Managing Digital Piracy

Arun Sundararajan
New York University

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Motivation

Digital piracy is widespread

- 36% of software installations worldwide
- Majority of digital music from Internet-based sources
- eBooks, digital video, HBS cases,

Things that regulate (digital piracy)

- IP Law
- Architecture (Code)
- Norms
- Markets

Agenda for this talk

Assertions

- Managing digital piracy involves choosing an appropriate combination of pricing and digital rights management
- The DR conjecture: managing digital rights involves restricting them
  - More rights \( \rightarrow \) more value, but higher piracy as well

Research questions

- How does one design optimal monopoly (nonlinear) pricing in the presence of digital piracy?
- How does the ability to price-discriminate affect a seller’s optimal extent of technology-based protection?
- What are appropriate technological and pricing responses to a weakening of one’s DRM system?
- Is the DR conjecture supported by data from the ebook industry?

Summary of key results

Optimal pricing in the presence of digital piracy

- Nonlinear pricing schedules can be constructed by combining:
  - Pricing schedule in the absence of piracy (“zero-piracy”, known)
  - Piracy-indifferent pricing schedule (easily derived)

Optimal choice of level of DRM protection

- In the absence of price-discrimination: technologically maximal level
- When the seller can price-discriminate: strictly lower level

Responding to weakening DRM

- May involve either an increase or a decrease in pricing and digital rights
- Suggests a need to preemptively over- or under-protect
Review of nonlinear pricing

Marginal Utility

If consumer surplus > 0, then customer type θ buys legal good

Utility

Model: Overview

Monopoly seller of information good, used in varying quantities
- Legal good: "quality" v, pricing chosen by seller
- Pirated good: "quality" s, free

Heterogeneous customers
- Indexed by type θ ∈ [α, β] distributed as F(θ)
- WTP for legal good: vU(q, θ)
- Value from pirated good: sU(q, θ)
- Maximum desired usage: max(q, θ)
- Reservation utility: > 0

Model: Overview

Structure of pricing schedule
- Menu of quantity-price pairs q(θ), τ(θ), θ ∈ [α, β]
  that is incentive-compatible: 0 = arg max vU(q(θ), θ) - τ(θ)

Timeline

Optimal pricing: Building blocks

"Zero-piracy" pricing schedule qZP(θ), τZP(θ)
- Standard nonlinear schedule of prices and usage levels for each type in the absence of piracy (that is, when s = 0)
- A fraction of customers ZP is priced out of the market

"Piracy-indifferent" pricing schedule qPI(θ), τPI(θ)
- Incentive-compatible, affordable to all customers
- Provides each customer type with surplus equal to exactly his or her reservation utility
- Unique, always profitable for the monopolist, if v > s

Optimal pricing with digital piracy

Pricing schedule is comprised of two distinct segments
- piracy-indifferent (lower)
- adjusted zero-piracy (higher)

At a higher level of piracy s:
- piracy-indifferent segment expands to include more types
- prices fall for higher segment

The presence of digital piracy:
- decreases seller profits
- increases total surplus
- increases consumer surplus from legal usage
- Increases fraction of customers who can viably buy legally

The first three effects are higher at higher levels of piracy
Digital rights management (DRM): Model

**Premise (the DR conjecture)**
- DRM allows sellers to control the extent of piracy to some extent
- Managing digital rights involves restricting them, leading to degradation in the "quality" of the legal good

**Modeling endogenous levels of DRM protection**
- $\rho$: Level of DRM protection chosen by the seller (higher $\rho$, lower rights)
- $v(\rho)$: "Quality" of legal good at level of DRM protection $\rho$
- $s(\rho)$: "Quality" of pirated good at level of DRM protection $\rho$
  - $v(\rho) > s(\rho)$: The seller can make a profit
  - $s(\rho) < s(\rho)$: DRM ‘manages’ rights by restricting them
  - $v(\rho) < s(\rho)$: The DRM technology is effective, at least initially
  - $s(\rho) < s(\rho)$: The DRM technology has diminishing returns

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**Examples of changes in level of DRM $\rho$**
- Digital song plays exclusively on computer from which it was downloaded vs. plays on any iPod (increase in rights, decrease in $\rho$)
- 25 pages of ebook can be printed every 10 days vs. any number of pages of the ebook can be printed (increase in rights, decrease in $\rho$)
- DV can be played only on DVD vs. can be downloaded and played from any hard drive (increase in rights, decrease in $\rho$)

**Timeline**
- The seller announces pricing scheme $q(\theta)$, $\theta(\rho)$ and DRM-based protection level $\rho$
- Customers in set $\Theta$ purchase the legal good, others use the pirated good
- Customers and seller receive their surplus and profits

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**DRM and Pricing: Results**

**Technologically-maximal DRM**
- Level of DRM protection that maximizes $v(\rho) - s(\rho)$
- Maximizes the "effectiveness" of the DRM technology
- Also the optimal level of DRM when the seller cannot price-discriminate

**Profit-maximizing DRM**
- Level of DRM protection $\rho^*$ at which profits are maximized
- Always strictly lower than the technologically-maximal level $\rho^*$

**Weakening DRM: Overview**
- As a DRM technology gets hacked, $s(\rho)$ increases over time
- This is modeled as a continuous variation: $\Delta s(\rho)$, with $\Delta s(\rho) > 0$
- Sign of $s(\rho)$ influences direction of technological and pricing responses
- Disclaimer: Not a "true" dynamic model; also, value of legal good remains constant

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**Why $\rho^b$ is lower than $\rho^*$**
- A marginal decrease in the quality of the pirated good increases total price across all customer types
- A marginal decrease in the quality of the legal good:
  - Decreases total price
  - ...and decreases the seller’s ability to price-discriminate
- Direct effect $v(p)$ versus differential effect $\{v(p) - v(p^*)\}$
**Weakening DRM: Results**

When $s_1$ decreases over time:
- $s_{12}(\rho, t) < 0$: Granting more rights makes underlying technology easier to hack.
- $\rho^*$ should increase over time.
- Total prices reduce across all customer types.
- There may be reason to preemptively overprotect.

When $s_1$ increases over time:
- $s_{12}(\rho, t) > 0$: Granting more rights makes underlying technology harder to hack.
- $\rho^*$ should reduce over time.
- Total prices may either increase or reduce.
- There may be reason to preemptively underprotect.

**Summary of key results**

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- Nonlinear pricing schedules can be constructed by combining:
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  - Piracy-indifferent pricing schedule (easily derived).

**Optimal choice of level of DRM protection**
- In the absence of price-discrimination: technologically maximal level.
- When the seller can price-discriminate: strictly lower level.

**Responding to weakening DRM**
- May involve either an increase or a decrease in pricing and digital rights.
- Suggests a need to preemptively over- or under-protect.

**Final slide**

**Ongoing work**
- Analysis of eBook data based on a more sophisticated underlying model.
- Analytical model of the long-term effects on innovation and quality of legal goods.
- The effect of piracy-induced usage externalities.
- The impact of network effects.

**Questions?**