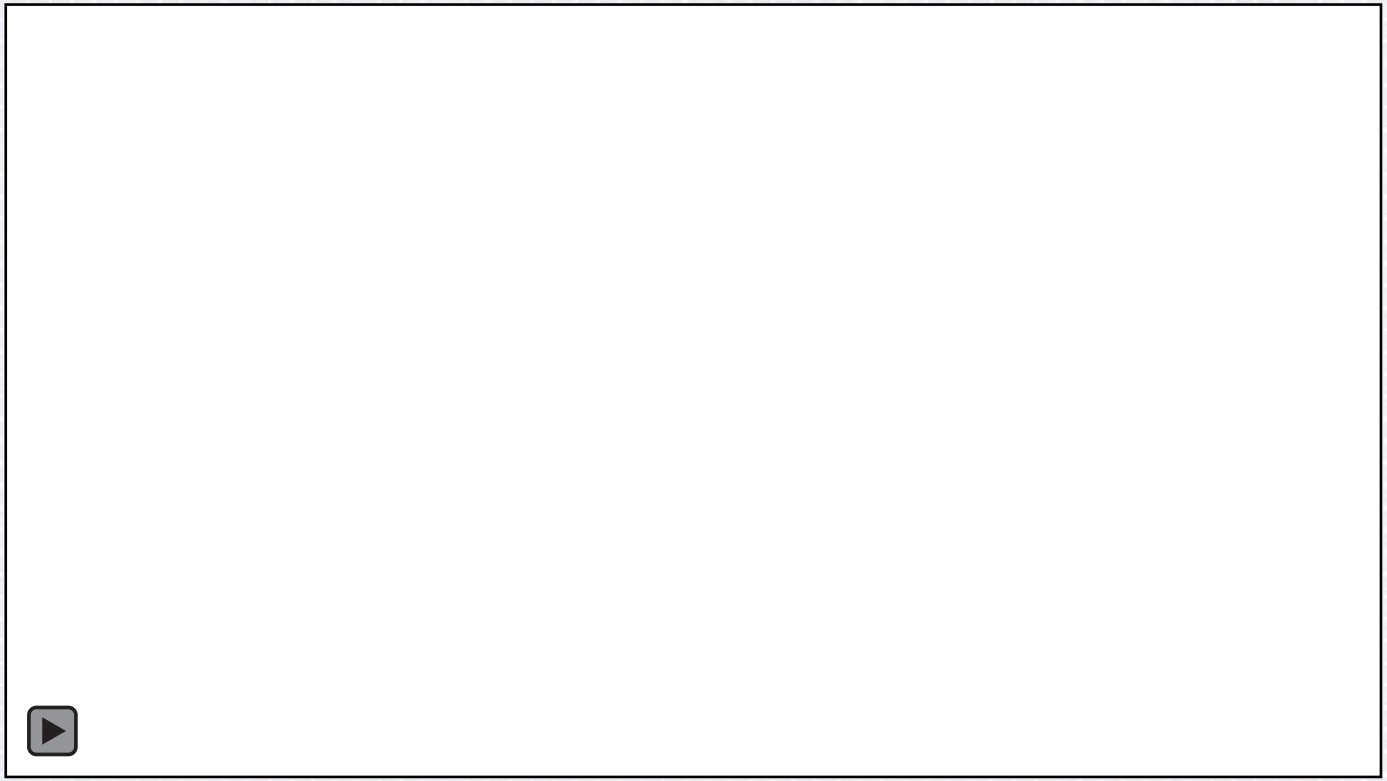
No Correlation



Some Correlation



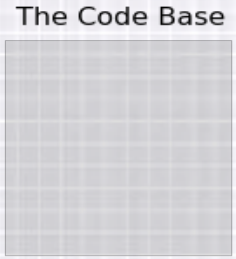
The 0day Market System Dynamics Model



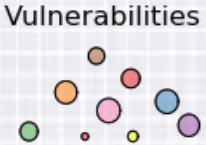
"Bug Collisions" Between Offense & Defense

- Discovery from offensive stockpile is very sensitive to the correlation. A powerful lever!
- Defensive capacity development or offensive capacity minimization have different levels of importance depending on the value of the correlation.

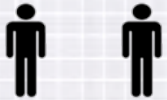
How does discovery correlation arise and behave?



Fixed code base

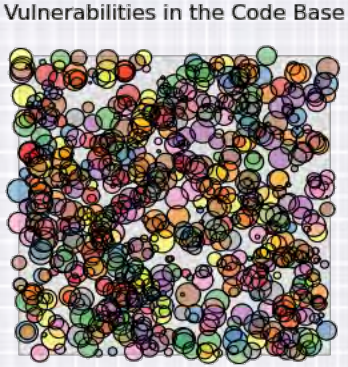


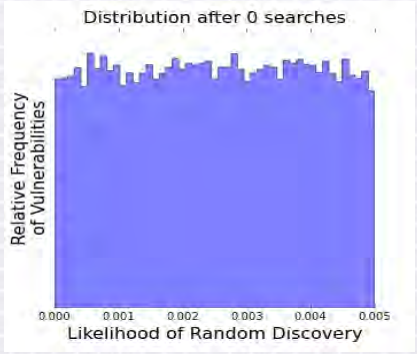
Heterogeneous vulnerabilities

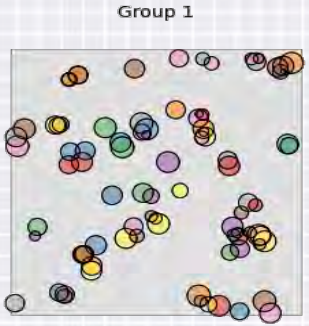


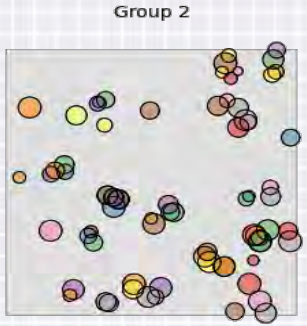
Common techniques between research groups

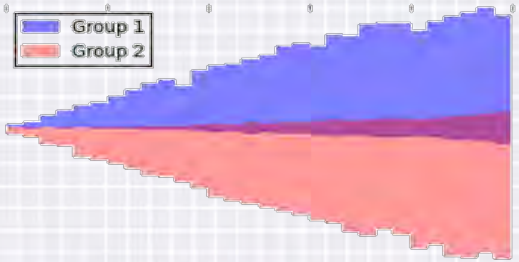
For a young piece of software





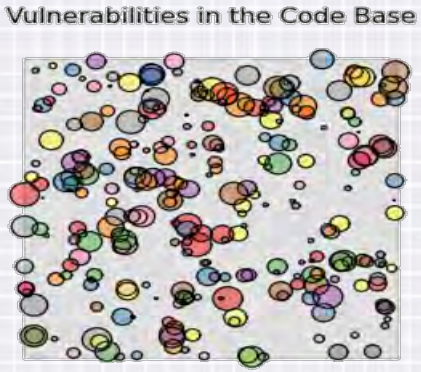


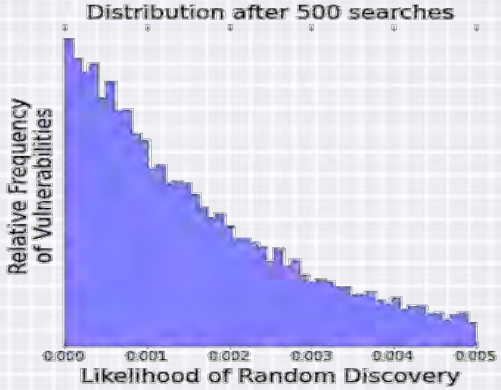


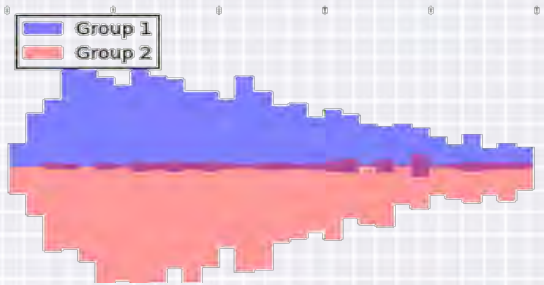


With our model parameters, 9% overlap

For a hardened piece of software







With our model parameters, 0.8% overlap

Rate of "Bug Collisions" Varies with Target

- Correlation can arise naturally due to varied discovery difficulty
- As software becomes more hardened, expect to see less correlation between discovery groups

Defenders Scale Best With Tools & Techniques

Money Changes Everything

- Be careful not to create perverse incentives
- Unintended consequences of draining resources if defense bounties are too high

Key Takeaways For Organizations

- Creating incentives for tools and techniques for vulnerability discovery is a more efficient way for defenders to drain the offensive stockpile
- Bug bounties are still effective to help find vulnerabilities, especially in less mature software
- The vulnerability market is not controlled by price alone.

Key Takeaways for Governments

- Many governments are in the role of both attacker and defender
- Governments need to broaden the focus of policy debates, it is not just about whether or not to stockpile individual vulnerabilities for offense
- Governments reap defense gains when they make vulnerability discovery tools and techniques available to defenders.

Applying this Research in the Real World

- Use Incentive programs!
- Bounty tools and techniques (e.g., fuzzers & tools that help determine exploitability). The most effective way to drain the offensive stock pile.
- Bug bounties are an effective way to help find vulnerabilities, especially in young software.

What Are We Doing?

- The Internet Bug Bounty is offering bounties for tools and techniques this year.
- We are looking to involve more organizations in our research with MIT

It Has Not Escaped Our Notice...

- The Wolves of Vuln Street are among us
- We are studying the dynamics of the pack to make the shepherds of the Internet Defense more effective
- More models are needed to identify and mobilize other levers besides price in the 0day market

Evolve the Model: All Hands on Deck