On the optimal level of protection on DRM

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CONTENT

• INTRODUCTION

• MODEL

• PROFIT MAXIMIZATION OF THE MONOPOLIST

• THE EFFECTS OF STRONGER COPYRIGHT ENFORCEMENT

• CONCLUSION
INTRODUCTION

• Piracy problem

• DRM is one option to protect digital products

• DRM (Digital Rights Management)
  – technologies designed to control to end-users can access, copy, or convert digital products

• Trade – off
  – ‘deterrent piracy’ vs ‘value reduction of the legal product’

• Purpose of this paper
  – find the profit-maximizing level of protection in DRM
MODEL

- **Utility function** with uniformly distributed consumer

\[
u = \begin{cases}
(1 - r)\theta - p & \text{buys the legitimate product} \\
sp\theta - (c + dr) & \text{buys unauthorized copy} \\
0 & \text{buys nothing.}
\end{cases}
\]

\[
\begin{align*}
\theta &: \text{valuation of product (0} \leq \theta \leq 1) \\
P &: \text{price for legal product} \\
s &: \text{quality degradation (0} \leq s \leq 1) \\
c &: \text{price for illegal product} \\
d &: \text{technical effectiveness (0} \leq d \leq 1)
\end{align*}
\]

- **Demand function**

\[
D_m(p, r) = 1 - \frac{p}{1-r} \quad \text{legal} \\
D_m(p, r) = 0 \quad \text{illegal}
\]

\[
D_C(p, r) = 1 - \frac{c + dr}{r} \quad \text{legal} \\
D_C(p, r) = 0 \quad \text{illegal}
\]

1) \(0 \leq p \leq c - r(1 - d)\)  
2) \(c - r(1 - d) \leq p \leq (1 - r)(c + dr)\)  
3) \((1 - r)(c + dr) \leq p\)
Optimal pricing for a given level of DRM

1) \(0 \leq r \leq r'\)
   - \(p(r) = c - (1 - d)r\)
   - \(D_m(r) = \frac{1-c-dr}{1-r}\)
   - \(\pi(r) = p(r)D_m(r) = \frac{[c-(1-d)r][1-c-dr]}{1-r}\)

The optimal pricing is to set the limit price to deter unauthorized copies

2) \(r' \leq r \leq 1\)
   - \(p(r) = \frac{(1-r)(c+dr)}{2}\)
   - \(D_m(r) = \frac{c+dr}{2r}\)
   - \(\pi(r) = p(r)D_m(r) = \frac{(1-r)(c+dr)^2}{4r}\)

The optimal strategy is to accommodate unauthorized copies by setting the price \(p(r)\)
The shape of the profit function

Increasing $r$ degrades the quality of the legitimate products.
- Decrease the price and the demand for the legitimate products.

Marginal cost of the quality degradation $<$ Marginal benefit of increasing the copying cost

Marginal revenue increases from the consumers who switch to the legitimate products due to the higher copying cost

$r = 0$ is profit-maximizing if $c \geq d/8$.
If $c < d/8$, there are two local maximums at $r = 0$ and $r = \hat{r}$.

If $c \geq d/8$, $r = 0$ is profit-maximizing point.
If $c < d/8$, $r = \hat{r}$ is profit-maximizing point.

Fig. 1. (a) $c \geq \frac{d}{8}$ and (b) $c < \frac{d}{8}$.
Optimal level of DRM

\[ r = \hat{r} \text{ is profit-maximizing if } c < c_0(d) \]

- \( c \) is small.
- The monopolist’s profit will be nearly down to 0 under the DRM-free strategy.
- The monopolist chooses \( r = \hat{r} \).

\[ r = 0 \text{ is profit-maximizing if } c > c_0(d) \]

- \( c \) is sufficiently large
- copying cost \((c + dr)\) is high enough that the competition becomes mild even without DRM protection \((r=0)\).
- Then the monopolist would be better off with DRM-free \((r=0)\).
The effects of stronger copyright enforcement

- Strengthening copyright enforcement will increase $c$ by government.

1) $r=0$ ($c > c_0(d)$)

$$
\pi_m = c(1 - c), \quad CS = \int_c^1 [\theta - c]d\theta = \frac{(1 - c)^2}{2},
$$

$$
SW = \pi_m + CS = \frac{1 - c^2}{2}.
$$

consumer surplus and social welfare decrease as $c$ gets larger.

2) $r>0$ ($c < c_0(d)$)

$$
\pi = p(\tilde{r})\left[\frac{c + d\tilde{r} - p(\tilde{r})}{r} - \frac{p(\tilde{r})}{1 - r}\right],
$$

$$
CS = \int_c^{c + d\tilde{r} - p(\tilde{r})} (\theta - c - d\tilde{r})d\theta + \int_{\frac{p(\tilde{r})}{1 - r}}^{c + d\tilde{r} - p(\tilde{r})} [(1 - \tilde{r})\theta - p(\tilde{r})]d\theta,
$$

$$
SW = \int_c^{c + d\tilde{r} - p(\tilde{r})} (\theta - c - d\tilde{r})d\theta + \int_{\frac{p(\tilde{r})}{1 - r}}^{c + d\tilde{r} - p(\tilde{r})} (1 - \tilde{r})\theta d\theta.
$$

consumer surplus and social welfare increase as $c$ gets larger.

- $c = c_0(d)$

the level of $c$ at which the monopolist starts to opt for the DRM-free strategy
Extension to general distribution of consumer types

- Generalize the consumer types $F(\theta)$: cumulative distribution function

- The effects of stronger copyright enforcement on social welfare and consumer surplus are ambiguous.

- A sufficient condition for social welfare to increase is that the copying cost decreases as copyright enforcement is strengthened.
Conclusion

Contribution

• There is no quality degradation for unauthorized product. (s=1)
• Consumers who buy unauthorized products pay copying cost (c + dr)

Conclusion

• Stronger copyright enforcement, DRM-free becomes a more profitable option for the seller.
• Weaker copyright enforcement, the firm has an incentive to keep a positive level of DRM.
THANK YOU