Versioning Strategy of Information Goods with Network Externality in the Presence of Piracy

Shivendu Shivendu  
University of California Irvine  
sshivend@uci.edu

Zhe Zhang  
University of California Irvine  
zhez1@uci.edu

Abstract

In our model, market consists of two types of consumers who receive some common utility from the basic functionality of the information good but have heterogeneous valuation for other value enhancing functionalities. We show that in absence of piracy, versioning is optimal when the proportion of high valuation consumers is neither too large nor too small. In the presence of piracy, when the cost of piracy is too low for the lower valuation consumers, the information good provider offers only high quality product. Presence of network effect makes versioning strategy less likely to be optimal for the provider.

1. Introduction

Many information good providers have adopted versioning as a key product strategy. For instance, TurboTax offers tax software in Basic, Deluxe and Premier versions, Norton Internet Security has Basic and Professional packages and Microsoft markets Windows 7 in Home Basic, Home Premium, Professional, and Ultimate versions. Information good providers offer products in different versions to increase the installed base [20] in order to take advantage of positive network externality since larger market coverage is associated with adoption of versioning strategy [21]. Ability to create multiple versions at almost zero additional cost [23] makes versioning a popular strategy for the information good providers. The same characteristics of information goods that allow easier versioning also lead to a higher level of piracy activities [6].

Recent waves of new technologies have led to higher levels of Internet connectivity that makes pirating easier and cheaper [7]. Information goods industry takes a big loss of revenue due to widespread incidences of digital piracy [13]. For instance, worldwide music sales plunged in value from 2003 to 2007 by around $6 billion and this decline has been primarily attributed to illegal file sharing P2P networks and widespread online piracy [10].

Our paper focuses on how market characteristics influence an information good provider’s decision on whether to adopt versioning in the presence of piracy and network effects. More specifically, this research addresses the following questions: (1) How do market characteristics influence a firm’s decision on versioning? (2) How does the threat of piracy influence a firm’s decision on versioning? (3) Does network effect impact versioning strategy and does it mitigate adverse impact of piracy?

We show that under some conditions on the market characteristics, in this case the distribution of targeted consumer types in the market; the versioning is an optimal strategy for the firm. This is true only when all the consumers derive some homogeneous common utility from the consumption of the information good. This common utility that all consumers derive from the basic functionality of the information good is akin to the network effect described in the literature [5]. Our results are different from previous literature which finds that producer should always offer single version as the optimal strategy when the marginal cost of production is zero [5, 15] or should offer multiple versions when marginal cost of production is concave [4] as in our setting marginal cost of production is zero. We show that in the presence of piracy, versioning strategy becomes more attractive to the provider under some conditions on heterogeneity of consumer piracy costs.

Our paper contributes to the literature by explaining firm’s decision on versioning based on market characteristics. We demonstrate that the firm must consider heterogeneous piracy costs of two types of consumers segments in evolving versioning strategy. Our research provides a general guideline for information good providers who need to decide on their pricing strategy with or without concern for piracy. We also explain phenomenon that firms tend to offer more versions of information goods in developed countries compared to developing countries. We posit that it is optimal for a firm to offer only a single version to consumers in markets where intellectual property rights protection is weak.
2. Literature Review

Information goods are fundamentally different from physical goods as the fixed cost of creating the first copy is very high but the marginal cost of creating additional copies is very low or close to zero in case of on-line distribution [22]. Thus, cost-based pricing is not appropriate in the context of information goods and firms turn to value-based pricing wherein consumers are charged according to their valuation for the information goods [17]. Low marginal cost of creating additional copy also makes information goods an easy target for piracy and prior research has found price and cost of pirating as two most important factors in determining rates of piracy [8]. While pricing decisions are influenced by versioning strategy [10], cost of pirating depends on level of enforcement [18], moral beliefs [8], cultural factors [16] and income levels [13].

Information goods often exhibit strong positive network effects due to scale economies in usage [14], sharing of the content [1] and high learning time in case of software [7]. Some prior work has shown that under certain conditions no protection against piracy may be the optimal strategy of an information good provider in the presence of strong network externality [11]. Industry response to fighting piracy has been varied; legal action against pirates [12], technological deterrence [3] and sampling strategies [9] though effectiveness of these approaches has not yet been established.

3. Model

We model the information good provider firm as a monopolist. We extend the model in previous studies [2, 4, 9, 19] and assume that the variable cost of production and distribution of information good is zero. We further assume that the consumer utility consists of two separate components: one from the basic functionality of the information good and the other from additional features that enhance the basic functionality.

The market consists of consumers who have homogenous preference for the basic functionality and derive utility $k$, but have heterogeneous taste for additional functionality enhancing features. There are some high type consumers with a taste parameter $\theta_H$ and some low type consumers with a taste parameter $\theta_L$ ($\theta_H > \theta_L$). The proportion of high (low) valuation consumer type is $\mu$ ($1 - \mu$). The firm only knows the distribution of the types which is common knowledge, while consumers know their own types.

Moreover, a consumer purchases at most one unit of the information good.

In our model $k$ is the baseline utility from consuming the basic functionality of an information good and it is same across all consumers in the market. The additional functionality enhancing features measured by $q$ are valued differently by consumers and are equivalent to quality in that sense. For instance, Notepad and Microsoft Word both allow users to write and edit texts and thus their basic functionality is simple text typing/editing. The baseline utility of this basic functionality can be seen homogenous to all consumers and is represented by $k$. Microsoft Word allows users to perform more editing tasks relative to Notepad, like inserting pictures, changing font colors and etc. These are considered as the additional functionality enhancing features which are valued differently across consumer groups, like school students, professional publishers and etc. Thus in our conceptualization Microsoft Word has higher number of functionality enhancing features than Notepad and has higher quality $q$, though consumers derive the same amount of baseline utility from both the products.

The utility of a consumer with taste parameter $\theta$ from consuming a quality $q$ is defined as:

$$U(\theta, q) = k + \theta q.$$

An individual consumer values higher quality more than lower, i.e., $U(\theta, q_H) > U(\theta, q_L)$ where $q_H > q_L$, and a high type consumer will value any level of additional features more than a low type consumer, i.e., $U(\theta_H, q) > U(\theta_L, q)$.

A consumer with valuation for quality $\theta$ will purchase information good of quality $q$ at a price $p$ if $U(\theta, q) - p \geq 0$. She prefers a quality $q_1$ at a price $p_1$ to a quality $q_2$ at a price $p_2$ if $U(\theta, q_1) - p_1 \geq U(\theta, q_2) - p_2$. She has zero utility if she purchases nothing.

Given that there are two types of consumers in the market, the provider will offer at most two qualities under some technological constraints. The firm produces information goods of quality $q_H$ which is the highest quality level possible and we assume that the firm can create another lower quality (removing some functionality) product $q_L$ without incurring any cost.

We assume the values of $q_H$ and $q_L$ are exogenously determined by technology constraints of the firm and cannot be altered, at least in the short run.

4. Versioning in the absence of piracy
The information good provider firm can either offer only one version of the product or offer both the versions, i.e., high quality \( q_H \) and low quality \( q_L \) in the market. The firm can sell information goods of quality \( q_H \) at a single price to either only the high type consumers or both types of consumers.

The information good provider can sell information good \( q_H \) to only the high type consumers at a price \( p_H \). The revenue maximization objective function is:

\[
R_H = \mu p_H \quad \text{s.t.} \quad U(\theta_H, q_H) - p_H \geq 0
\]

The optimal price for quality \( q_H \) and the revenue is:

\[
p^*_H = k + \theta_H q_H \\
R^*_H = \mu(k + \theta_H q_H)
\]

The information good provider can sell information good of quality \( q_H \) at a price \( p_A \) to all consumers. The revenue maximizing objective function is:

\[
R_A = p_A \quad \text{s.t.} \quad U(\theta_L, q_H) - p_A \geq 0
\]

The optimal price for quality \( q_H \) and the revenue is:

\[
p^*_A = k + \theta_L q_H \\
R^*_A = k + \theta_L q_H
\]

The producer can also sell the higher quality good \( q_H \) to the high type consumers at a price \( p_{HH} \) and sell the lower quality good \( q_L \) to the low type consumers at a price \( p_{LL} \), and the producer’s revenue maximization objective function is:

\[
R_v = (1 - \mu)p_{LL} + \mu p_{HH} \quad \text{s.t.} \quad
\]

(1) \( U(\theta_H, q_H) - p_{HH} \geq 0 \): the high type consumers buy \( q_H \)

(2) \( U(\theta_L, q_L) - p_{LL} \geq 0 \): the low type consumers buy \( q_L \)

(3) \( U(\theta_H, q_H) - p_{HH} \geq U(\theta_H, q_L) - p_{LL} \): the high type consumers prefer \( q_H \) to \( q_L \)

(4) \( U(\theta_L, q_L) - p_{LL} \geq U(\theta_L, q_H) - p_{HH} \): the low type consumers prefer \( q_L \) to \( q_H \).

Conditions (1) and (2) ensure that both types of consumers buy the product offered for their segment, and conditions (3) and (4) ensure that the high type consumers self-select quality \( q_H \) and the low type consumers self-select quality \( q_L \). In the end, the provider needs to figure out the option that yields the maximum revenue based upon the given market characteristics.

The optimal prices for qualities \( (q_L \) and \( q_H \) \) and the revenue are:

\[
p^*_L = k + \theta_L q_L \\
p^*_H = k + \theta_H (q_H - q_L) + \theta_L q_L \\
R^*_v = k + \mu \theta_H (q_H - q_L) + \theta_L q_L
\]

Figure 1 illustrates firm’s revenues under each option with respect to the value of \( \mu \), the proportion of the high type consumers in the market. Points \( \mu_A \) and \( \mu_B \) represent the values of \( \mu \) corresponding to the two interception points of the three revenue lines, and are:

\[
\mu_A = \frac{\theta_L}{\theta_H} \quad \text{and} \quad \mu_B = \frac{k + \theta_L q_L}{k + \theta_H q_L}
\]

In Figure 1, the high type consumers self-select quality \( q_H \) and the low type consumers self-select quality \( q_L \), and offer quality \( q_H \) to only high type consumers by setting the price \( p^*_H = k + \theta_H q_H \) when \( 0 < \mu < \mu_A \), implement versioning strategy when \( \mu_A < \mu < \mu_B \), and offer quality \( q_H \) to only high type consumers by setting the price \( p^*_H = k + \theta_H q_H \) when \( \mu_B \leq \mu < 1 \). Thus, the firm should implement versioning only when the proportion of consumers with high taste for additional functionality is neither too small (less than \( \mu_A \)) nor too large (greater than \( \mu_B \)) as only in that range \( R^*_v \) is greater to both \( R^*_H \) and \( R^*_A \).

**Figure 1 Comparison of revenues under different options**

**Proposition 1:** The monopolistic information good provider should do versioning only if the portion of the
high type consumers is between the ratio of the high type and low type consumers’ valuation of quality and the ratio of the high type and low type consumers’ utilities of consuming the lower quality.

The economic intuition behind this result is as follows. When $0 < \mu \leq \mu_A$, there are too few high type consumers in the market, the provider can generate more revenue by selling $q_H$ to a relatively larger population of the low type consumers. When $\mu_A < \mu < \mu_B$, the gain in revenue from the high type consumers is more than the loss from low type consumers by offering them low quality version and charging lower price $(k + \theta_L q_L)$. Thus firm offers both the versions and offers prices such that consumers self-select quality. Finally when $\mu_B \leq \mu < 1$, the provider would forgo more rent to a large population of the high type consumers than gain in revenue from a small population of the low type consumers, if she decides to offer both versions, and therefore, the provider stops covering the low type consumers and only the high type consumers are served.

We define $D_\mu = \mu_B - \mu_A$ as the range of $\mu$ within which versioning is optimal. We summarize the changes to $D_\mu$, $\mu_A$ and $\mu_B$ with respect to changes in consumers’ taste parameter differential $\theta_H - \theta_L$, quality differential $q_H - q_L$, and utility derived by all consumers from the basic functionality $k$.

**Proposition 2:** As the taste parameter differential increases, it is more likely that the firm will adopt versioning strategy. As the common utility derived from the basic functionality of the information good by all the consumers increases, the likelihood of versioning strategy being optimal for the firm increases.

<table>
<thead>
<tr>
<th>$\theta_H - \theta_L$</th>
<th>$\mu_A$</th>
<th>$\mu_B$</th>
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<tbody>
<tr>
<td>increase</td>
<td>decrease</td>
<td>decrease</td>
</tr>
<tr>
<td>$q_H - q_L$</td>
<td>increase</td>
<td>no change</td>
</tr>
<tr>
<td>$k$</td>
<td>increase</td>
<td>no change</td>
</tr>
</tbody>
</table>

In Table 1, we see that with a greater $\theta_H - \theta_L$, though $\mu_A$ and $\mu_B$ decrease, the range on the proportion of the high type consumers $D_\mu$ increases which implies that provider is more likely to employ versioning strategy. It implies that it is more likely that versioning strategy is optimal if the high type and the low type consumers have very different valuation of quality. The firm can extract more revenue from selling the high quality good to the high type consumers at a higher price in the case of versioning than selling the high quality goods to all consumers at a lower price. Value of the common basic utility $k$ has no influence on $\mu_A$. It is because $k$ does not affect the revenue gain from the high type consumers or the revenue loss from the low type consumers when the provider switches from selling one quality to all consumers to versioning strategy. As $k$ increases, the value of $\mu_B$ also increases, as it is a part of the revenue loss from the low type consumers when the provider switches from versioning strategy to serving only the high type consumers. A bigger $k$ makes it less likely for the provider to shut down the low type consumers. Therefore a higher value of the common basic utility $k$ allows a higher value of $D_\mu$ and thus a higher likelihood of versioning being optimal strategy for the provider. We also consider the special case when $k = 0$ which means that there is no common utility of the baseline functionality of the information good across all consumers. Then $\mu_A$ and $\mu_B$ become one point leading to $D_\mu = 0$ and it is never optimal to implement versioning as a strategy. This is so because revenue of selling single quality always weakly dominates selling two versions of qualities. This result is in conformity with literature [5, 10]. The following Proposition summarizes the result.

**Proposition 3:** The monopolistic information good producing firm should never engage in versioning if there is no common utility of the baseline functionality of the information good.

The proportion of the high type consumers is determined by many social and economic factors. For instance, many consumers do not understand the concept of intellectual property and are not willing to pay a premium to creators of information goods in many developing countries [17]. It implies that the in those countries, the proportion of the high type consumers is small. Therefore, we should not observe much versioning practices in these countries. Another example is that it is very popular to have a distinct cell phone ringtone in Asia. There are a much higher proportion of the consumers in some Asian countries.
who may be willing to pay premium for personalized ringtones than in North America, and from our analysis, more versions of ringtones should be sold by providers in Asia than in North America. In general, one should observe more versioning strategies adopted by information good providers in a market where the proportion of the high type consumers are moderate than in a market where the proportion is either too low or too high.

5. Versioning strategy in the presence of piracy

In the presence of piracy, consumer heterogeneity allows the coexistence of legal and pirated information goods in the market. We assume there is no quality degradation of the pirated information good from the legal one. Each consumer who uses a pirated copy of the information good incurs a piracy cost which includes the cost of searching for a pirated copy of the information good, the cost of “unlocking” programs to break protection mechanism of the information good, and the cost of storage media. The piracy cost could also include the opportunity costs of forgone support and the potential penalty of being caught of pirating. We assume that the high type consumers bear a piracy cost \( \theta_H \), and the low type consumers incur a piracy cost \( \theta_L \).

The net utility of a consumer who pirates is:

\[
U(\theta, q) - T = \theta q + k - T
\]

In the presence of piracy, the firm has to take the cost of pirating the good into consideration. In our conceptualization consumers are heterogeneous in cost of piracy. Note that any consumer who decides to pirate will always pirate the high quality good, if offered by the firm, as the utility from high quality is higher while the cost of piracy is same for both qualities. The information good provider has the same options as discussed in the previous section.

5.1 Single quality at a flat price in the presence of piracy

The information good provider can sell the information goods of quality \( q_H \) at a price \( p_H^* \) to only the high type consumers. The revenue maximizing objective function is:

\[
R_H^* = \mu p_H^* \quad \text{s.t.}
\]

\[
U(\theta_H, q_H) - p_H^* \geq 0
\]

\[
U(\theta_H, q_H) - p_H^* \geq U(\theta_H, q_H) - T_H
\]

Therefore, the price and revenue are:

\[
p_H^* = \begin{cases} 
\theta_H q_H + k, & \text{if } T_H > \theta_H q_H + k \\
T_H, & \text{otherwise}
\end{cases}
\]

\[
R_H^* = \begin{cases} 
\mu(\theta_H q_H + k), & \text{if } T_H > \theta_H q_H + k \\
\mu T_H, & \text{otherwise}
\end{cases}
\]

The information good provider can sell information goods of quality \( q_H \) at a price \( p_A^* \) to all consumers. The provider covers the entire market. The revenue maximizing objective function is:

\[
R_A^* = p_A^* \quad \text{s.t.}
\]

\[
U(\theta_L, q_H) - p_A^* \geq 0
\]

\[
U(\theta_H, q_H) - p_A^* \geq U(\theta_L, q_H) - T_L
\]

\[
U(\theta_H, q_H) - p_A^* \geq U(\theta_H, q_H) - T_H
\]

Therefore, the price and revenue are:

\[
p_A^* = \begin{cases} 
\theta_L q_H + k, & \text{if } T_L > \theta_L q_H + k \\
T_L, & \text{otherwise}
\end{cases}
\]

\[
R_A^* = \begin{cases} 
\theta_L q_H + k, & \text{if } T_L > \theta_L q_H + k \\
T_L, & \text{otherwise}
\end{cases}
\]

5.2 Two qualities at two prices in the presence of piracy

The information good provider can sell the higher quality good \( q_H \) at a price \( p_H^* \) and the lower quality good \( q_L \) to the low type consumers at price \( p_L^* \). The objective function of the information good seller is when selling two versions of quality \( q_H \) and \( q_L \) is to maximize revenue:

\[
R_H^P = (1 - \mu)p_V^L + \mu p_H^* \quad \text{s.t.}
\]

\[
(5) U(\theta_H, q_H) - p_H^* \geq 0: \text{ the high type consumers buy } q_H
\]

\[
(6) U(\theta_L, q_L) - p_L^* \geq 0: \text{ the low type consumers buy } q_L
\]

\[
(7) U(\theta_H, q_H) - p_V^P \geq U(\theta_H, q_L) - p_V^P: \text{ the high type consumers prefer } q_H \text{ to } q_L
\]
(8) $U(\theta_L, q_L) - p^*_V \geq U(\theta_L, q_H) - p^*_H$: the low type consumers prefer $q_L$ to $q_H$
(9) $U(\theta_L, q_L) - p^*_L \geq U(\theta_L, q_H) - T_L$: the low type consumers buy $q_L$ to pirating $q_H$
(10) $U(\theta_H, q_H) - p^*_H \geq U(\theta_H, q_H) - T_H$: the high type consumers buy $q_H$ to pirating $q_H$

Conditions (5) and (6) ensure that both types of consumers participate, condition (7) and (8) ensure self-selection and condition (9) and (10) ensure that no one pirates. Note that in this case entire market is served.

Versioning strategy works when any one of the following two conditions holds:
A: $k + \theta_L q_L \leq T_H \leq k + \theta_H q_H - (\theta_H - \theta_L)q_L$ and $T_L \geq \theta_L q_L + k$, or
B: $T_H > k + \theta_H q_H$ and $\theta_L(q_H - q_L) < T_L < k + \theta_H q_H$.

The optimal prices and revenue under condition A are:

$$p^*_H = T_H$$
$$p^*_L = k + \theta_L q_L$$
$$R^*_V = \mu T_H + (1 - \mu)(k + \theta_L q_L)$$

The optimal prices and revenue under condition B are:

$$p^*_V = T_L + (\theta_H - \theta_L)(q_H - q_L)$$
$$p^*_L = T_L - \theta_L(q_H - q_L)$$
$$R^*_V = T_L + (\mu \theta_H - \theta_L)(q_H - q_L)$$

Condition A implies that the high type consumers have a relatively low piracy cost as it is less than their valuation of the high quality good, and the low type consumer have a relatively high piracy cost as it is more than their valuation of the low quality good. In this scenario, the high type consumers are likely to pirate.

We now compare the revenue from selling single quality at a flat price and selling two qualities at two prices under the condition A. Figure 2 gives the comparison of revenues in the presence of piracy when condition A is met. When $\mu$ is between $\mu^*_A$ and $\mu^*_B$, then versioning is optimal strategy for the firm. But if $\mu$ is outside this range then the firm should not version. We can calculate $\mu^*_A$ and $\mu^*_B$ by determining the intersection points of the revenue curves:

$$R^*_V = R^*_A \iff \mu^*_A = \frac{\theta_L(q_H - q_L)}{T_H - k - \theta_L q_L}$$

$$R^*_V = R^*_B \iff \mu^*_B = \frac{\theta_L(q_H - q_L)}{T_H - k - \theta_L q_L}$$

**Proposition 4:** In the presence of piracy when high type consumers have relatively low piracy cost while low type consumers have relatively high piracy cost, versioning strategy is optimal for the firm when the proportion of the high type consumers is greater than $\frac{\theta_L(q_H - q_L)}{T_H - k - \theta_L q_L}$.

The Proposition 4 implies that when the high type consumers have a relatively low piracy cost and the lower type consumers have a relatively high piracy cost, the provider should adopt versioning strategy under some condition on the proportion of the high type consumers. Further, it is easy to see that as $T_H$ increases, the value of $\mu^*_B$ decreases and the range of $\mu$ in which versioning is optimal increases. Under this situation, the piracy cost of the low type consumers is less important in the firm’s versioning decision. Moreover, because the high type consumers have a relatively low piracy cost, the provider has to lower the price of the high quality good $q_H$ which limits the additional revenues that she might be able to generate by only serving the high type consumers. It makes versioning strategy more appealing. It also explains why the higher limit of the range of $\mu$, that is $\mu^*_B$ for which versioning is optimal in Proposition 4 is one.

The condition B implies the high type consumers have a relatively higher piracy cost as it is higher than
their valuation of the high quality good, and the low type consumer have a relatively lower piracy cost as it is lower than their valuation of the high quality good. This means under condition B the low type consumers may pirate and high type consumers do not pirate.

We compare the revenues from selling single quality at a flat price and selling two qualities at two prices under the condition B in Figure 3.

![Figure 3 Comparison of revenues under condition B](image)

From the intersection points of the revenue curves in Figure 3, we get $\mu_A^p$ and $\mu_B^p$:

$$R_{V}^{p^*} = R_{A}^{p^*} \Leftrightarrow \mu_A^p = \frac{\theta_L}{\theta_H} = \mu_A$$

$$R_{V}^{p^*} = R_{H}^{p^*} \Leftrightarrow \mu_B^p = \frac{\mu}{\theta_Hq_H + \frac{k}{1}} < \frac{\theta_Hq_L + k}{\theta_Hq_L + \frac{k}{1}} = \mu_B$$

By comparing the value of $\mu_A^p$ and $\mu_B^p$, if

$$\theta_L(q_H - q_L) < \frac{T_L - \theta_L(q_H - q_L)}{\theta_Hq_H + \frac{k}{1}}$$

then $R_{V}^{p^*}$ is dominated by either $R_{V}^{p^*}$ when $\mu < \frac{T_L}{\theta_Hq_H + \frac{k}{1}}$, or by $R_{H}^{p^*}$ when $\mu > \frac{T_L}{\theta_Hq_H + \frac{k}{1}}$. The prices the provider charges are driven by the piracy cost of the low type consumers:

$$\nu_{VH}^{p^*} = T_L + (\theta_H - \theta_L)(q_H - q_L), \quad \nu_{A}^{p^*} = T_L - \theta_L(q_H - q_L).$$

It means that the provider has to price the two qualities at a lower level to fight piracy by the low type consumers. It explains why versioning strategy is never optimal when the piracy cost of the low type consumers is very low $T_L < \frac{\theta_Lq_H + \frac{k}{1}}{\theta_H}$, as the provider needs to lower the prices of both qualities to combat piracy.

**Proposition 5:** In the presence of piracy, when the high type consumers have relatively high piracy cost and the low type consumers have relatively low piracy cost, the versioning strategy is optimal for the information good provider when $\frac{\theta_L}{\theta_H} < \mu < \frac{T_L - \theta_L(q_H - q_L)}{\theta_Hq_L + \frac{k}{1}}$ and the provider lowers the prices of both qualities to combat lower piracy cost of the low type consumers when versioning strategy is optimal.

In the presence of piracy the condition on proportion of high type consumers is more stringent, and it makes versioning strategy less likely. It is easy to see that the higher end $\mu_B^p$ further depart from the higher end $\mu_B$ in the case of no piracy while the lower ends $\mu_A^p$ and $\mu_A$ are the same. It makes the range of proportion of the high type consumers for which versioning is optimal narrower in the presence of piracy. It is because the firm is able to extract lower revenue by selling two versions to both types of consumers as it has to lower prices to fight a lower piracy cost of the low type consumers. The firm can extract full surplus from the high type consumers if it only sells the high quality to the high type consumers. Further, when $T_L$ increases, it is more likely that versioning strategy will be optimal.

**Proposition 6:** When the piracy cost for the low type consumers is very low, the information good provider should only sell high quality good to the high type consumers.

In a market where the piracy cost for low type consumers is very low ($T_L \approx 0$), the firm’s optimal strategy is to sell only the high quality product at high price and only high type consumers will be legally served. From Figure 3, the revenue line representing offering single quality to all consumers, $R_{A}^{p^*} = T_L$, is very close to 0, and revenue line of versioning strategy, $T_L + (\mu(q_H - q_L))$, starts at negative region of the graph. Both these revenue lines will be dominated by the revenue line of selling single quality to the high type consumer only. It suggests that we should observe no versions of information goods in market where the piracy cost for consumers with low taste for quality is very low.
6. Versioning in the presence of piracy and network effect

One of the characteristics of the information goods is network externality. A user of Microsoft Word derives higher utility if there are more Microsoft Word users as she has more opportunities to share Word files. We assume that network externality adds to each consumer’s valuation of quality by \( rQ \) where \( Q \) is the market coverage, and \( r \) is the externality intensity [14]. A high \( r \) implies a stronger externality effect of the information good as consumers are willing to pay more when an additional consumer joins the network. The modified consumer utility function in the presence of network externality is:

\[
U(\theta, q) = (\theta + rQ)q + k \quad \text{where} \quad r > 0.
\]

There are still two types of consumers, the high type and the low type consumers with taste parameter \( \theta_H \) and \( \theta_L \). In the presence of piracy, each type of consumer has different piracy cost, \( T_H \) and \( T_L \). The model setup is same as in the Section 3.

The information good provider could market the high quality \( q_H \) to only the high type consumers which implies that the market coverage is the proportion of the high type consumers \( (Q = \mu) \). The optimal prices and the maximum revenue are:

\[
p_{H}^{PE} = \begin{cases} 
\theta_H + r\theta_H q_L + k, & \text{if} \quad T_H > (\theta_H + r\theta_H)q_H + k \quad \text{and} \quad T_L \geq (\theta_L + r)q_H \\
\theta_H + r\theta_H q_L + k, & \text{if} \quad T_H > (\theta_H + r\theta_H)q_H + k \quad \text{and} \quad T_L < (\theta_L + r)q_H \\
\mu(\theta_H + r\theta_H q_L + k), & \text{otherwise}
\end{cases}
\]

\[
r_{H}^{PE} = \begin{cases} 
\mu(\theta_H + r\theta_H q_L + k), & \text{if} \quad T_H > (\theta_H + r\theta_H)q_H + k \quad \text{and} \quad T_L \geq (\theta_L + r)q_H \\
\mu(\theta_H + r\theta_H q_L + k), & \text{if} \quad T_H > (\theta_H + r\theta_H)q_H + k \quad \text{and} \quad T_L < (\theta_L + r)q_H \\
\mu q_H, & \text{otherwise}
\end{cases}
\]

The provider can also provide the high quality to both the high and the low type consumers, and thus cover the entire market \( (Q = 1) \). The optimal prices and maximum revenues are:

\[
p_{A}^{PE} = \begin{cases} 
(\theta_L + r)q_H + k, & \text{if} \quad T_L > (\theta_L + r)q_H + k \\
T_L, & \text{otherwise}
\end{cases}
\]

\[
r_{A}^{PE} = \begin{cases} 
(\theta_L + r)q_H + k, & \text{if} \quad T_L > (\theta_L + r)q_H + k \\
T_L, & \text{otherwise}
\end{cases}
\]

The provider can engage in versioning strategy by offering the high quality and the low quality to the high type and the low type consumers. Versioning strategy is feasible under either of these two conditions:

**C:** \( k + (\theta_H + r)q_H \leq T_H \leq k + (\theta_H + r)q_H - (\theta_H - \theta_L)q_L \) and \( T_L > k + (\theta_L + r)q_H \)

or **D:** \( T_H > k + (\theta_H + r)q_H \) and \( (\theta_L + r)(q_H - q_L) < T_L < k + (\theta_L + r)q_H \).

The optimal prices and revenues under condition **C** are:

\[
p_{H}^{PE} = T_H \\
p_{L}^{PE} = (\theta_L + r)q_L + k \\
r_{H}^{PE} = \mu T_H + (1 - \mu)((\theta_L + r)q_L + k)
\]

The optimal prices and revenues under condition **D** are:

\[
p_{H}^{PE} = T_L + (\theta_H - \theta_L)(q_H - q_L) \\
p_{L}^{PE} = T_L - (\theta_L + r)(q_H - q_L) \\
r_{H}^{PE} = T_L + (\mu T_H - (1 - \mu)r - \theta_L)(q_H - q_L)
\]

The Condition **C** implies the piracy cost of the high type consumers is relatively low and the piracy cost of the low type consumers is relatively high. Figure 4 shows the revenue functions under the three options and the intersection points of these functions give \( \mu_{A}^{PE} \) and \( \mu_{B}^{PE} \).

Figure 4 shows the revenue functions under the three options and the intersection points of these functions give \( \mu_{A}^{PE} \) and \( \mu_{B}^{PE} \):

\[
r_{H}^{PE} = R_{A}^{PE} \iff \mu_{A}^{PE} = \frac{(\theta_L + r)(q_H - q_L)}{T_H - (\theta_L + r)q_L - k} \geq \frac{\theta_L(q_H - q_L)}{T_H - \theta_L q_L - k} = \mu_{A}^{P} \\
R_{H}^{PE} = R_{A}^{PE} \iff \mu_{B}^{PE} = 1
\]

**Proposition 7:** In the presence of piracy and positive network externality, versioning strategy is optimal for the information good provider only when the proportion of the high type
consumers $\mu > \frac{\theta_L(q_H - q_L)}{T_H - \theta_L q_L - k}$. As the network externality increases, the likelihood of versioning strategy being optimal decreases.

The value of $\mu_{PE}^A$ in the presence of network effect is higher than $\mu_{A}^0$ in absence of network effect and value of $\mu_{PE}^A$ increases in $r$ while the higher ends $\mu_{B}^P$ and $\mu_{B}^0$ are the same under condition A and C. It means the range of proportion of the high type consumers is narrower when network externality grows stronger. The information good provider has to lower the price of the high quality to fight piracy among the high type consumers and suffer a revenue loss. It makes versioning strategy less attractive to the provider in this context.

The condition D implies the piracy cost of the high type consumers is relatively high and the piracy cost of the low type consumers is relatively low. Figure 5 shows the revenue functions of the three options and the intersection points of these functions give $\mu_{PE}^A$ and $\mu_{PE}^B$:

$$R_{V}^{PE*} = R_{A}^{PE*} \Leftrightarrow \mu_{A}^{PE} = \frac{\theta_L + r}{\theta_H + r} > \frac{\theta_L}{\theta_H}$$

$$R_{V}^{PE*} = R_{H}^{PE*} \Leftrightarrow \mu_{B}^{PE} = \frac{T_L - (\theta_H - \theta_L)(\theta_L + r)}{k + (\theta_H + r)(q_H - \theta_H + \theta_L)}$$

**Figure 5 Comparison of revenues under condition D**

By comparing the value of $\mu_{A}^{PE}$ and $\mu_{B}^{PE}$, $R_{V}^{PE*}$ is dominated by either $R_{A}^{PE*}$ when $\mu < \frac{T_L}{(\theta_H + r)q_H + k}$, or by $R_{H}^{PE*}$ otherwise, if $(\theta_L + r)(q_H - q_L) < T_L < (\theta_L + r)q_H + \frac{\theta_L + r}{\theta_H + r} k$.

**Proposition 8:** In the presence of piracy and network externality when the proportion of the high type consumers is between $(\frac{\theta_L + r}{\theta_H + r})$, piracy costs of the low type consumers are from $(\frac{\theta_L + r}{\theta_H + r} k + k + (\theta_L + r)q_H)$ and piracy costs of the high type consumers are relatively high, versioning strategy is optimal. As the network externality becomes stronger, the likelihood of versioning strategy decreases.

When $r$ increases, the lower limit $\mu_{A}^{PE}$ and higher limit $\mu_{B}^{PE}$ narrows. It implies that with higher network externality, the information provider is able to generate even more revenue from selling single quality to only the high type consumers when the piracy cost of lower type consumers is very low. This makes versioning strategy less attractive.

7. Conclusions

Versioning strategy is optimal only when all consumers derive some common utility from the basic functionality of the information good. Larger is the value of this common utility the more likely the provider adopts versioning strategy. It holds as long as there is no concern of piracy. Versioning strategy is optimal for the information good provider under some conditions on the proportion of the high type consumers in the market. These conditions vary with costs of piracy of two consumer segments and strength of network externality.

The piracy cost of the high type consumers plays a vital role in the pricing strategy decision of the information good provider when the high type consumers have a relatively low piracy cost and the low type consumers have a relatively high piracy cost. In this case, when the piracy cost of high type consumers increases, the likelihood of the provider adopts versioning strategy increases. The network externality of information goods mitigates this relationship. If the information goods deliver additional
utility due to a large user base, the likelihood of versioning strategy being optimal increases when the piracy cost of the high type consumers increases, but not as much as in the absence of network effect.

The provider needs to consider the piracy cost of the low type consumers in the decision of versioning strategy when the high type consumers have a relatively low piracy cost and the low type consumers have a relatively high piracy cost. Battling with a low piracy cost of the low type consumers, it reduces the provider’s prices and revenue of versioning strategy. When the piracy cost of the low type consumers is extremely low, the provider should always offer one single quality to the high type consumers. It is less likely for the provider to adopt versioning strategy when the information good has a stronger network externality. This prescription holds regardless of the presence of piracy.

References


