# Externalities in Communications and Information Technology: Market Failures and Remedies

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# Our definition of NET

- Instead of the terms:
  - Internet Economy
  - technological advancement of the 90s
  - (PCs, PDAs, cellular, …)
  - information superhighway
  - internet, etc.
- We use a shortcut for brevity and call all of this

NET

# problem statement

- Economics of NET reliability & security (R&S)
- Negative externalities make NET unreliable and insecure
- Are there any mechanisms to reduce NET incentive suboptimality?
- Is current NET R&S provision at a constrained Pareto frontier? In other words:

# NET externalities [the causes]

- For technology reasons NET is a public good: NET depends on actions of many players (manufacturers and users). This results in suboptimal manufacturer incentives, see Varian (2002) review
- NET property rights deficiencies & high enforcement costs distort investment incentives
- Due to aforementioned externalities NET R&S are underprovided (levels are lower that socially optimal)

# The literature

- The literature: NET externalities cause suboptimal manufacturer incentives due to
  - NET Public good nature [Varian (2002)].
  - NET information deficiencies
  - NET property rights deficiencies and high enforcement costs

# Our contribution

- Summarize factors contributing to NET externalities
- Compare mechanisms to alleviate NET externalities [all mechanisms we have found in the literature]
- Propose a mechanism to alleviate NET externalities
- Provide Political-Economic Outlook

# Deficient property rights

- Property rights are deficient when they are
  - poorly defined or conflicting ➔ divergence of *ex ante* and *ex post* investment incentives [hold-up problem]
  - poorly enforceable [high enforcement costs]

# Insecure NET property rights

- NET property rights are insecure:
  - Conflicting property rights due to NET public good features & information deficiencies
- enforcement costs depend on
  - Technology [Technological environment and forensics]
  - Legalities
- both drive NET enforcement costs up

# NET enforcement costs are high

- Technological reasons:
  - information deficiencies:
  - high costs of determining the specific cause of failure
    - exact software product that failed
    - exact reason of the failure (reliability or security (R or S))?
- Legal reasons
  - need to develop new legal rules
  - need to accumulate legal precedents
  - high contract costs due to legal and technological barriers

# High costs of NET enforcement

- High NET enforcement costs are due to:
- Technological factors
  - information deficiencies:
  - high costs of determining the specific cause of NETfailure
    - exact software product that failed
    - exact reason of the failure (reliability or security)?
- Legal factors
  - need to develop new legal rules
  - need to accumulate legal precedents
  - need to develop NET forensics
- High enforcement costs ➔ high contract costs

# Urgently needed: reliable and secure NET

- Volume of NET financial transactions: [cite]
- Low R&S make NET transactions riskier
- Urgency to make NET more reliable and secure is well understood [cite]
- Can NET reliability and security be improved fast? I.e., can NET externalities be alleviated fast?

# Tools of alleviating NET externalities

- Tools = Means/Mechanisms (tentative grouping)
  - Legal
  - Contractual
  - Technological
  - Regulatory
- Tools characteristics:
  - Speed
  - Efficiency
  - Political Economic Outlook (Implementation: easy / hard / impossible) [Political economy constraints of implementation affect speed and efficiency]

# Players

- whose incentives matter?
- 1. Manufacturers
- 2. Consumers / Users
  - average /regular users
  - system administrators
  - Specialists
- 3. Hackers - users, whose objectives differ from usual user objectives
- 4. Government (s)

# the literature & the players

- The literature
  - mostly focuses on manufacturer incentives, for example a concise Varian (2002) review
- The literature approach is justified:
  - Hard to alter user or hacker incentives ➔
  - The literature treats them as given (fixed)
- Surprisingly, considering user and hacker incentives gives some interesting intuition

# NET externalities. Player impact.

- Production side [Manufacturers slide]
- Consumption side [Users slide]
- Hackers slide: production and consumption?
- Government slide NET and government incentives. Political economy of legal advances and regulatory reforms

# Player incentives: 1. Manufacturers

- On what factors player incentives depend?
- 1. Manufacturer objective is to maximize expected profit, which depends on
  - Technological and informational environment
  - Legal environment (property rights and their enforcement)
  - Market structure
  - consumer (user) demand

# Player incentives: 2. Users

- NET R&S are public goods, ➔ individual user demand for NET R&S is suboptimal (Analogous to other public goods, ex. Pollution)
- Individual user demand is lower than social optimum because users do not differentiate between R&S failures (the task is too cumbersome)
- See our analysis on the next two slides:
- Users I: user actions when NET fails
- Users II: why R&S demand is suboptimal

# User I: user actions when NET fails

- User response to NET failures [think of yourself]:
  - find a fix, download and apply it
  - reinstall the system from scratch
  - Reboot. Wait. Try again
  - Go to the kitchen
  - Read the manual if the situation gets really desperate
- ➔ Same user response to R&S NET failures
- users of all types:
  - only occasionally tune the system reliability and security
  - interest in R&S is dormant until major financial or information loss happens

# User II: why R&S demand is suboptimal

- for users R&S NET failures are undistinguishable, as **if** their utility loss from NET failures driven by unreliability and insecurity is **identical**
- This creates inefficiency as expected loss from insecurity is **not identical** to the one from unreliability
- [last argument need to be cleaned]

# Player incentives: 3. Hackers

- Are hackers best enforcers of secure NET?
- Are hackers worst enemies of secure NET?
- See next six slides for our analysis:
  - Hack I hacker types
  - Hack II hacker differences and similarities
  - Hack III hacker means to conceal the presence
  - Hack IV hacked NET ≈ buggy NET
  - Hack V reliability ↑ ➔ incentives to hack ↓
  - Hack VI positive externality of reliability on security [its size is tiny]

# Hack I: hacker types

- hacker types
  - White Hat
  - Grey Hat
  - Black Hat
  - ?

# Hack II: differences and similarities

- Hackers differ [and a lot!] by
  - resources [means]
  - expertise [means]
  - reasons to hack
- Q: what do all hackers have in common?
- A: A dislike to be persecuted / arrested / imprisoned
- all hackers avoid being caught ➔
- all hide their penetration / presence

# Hack III: hackers: means of concealment

- hackers: hide the evidence of penetration and presence via:
- alteration of the system (files and directories):
  - changing, renaming, erasing, adding

# Hack IV: hacked system ≈ buggy system

- Discrimination between insecure (hacked) and unreliable (buggy) systems is too costly for users
- from user perspective hacked and buggy systems behave similarly:

  hacked system ≈ buggy system

# Hack V: Reliability and incentives to hack

- Statement:

  reliability ↑ ➔incentives to hack ↓
- Reasons why it holds: Incentives to hack a more reliable system are lower because improved reliability makes hacker concealment harder ➔
- Positive externality of reliability on security via reduction of hacker incentives to hack
- This externality reinforces production complementarity of R & S

# Hack VI: a positive externality?

- This externality is tiny due to prohibitively high NET enforcement costs, which by and large make hackers immune
- The importance of this externality will raise as its size increases with
  - higher reliability
  - lower enforcement costs

# Player incentives: 4. Governments

- 4. NET and government objectives
- Complex and conflicting objectives of different government institutions
- We focus on political economy of government actions (legal and regulatory) with respect to NET externalities
- Next 3 slides:
  - Gov I: public vs. private provision of public goods
  - Gov II: an application to NET
  - Gov III: National security & forensics

# Gov I: public good provision

- Governments versus Markets: In general:
  - Markets are more Efficient than Governments OR:
  - Private provision is more efficient than public one
- Conditions warranting government intervention:
  - 1. Externalities, Externalities, Externalities
  - 2. Tools/Means/Mechanisms to resolve them that Markets lack [do not have]
- Examples of Externalities
  - I. Public goods II. Missing markets
- Governments alleviate Externalities via:
  - I. Legal Channels II. Regulatory Channels

# Gov II: NET: Can government help?

- Do NET externalities warrant Government Intervention (legal and/or regulatory), or laissez faire approach preferable?
- NET Laws [NET related legal rules, NET property rights & enforcement]
  - what do we have? DMCA
  - what do we expect? More DMCAs?
- NET Regulations
  - Can regulations help?

# Gov III: Forensics & national security

- Is there a conflict of interests?
- Forensics: To lower NET enforcement costs and improve property rights security government objective is to make NET more R & S
- National security: The interests might be in conflict with NET security improvement

# Production externalities: a closer look

- NET R&S: causes of production externalities
  - NET R&S are public goods
  - weakest-link technology in both: reliability and security
  - free riding problem (s)
  - heterogeneous manufacturers
  - ► deficient property rights & high enforcement costs

# laissez faire approach

- If technological breakthrough does not happen, laissez faire approach is slow
- laissez faire approach via information aggregation by VI is slow due to missing demand for VI
- laissez faire approach via mechanism design (contracts) is slow due to missing advanced NET law. [Law advancement is a slow process by its very nature]

# I. Mechanisms: Contractual Solution

- Mechanism design (contract theory)
- Efficient [because market based]
- Inherently slow - because current tools (NET legalities) are underdeveloped, see
  - Slide summary deficient property rights
  - Slide NET summary deficient NET property rights
  - Slide enforcement high NET enforcement costs

# II. Mechanisms: voluntary insurance (VI)

- If no technology breakthrough, VI is a slow mechanism, reviewed by Soo Hoo (2000)
- VI aggregates information slowly (due to missing demand)
- VI has little means to coop with moral hazard
- VI alone = a laissez faire tool
- VI is actually not a mechanism, VI is one of the tools through which laissez faire approach would work.

# III. Mechanisms: Legal Liability (LL)

- LL for NET products
- LL is slow due to
  - Political-economic constraints (Strong computer industry lobby against)
  - Legal constraints (enforcement of LL will be slow and costly)
- Imposition of LL creates a positive externality via increased demand for VI

# IV. Mechanisms: UI

- Universal Insurance of Internet Users (UI)
- UI works through regulatory channel
- Thus, UI is faster than legal channel mechanisms
- UI is a regulatory mechanism, but UI is implemented via market [private provision ➔ higher efficiency]
- UI features:
  - Improves incentives of all players (Manufacturers, Users, Hackers)
  - Favorable political-economic perspective
  - Reduces Manufacturer heterogeneity
  - Efficient and fast information aggregation

# V. Mechanisms: other from the literature

- To Peter: [find papers and give me for trashing them]
- General approach to trashing:
- All their suggestions are essentially laissez faire
- They do not affect player incentives [objective functions].
- They do not change parameters of these objective functions.
- They do not provide effective /fast means to change
  - Legalities or Technology
- Or: they do not embed:
  - Improved Information aggregation
  - Improved NET enforcement and /or property rights
  - Improved player [manufacturer, user, hacker] incentives

# I. Compare: VI and UI

- VI can be considered a subset of UI
- Ceteris paribus
  - VI and UI have the same technical tools
  - UI embeds tools to mitigate moral hazard problem, which VI lacks
- Statement: There exists an implementation of UI that is Pareto superior to VI

# II. Compare: LL and UI

- LL works through government policy [legal system advancement]
- UI works through government policy [regulation]
- Statement: There exists an implementation of UI that is Pareto superior to LL

# III. Compare: LL and laissez faire

- LL is faster and more efficient than laissez faire approach
- Statement: there exists an implementation of LL that is Pareto superior to laissez faire

# IV. Compare: UI and laissez faire

- Statement: From two previous slides, there exists an implementation of UI that is Pareto superior to laissez faire.

Slide comparing LL and UI

Side comparing LL and laissez faire

# thank you for your attention

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