

## Managing Digital Piracy

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December 3, 2004



## Motivation

### Digital piracy is widespread

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



"Son, you don't realize how easy you have it... when I was your age, I walked 2 miles to the store to steal a record from a record store..."

## Motivation

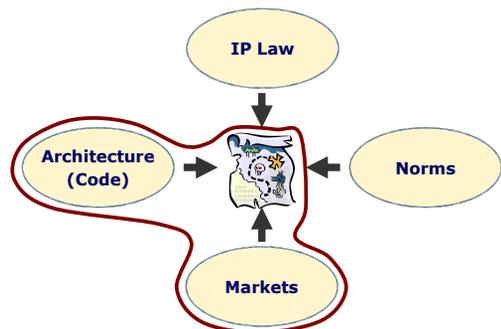
### It is impossible to eliminate digital piracy

- Digital goods are easily replicated, distributed, stored
- Inferior substitutes can always be created
- Enforcing legal deterrents can be difficult
- Technological deterrents are eventually hacked (at least partially)



## Motivation

### Things that regulate (digital piracy)



## 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 → 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)

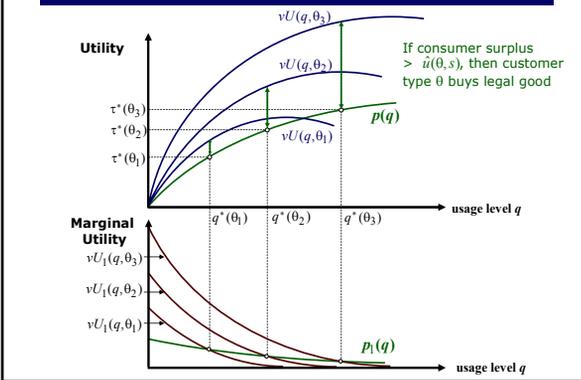
### Optimal choice of level of DRM protection

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

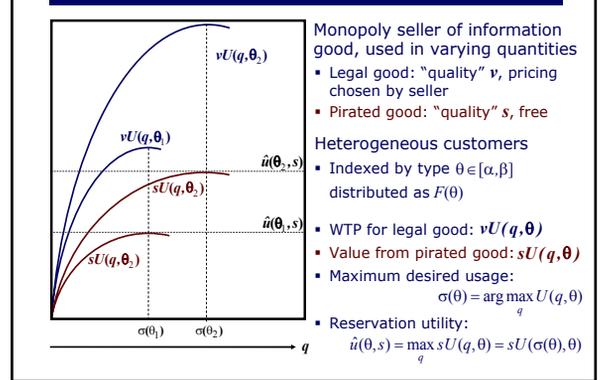
### Responding to weakening DRM

- 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



## Model: Overview



## Model: Overview

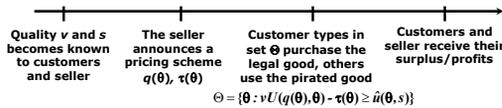
### Structure of pricing schedule

- Menu of quantity-price pairs  $q(t), \tau(t), t \in [\alpha, \beta]$  that is incentive-compatible:  $\theta = \arg \max_t vU(q(t), \theta) - \tau(t)$

$q(\theta, v, s)$ : Usage by customer of type  $\theta$

$\tau(\theta, v, s)$ : Total price paid by customer type  $q$  for usage  $q(\theta)$

### Timeline



## Optimal pricing: Building blocks

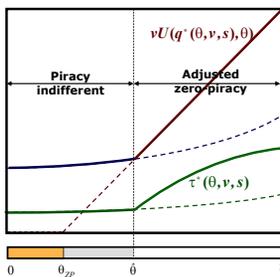
### "Zero-piracy" pricing schedule $q^{zp}(\theta, v), \tau^{zp}(\theta, v)$

- Standard nonlinear schedule of prices and usage levels for each type in the absence of piracy (that is, when  $s = \theta$ )
- A fraction of customers  $[\theta, \theta_{zp}]$  is priced out of the market

### "Piracy-indifferent" pricing schedule $q^{pi}(\theta, v, s), \tau^{pi}(\theta, v, s)$

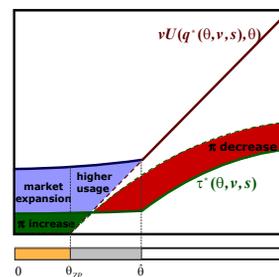
- Incentive-compatible, affordable to all customers
- Provides each customer type with surplus equal to exactly his or her reservation utility  $\hat{u}(\theta, s)$
- Unique, always profitable for the monopolist, if  $v > s$

## Optimal pricing with digital piracy



- Pricing schedule is comprised of two distinct segments
  - piracy-indifferent (lower)
  - adjusted zero-piracy (higher)
- Customers who were priced out of the market are now included
- At a higher level of piracy  $s$ :
  - piracy-indifferent segment expands to include more types
  - prices fall for higher segment

## Optimal pricing with digital piracy



- 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

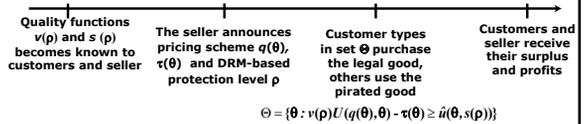
- $\rho$ : Level of DRM protection chosen by the seller (higher  $\rho$ , lower rights)
- $v(\rho)$ : "Quality" of legal good at level of DRM protection  $\rho$
- $s(\rho)$ : "Quality" of pirated good at level of DRM protection  $\rho$ 
  - $v(\rho) > s(\rho)$ : The seller can make a profit
  - $v_1(\rho) < 0, s_1(\rho) < 0$ : DRM 'manages' rights by restricting them
  - $s_1(\theta) < v_1(\theta)$ : The DRM technology is effective, at least initially
  - $v_{11}(\theta) < s_{11}(\theta)$ : The DRM technology has diminishing returns

## DRM: Model

### Examples of changes in level of DRM $\rho$

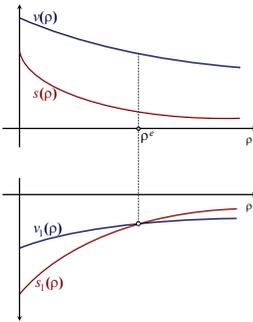
- Digital song plays exclusively on computer from which it was downloaded vs. plays on any iPod (increase in rights, decrease in  $\rho$ )
- 25 pages of ebook can be printed every 10 days vs. any number of pages of the ebook can be printed (increase in rights, decrease in  $\rho$ )
- DV can be played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

### Timeline



## DRM and Pricing: Results

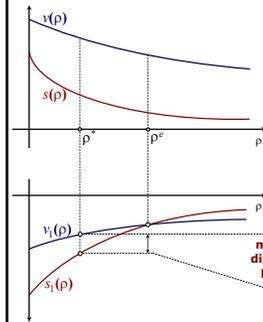
### Technologically-maximal DRM



- 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

## DRM and Pricing: Results

### Profit-maximizing DRM

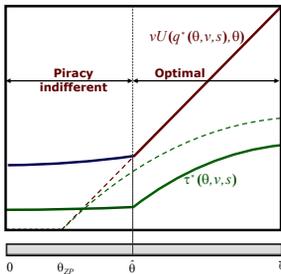


- Level of DRM protection  $\rho^*$  at which profits are maximized
- Always **strictly lower** than the technologically-maximal level  $\rho^r$

$$v_1(\rho^*) - s_1(\rho^*) = \frac{-2v_1(\rho^*)}{\alpha^2} \int_{\alpha}^{\beta} \left( H(\theta) - \frac{h(\theta)^2}{2} \right) f(\theta) d\theta > 0$$

## DRM and Pricing: Results

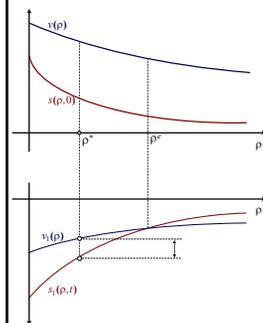
### Why $\rho^*$ is lower than $\rho^r$



- 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  $v(\rho)$  versus differential effect  $[v(\rho) - s(\rho)]$

## Weakening DRM: Overview

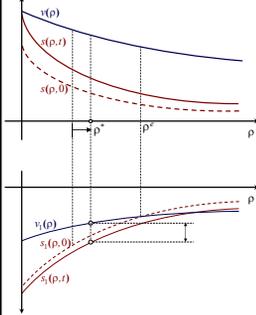
### DRM gets weaker over time



- As a DRM technology gets hacked,  $s(\rho)$  increases over time
- This is modeled as a continuous variation:  $s(\rho, t)$ , with  $s_2(\rho, t) > 0$
- Sign of  $s_{12}(\rho, t)$  influences direction of technological and pricing responses
- Disclaimer: Not a "true" dynamic model; also, value of legal good remains constant

## Weakening DRM: Results

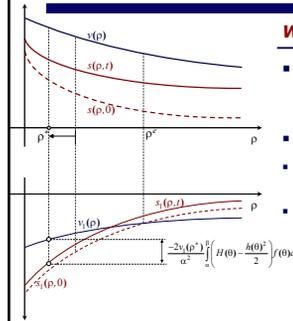
### When $s_1$ decreases over time



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

## Weakening DRM: Results

### When $s_1$ increases over time



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

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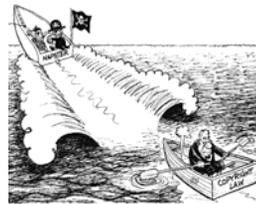
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## Final slide



### 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?