The Social Cost of Sharing

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Consumers often share intellectual property. Sometimes sharing is facilitated by intermediaries such as libraries, license servers, used-book shops or video rental stores. Sometimes sharing is illicit, such as with pirated software or Napster. Sometimes sellers of intellectual property welcome sharing, as with site licenses or special prices for libraries, and sometimes they discourage it.

Intellectual property that is intended to be shared normally sells for a higher price than intellectual property that is meant to be consumed by individuals. Think, for example, of the differential pricing of journal subscriptions for libraries and individual users. In other cases, such as books, sellers cannot easily discriminate between shared and individual users, so pricing tends to reflect the dominant use.

I have examined the pricing behavior of profit-maximizing sellers of intellectual property when sharing is possible in Varian [2000]. Here I examine a related question: what kinds of products are not produced due to sharing? That is, what is the social cost of sharing?

1. THE BASELINE CASE

Suppose that there are n consumers, all of whom value a potential product at v. The product costs D to develop, and can be produced a marginal cost of zero. Let p be the price at which the product is sold to the consumers. Then a price p is *viable* if it (1) leaves the consumers with non-negative surplus ($v - p \geq 0$) and (2) leaves the sellers with non-negative surplus ($pn - D \geq 0$). Letting $d = D/n$ be the average development costs, we can write these conditions as

$$v \geq p \quad (1)$$
$$p \geq d. \quad (2)$$

Any price in the interval $v \geq p \geq d$ will result in the good being produced and sold. In particular, this includes the monopoly price $p_m = v$ and the regulated, zero-profit price $p_z = d$.

2. SHARING

Now imaging that groups of consumers of size k form that share the price of the good among themselves, with each consumer paying p/k. This could occur because the consumers require equal payments for sharing, or there are competitive intermediaries such as video stores. Due to this sharing, the seller will sell at most n/k units of good in total..

We suppose that sharing is an inefficient technology, so that the shared consumption incurs some transactions costs t. This transactions cost is the cost of returning the book to the library, the video to the rental store, or waiting until an item becomes available. It could also reflect an inferior quality of a shared product, as with truncated recordings on Napster, or even feelings of guilt from using a shared copy. Below I examine an interpretation in which the t is the expected cost of a penalty.

Economic viability now requires

$$v - p/k - t \geq 0 \quad (3)$$
$$p\frac{n}{k} \geq D. \quad (4)$$

If $t \geq v$, then there is no p at which sharing is viable. Otherwise, we can rearrange these inequalities to read

$$(v - t)k \geq p \quad (5)$$
$$p \geq kd. \quad (6)$$

Combining these inequalities, we see that any price p that lies in the interval

$$(v - t)k \geq p \geq dk$$

will be viable. Obviously a necessary and sufficient condition for such a price to exist is that $v \geq d + t$.

Consider what happens with the profit-maximizing monopoly price, $p_m = v - t$. When the group of size k forms, the monopolist would set the price to be

$$p_m = (v - t)k. \quad (7)$$

If $t = 0$ this would completely offset the revenue losses from sharing. When $t > 0$ some revenue is lost due to the inefficiencies from sharing. Since the monopolist is able to extract all the surplus from consumers, the loss due to the choice of the inefficient technology shows up as lost profits.

Note that when k goes up or t goes down, the price of the shared good increases. This point has been made by

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Liebowitz [1985] who argues that the introduction of photocopying machines into libraries led publishers to increase the price of journals. See also Besen [1986] and Besen and Kirby [1989].

In our model the "full price per reader" (including transactions costs) is given by

$$p_r = \frac{p_m}{k} + t = v$$

so it is independent of k or t. This is, of course, simply a consequence of the fact that the monopolist is able to fully extract all consumer surplus.

There is an interesting implicit dynamics in this model. Facing the original high monopoly price, v, the consumers will want to form groups in order to share the cost of the good, as long as the transactions costs to sharing are not too large. But when everyone shares, the monopolist just raises the price of the product to offset the lost profits due to sharing. Consumers end up exactly where they were, with zero net gain in utility, while the producer is worse off since he is extracting $v - t$ from each consumer rather than v.

Suppose, on the other hand, that the price is set to be the regulated, zero-profit price. Think, for example, of a journal published by a non-profit professional society. The consumers still have an incentive to share, so that price must necessarily rise to cover costs. The consumers end up worse off in the sharing equilibrium since a representative consumer gets a surplus of $v - d - t$ rather than $v - d$.

So either way, the no-sharing price is unstable. When transactions costs are low consumers will want to share. The seller will raise its price to offset this loss, and the economy as a whole ends up at an inefficient equilibrium.

The social loss from sharing are illustrated in Figure 1. In this model, a product is described entirely by its value and its per-capita development cost, (v, d), so we can represent it as a point in $v \times d$ space. From a social point of view, every product with $v \geq d$ is worth developing. Under sharing, every product with $v \geq d + t$ will be developed. Hence, the products that aren't developed are those that lie in the gray area in Figure 1. We see that the goods that aren't produced are those whose values are only slightly greater than their development costs.

Roughly speaking, in this model, if the transactions costs are not too large, the social losses from sharing are not too large.

3. LIMIT PRICING MONOPOLIST

The monopolist in the previous model was rather passive: it did not recognize its influence of its price on group formation. Suppose, instead that the monopolist set its price so as to discourage formation of the group. This is like "limit pricing" to deter entry.

If we formulated this interaction as a game, the first model was a Nash game in which the monopolist chooses p and the consumers choose k independently. The limit price game is a Stackelberg game where the monopolist first chooses p and the consumers follow with a choice of k.

Suppose that the monopolist chooses k so as to make sharing unattractive. This requires

$$\frac{p}{k} + t \geq p.$$

Here we are assuming that the consumers are myopic enough not to recognize that the monopolist will not change its price

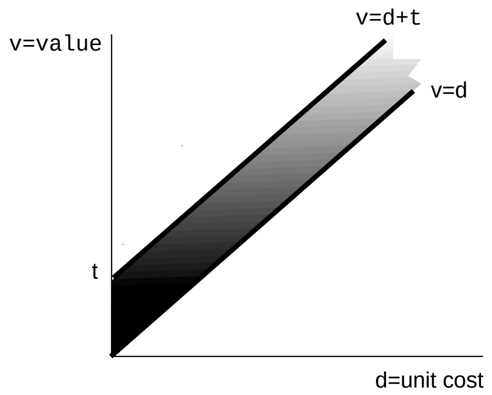

Figure 1: Shaded area indicates products that won't be produced due to sharing.

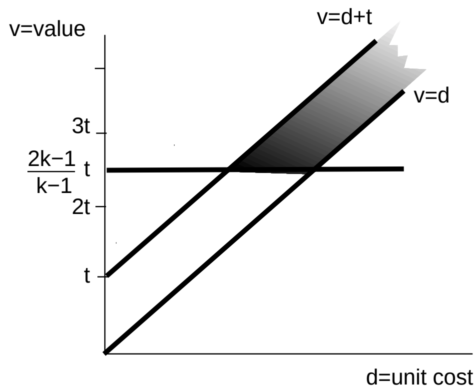

Figure 2: Shaded area indicates lost welfare from sharing.

when groups are formed.

The limit price, p_ℓ, is therefor

$$p_\ell = \frac{k}{k-1} t. \tag{8}$$

Since $k > 1$ by definition of a "group," this is always well defined.

This will be more profitable than allowing the group to form when

$$p_\ell n - D \geq p_m \frac{n}{k} - D,$$

where p_m is defined in equation (7). Substituting, we have

$$p_\ell = \frac{k}{k-1} t \geq v - t,$$

which implies

$$\left(\frac{2k-1}{k-1} \right) t \geq v.$$

The left-hand side of this expression varies from $3t$ to $2t$ as k varies from 2 to ∞, so we have the situation depicted in Figure 2, where the lost value is again depicted by the gray area.

Note that there are now no social costs to sharing for goods with low value, low development costs, or large numbers of users. The threat of sharing induces the monopolist to cut its price to discourage sharing, thereby avoiding the inefficiencies for these goods.

Since the limit price depends only on the transactions cost, when the value or unit cost is large enough, it is not in the interest of the monopolist to limit price. In this case, it will find it more profitable to let the price vary with group size as in the earlier model.

If the parameters are such that the monopolist finds it optimal to limit price and deter entry, the comparative statics results of the previous model are reversed. Now an increase in t will increase the price that the monopolist can charge and an increase in k will decrease it. Increasing t makes the shared good less of a substitute for the unshared version, allowing the monopolist to raise its price. Increasing k decreases the limit price since the shared good becomes relatively more attractive, so the limit price has to decrease to compensate.

It is worth observing that limit pricing does not work for the nonprofit seller of intellectual property. It produces where $p = d$, but the buyers may still find it attractive to share the product when $d/k + t < d$. But since the producer is already charging the lowest possible price, it can't cut it any more. The groups form, the price is then pushed up, and everyone consumes in an inefficient manner.

Hence for the nonprofit seller to be viable transactions costs to sharing much be large enough to make it not worthwhile to share. That is $t > d(1 - 1/k)$. For large k, this essentially requires that $t > d$, i.e., that the transactions costs are greater than the unit production costs.

4. PENALTIES FOR SHARING

Suppose that the monopolist or the state can impose a cost c on those who share. For example, the monopolist could choose a copy protection mechanism that made it more difficult to share. Or the monopolist could bundle the good with something that was difficult or impossible to share, so that the copy was not as good as the original in some way. Alternatively, the state could impose penalties for sharing, so that c would represent the expected cost of punishment.

Since c enters additively with t, we can simply replace t with $c + t$ in the earlier expressions. In the first case of the Nash monopolist, the condition for viability becomes:

$$v - p/k - t - c \geq 0 \quad (9)$$

$$p\frac{n}{k} \geq D. \quad (10)$$

where we are assuming (for the moment) that $v \geq t + c$.

Equilibrium price and profit will be

$$p_m = (v - t - c)k \quad (11)$$

$$\pi_m = (v - t - c)kn - D. \quad (12)$$

Note that the profit is decreasing in c. This counterintuitive result occurs because in equilibrium c is not large enough to discourage sharing, and the monopolist has to cut its price to compensate for the inferior product.

Think, for example, of a poor copy protection mechanism that imposes inconvenience on consumers, but not enough for them to be discouraged from sharing. This makes the monopolist worse off than it would be with no copy protection mechanism since it has to cut price to compensate for the inconvenience the mechanism imposes on consumers.

On the other hand, suppose that $c \geq v - t$ or that the monopolist behaves as a limit pricing monopolist. In either of these cases, the consumers would be discouraged from sharing. Price and profit are now given by

$$p_\ell = \frac{k}{k-1}(t + c) \quad (13)$$

$$\pi_\ell = \frac{k}{k-1}(t + c)n - D. \quad (14)$$

Now price and profit increase linearly in c so a larger cost of sharing makes the monopolist better off. Of course, p_ℓ can never be larger than v, which says that the monopolist will want to have c set at

$$c = v - \frac{k-1}{k}t.$$

At this value of c (or any larger value) the monopolist will price at v, no groups will form, and the outcome will be efficient.

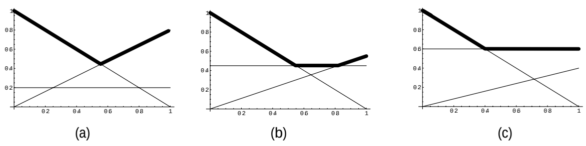

Figure 3: When the number of sharers is low, the monopolist prices at v. As the number of sharers increases, the monopolist may (a) switch directly to pricing for sharers, (b) limit price, then switch to pricing for sharers, (c) limit price all the way.

5. SOME SHARE, SOME DON'T

Let us now suppose that a fraction π of the population is willing and able to share, while other remainder of the population is unable or uninterested in sharing. The monopolist has 3 strategies: 1) set a price of v and tolerate the sharers, 2) sell to both types at the limit price, 3) sell only to the sharers. All consumers have the same value for the product and the same transactions cost of sharing.

The revenue from each of these strategies is

$$\text{sell to both at } v = v[\pi/k + (1-\pi)] \approx v(1-\pi) \quad (15)$$

$$\text{sell to both at } p_\ell = \left(\frac{k}{1-k}\right) t \approx t \quad (16)$$

$$\text{sell only to sharers} = \pi(v - t) \quad (17)$$

The approximation at the end is for the large k case.

In general, any of these strategies may be optimal, depending on the values of the parameters. In Figure 3 I have plotted profit from the three strategies for large k case with $v = 1$ as π ranges from 0 to 1 on the horizontal axis.

6. ENDOGENOUS GROUPS

In the previous example the group size and the transactions costs were exogenous. Now let us suppose that the transactions cost of sharing depends on the size of the group. The simplest specification is $t = w(k - 1)$.

Consider, for example, transactions costs due to waiting your turn. If the group is size 2, then you get the item first half the time, and second half the time. If the group is size 3 you get the item first one-third of the time, and so on. The

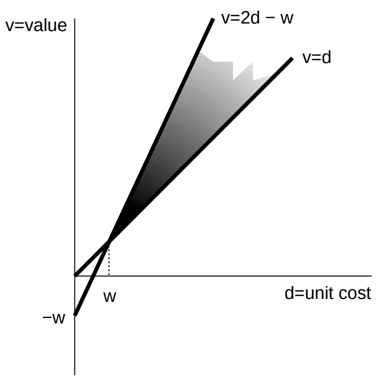

Figure 4: Shaded area indicates products that won't be produced due to sharing.

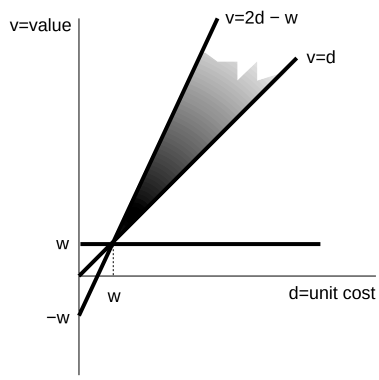

Figure 5: This is Figure 2 with the addition of the horizontal line at $v = w$.

transactions costs from waiting your turn go up linearly with the size of the group.

With this specification, the optimal group size minimizes the cost of purchasing the good plus the transactions costs of sharing:

$$\min_k \frac{p}{k} + w(k-1).$$

The answer to this minimization problem is

$$k = \sqrt{\frac{p}{w}},$$

yielding a minimized value for the transactions cost of

$$2\sqrt{pw} - w.$$

In this model a price p is viable if it satisfies

$$v - 2\sqrt{pw} + w \geq 0, \quad (18)$$

$$\sqrt{pw} \geq d. \quad (19)$$

A monopolist will choose p to eliminate all consumer surplus; i.e., so that inequality (7) binds. The monopoly price is given by

$$p_m = \frac{1}{w}\left(\frac{v+w}{2}\right)^2,$$

and monopoly profits are given by

$$\pi_m = \frac{v+w}{2}n - D.$$

A regulator will set p so that profits are zero; this says

$$p_z = d^2/w.$$

It can be checked that either way, the condition for viability reduces to

$$v \geq 2d - w.$$

This line is plotted in Figure 4, with the shaded area indicating the goods that are not produced.

In this model, the distortion from sharing is different that in the previous model. Low-value, low-cost goods are not worth sharing since the transactions cost exceeds the benefit of sharing. These goods will be produced with or without sharing, so there is no distortion.

High-cost goods are attractive as candidates for sharing. However, the large group sizes to facilitate sharing generate large transactions costs, discouraging the production of such goods unless they also have high value.

To summarize:

- Goods with low per-capita development costs (low D or high n) will be produced even if sharing is allowed, since the price is so low relative to transactions costs that they are not worth sharing;

- Goods with high enough value (more than twice the unit cost) will be produced if sharing is allowed, since enough will be sold to groups cover costs.

The goods that are lost are those with large development costs, small numbers of consumers, and mid-range valuation by the consumers.

7. LIMIT PRICING WITH ENDOGENOUS GROUPS

We assume the monopolist recognizes that its choice of price affects group size, so it chooses the limit price p_ℓ to satisfy

$$\frac{p}{k} + w(k-1) = p \quad (20)$$

$$k = \sqrt{p/w}. \quad (21)$$

The answer is $p_\ell = w$.

This will be more profitable than allowing the groups to form when

$$wn - D \geq \frac{v+w}{2}n - D,$$

which reduces to

$$w \geq v.$$

The situation is depicted in Figure 5. Note that limit pricing to avoid group formation is only profitable in the region where the transactions costs are too low for groups to form anyway. Hence, limit pricing is irrelevant when the transactions costs vary linearly with group size.

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