Openness, Open Source and the Veil of Ignorance[1]

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Abstract: Open source collaborations are increasingly among commercial firms whose interest is profit. Why would profit-motivated firms voluntarily share code? One reason is that cost reductions can outweigh increases in rivalry. This is especially persuasive when the contributors make complementary products. However, cost reductions do not explain why open source is a more profitable way of sharing than other forms of licensing. Why would firms use an inflexible contract like the GPL? I present a model that shows how open source licensing can lead to higher industrywide profit than would result if a first innovator could choose the most profitable license once it finds itself in the position of first innovator. From behind a veil of ignorance, that is, not knowing which firm will be first, open source licensing creates higher expected profit for the industry as a whole, and thus for each firm, than if first innovators were allowed to choose.

In the 1990's, open-source collaborations emerged as a new way of organizing software development (Eric S. Raymond, 1999). In an open-source collaboration, members disclose their code so that others can improve it. This is done under various licensing arrangements, for example, a "general public license" (GPL) that grants others the right to use the code in return for a similar right attached to any derivative work of their own. Generally, no money changes hands between contributors.

The open source movement evolved in the one industrial context where openness is not required by intellectual property law.[2] Nevertheless, openness itself cannot be the driving force behind the open source movement. This is because openness can be achieved in many ways other than the GPL, for example, with proprietary licenses, or licenses that are even more permissive than the GPL, such as the BSD license.[3]

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[2]This is emphasized by Maurer and Scotchmer (2006). Patent practice has evolved so that very little about the nature of a program must be disclosed in a patent; see Lemley et al. 2002 at 204-205. For copyrighted source code, there is an explicit exemption. See U.S. Copyright Circular 61. The anomaly is interesting in its own right. It reveals that the theory behind disclosure is a little shaky.

[3]The Berkeley Software Development license relieves the user of any financial obligations, and unlike the GPL, does not require a reciprocal promise to do the same.

The open-source framework contrasts sharply with the secrecy and exclusivity that usually accompany intellectual property protection. Early commentators explained this new development model as signaling. A programmer who gets her code accepted into the project is evidently competent, and will get a good job. There are other indirect advantages as well (see the survey by Maurer and Scotchmer (2006)).

Demonstrating skills does not explain why firms, as opposed to individuals, participate in open-source collaborations. Firms sometimes contribute significant resources, including experienced programmers (Joachim Henkel, 2006, Dirk Riehle, 2009). Sebastian Englehardt and Stephen Maurer (2009) and Henkel (2008) show that doing so can be profitable even if the contributors are rivals in the market. The quality improvements provided by a rival's open-source contributions may outweigh the deleterious effect of empowering the rival to be a better competitor. Sharing can be especially profitable when contributors earn their profit from goods that are complementary. For example, Justin P. Johnson (2002) considers innovations that are comprised of complementary "modules." Arnold Polansky (2007) considers a sequence of innovations, each of which adds to the profit of each other innovator, and Henkel (2008) considers a model where contributors are rivals in the market, but they create complementary code. The complementarity inspires them to higher effort than otherwise.

A profit-based explanation of the open-source movement should explain not only that open source can be profitable, but that it is more profitable than the alternatives. Polansky delivers bad news in this regard. He focuses on the fact that proprietary licensing leads to a hold-up problem, which can end the sequence of innovations prematurely. He shows that, to some extent, this problem can be overcome with the GPL. However, the first innovator will not choose the GPL except in special circumstances. The first innovator would generally find the proprietary model more profitable than the GPL. If the first innovator chooses proprietary licensing, it will propagate forward to every subsequent innovator. The string of sequential innovations may be shorter with proprietary licenses than with GPL, but the additional profit that the first innovator earns from proprietary licensing will outweigh that defect.

Like Polansky, I consider sequential innovations, although only two. Instead of assuming that the order of innovators is given, I imagine that after the firms join the collaboration, it is unknown which firm will develop the first contribution. Like Polansky, I show that the first innovator would choose proprietary licensing rather than the GPL.

However, proprietary licensing is not the best thing for the industry as a whole. Industry profit is higher with the GPL than if the first innovator sets in motion a sequence of proprietary licenses. This has an important implication, which is the main idea of this paper. If the industry as a whole can commit to the GPL from behind a "veil of ignorance" – before it is known which firm will be the first innovator – then all of them profit. This is a deal they would gladly make ex ante, even though each one would prefer proprietary licensing once he finds himself in the position of first innovator.[4]

1 A Simple Model of Symmetric Complements

I consider two products that do not compete in the market, but use technologies that can be complements. Each product has a stand-alone commercial value v if it uses only its own core technology. It has commercial value $2v$ if it also uses a complementary technology brought into existence with the other product. There is a compatibility issue: the second technology cannot be made compatible unless the first technology is "open."

As in Ted O'Donoghue, Suzanne Scotchmer and Jacques Thisse (1997), Suzanne Scotchmer (1999), and Nisvan Erkal and Suzanne Scotchmer (2009), I assume that ideas for innovation are scarce – not everyone has the same investment opportunities. An innovation requires both an idea and an incentive to invest in it. To keep it simple, I assume that a single random firm will receive an idea for each technology. To implement the idea, the idea recipient must invest an R&D cost that is drawn randomly from a uniform distribution on an interval that I will take to be $[0, 3v]$. Let c_1 be the random cost of the idea for the first technology , and let c_2 be the random cost of the idea for the second technology.[5]

There are a large number of potential idea recipients, and there is negligible probability that any firm receives ideas for both technologies. It is not known in advance which firms will receive ideas.

If the costs c_1 and c_2 are both revealed before making the investments, the profit max-

[4]Such commitments are not always possible. For example, Riele (2009) describes collaborations in some of which a proprietor owns the core product, and the open-source contributors are the users. That has a different structure that described here.

[5]This particular model is not necessary to the result. The important feature is that it is unknown which firm will innovate first. Such uncertainty also arises in a standard "production function for knowledge" model, where the time of innovation is uncertain.

imizing strategy is to invest in both ideas if

$$4v \geq c_1 + c_2 \tag{1}$$

The problem is that, if c_1 is high, these investments might not take place, even when (1) will eventually be satisfied.

Because the firms are identical at the outset, they will use the same strategy, namely, a pair of threshold values $(\bar{c}_1, \bar{c}_2)$ such that the firm invests in the first technology (similarly, the second) if it has an idea for the first (similarly, the second) with cost less than $\bar{c}_1$ (similarly, $\bar{c}_2$) .

Since a firm does not know in advance whether it will receive the first idea, the second idea, or any idea at all, firms should jointly favor investment strategies that maximize industry profit. I will use this as a benchmark. The best joint venture would be an agreement to wait for both ideas before investing, and to implement (1) in some cost-sharing agreement. I assume that is impossible due to the difficulties of coordinating a large number of potential innovators, and because it is unknown when and if the second idea will arrive. (The timing is not essential to my arguments and not modeled here.)

Instead, the benchmark I use for "efficiency" is a strategy that maximizes industry profits under the restriction that the planner cannot wait for both ideas before deciding whether to invest in the first idea. Investing in the first idea creates value v in its own right, but also creates a valuable option on the second investment. The second investment provides incremental value $3v$ because of the complementarity.

The industry's second-best strategy is a pair of threshold values for cost, (c_1^*, c_2^*), that maximize

$$\begin{aligned}
&\frac{1}{3v}\int_0^{c_1^*}\left[v - c_1 + \frac{1}{3v}\int_0^{c_2^*}(3v - c_2)\,dc_2\right]dc_1 \\
=\ &\frac{1}{3v}\int_0^{c_1^*}\left[v - c_1 + \frac{1}{3v}\left[3vc_2^* - \frac{1}{2}\left(c_2^*\right)^2\right]\right]dc_1 \\
=\ &\frac{1}{3v}\int_0^{c_1^*}\left[v - c_1 + c_2^* - \frac{1}{6v}\left(c_2^*\right)^2\right]dc_1
\end{aligned}$$

The maximum satisfies

$$\begin{aligned}
c_1^* &= \frac{5v}{2} \\
c_2^* &= 3v
\end{aligned} \tag{2}$$

This optimum entails two inefficiencies relative to a hypothetical first best where c_1 and c_2 are observed before making the investment decisions. First, investments might be made even when $c_1+c_2 > 4v$, which means that the investments together are unprofitable. This is because the first investment must be made before the option value on the second investment is realized. Second, the investments might not occur even when they would be profitable, that is, even when $c_1 + c_2 < 4v$. For example c_1 might be slightly higher than c_1^*, while c_2 is close to zero.

Decentralized choices will not implement either (1) or the second-best strategy (2). My objective is to understand whether the open-source framework can improve industry profits relative to what would happen without it.

What would happen without the open-source commitment depends on the types of licenses that can be made. I use the term "ex ante" license for the GPL, since the firms agree to the license before any investment opportunity has arisen. I assume that ex ante licenses cannot be made in proprietary mode, because it is unknown who the first and second innovators will be; how would they negotiate?

In proprietary mode, licenses are either at the "intermediate" stage or the "ex post" stage. The intermediate stage is after the first product is developed, and after the second idea has been received, but before the second product has been developed. The ex post stage is after both products have been developed. My main conclusion will be that GPL is more profitable for the industry as a whole if the alternative is ex post licensing, but not if firms can license at the intermediate stage. I comment later on the (in)feasibility of intermediate licensing.

2 The Open Strategy with Proprietary Licensing

2.1 Openness and Ex Post Licensing

If the firms are constrained to make ex post licenses, the first innovator will make his innovation open so that the second innovation can be compatible. This openness is purely informational – unlike the GPL, it allows the second innovator to use the proprietary information for compatibility, but the second innovator then has an infringing technology. To bring the second product into use, either by the first innovator or by the second innovator himself, the two firms must make a license ex post.

When the two firms license ex post, it is natural to suppose that they will divide the "bargaining surplus" equally. The bargaining surplus is the value made available by the licensing agreement. The second innovation contributes v to the first innovator and $2v$ to the second innovator, for a total of $3v$. Thus, each firm gets $3v/2$ in the ex post license. If the second innovator chooses to be incompatible, he only gets value v ex post, so he will always choose compatibility, in anticipation of licensing. The first innovator gets v "in kind", and in addition gets $v/2$ as a license price. The second innovation will take place if and only if $c_2 \leq 3v/2$.

Using the superscript "o" for "open," the profit and expected profit of the second innovation are the following, once the first innovation has been made:

$$\begin{aligned}
\pi_2^o(c_2) &= \max\left\{0, \frac{3}{2}v - c_2, 0\right\} \\
E\left[\pi_2^o(\cdot)\right] &= \frac{1}{3v}\int_0^{3v/2}\left(\frac{3}{2}v - c_2\right) dc_2 = \frac{3}{8}v
\end{aligned}$$

The first innovator's profit and expected profit are

$$\begin{aligned}
\pi_1^o(c_1) &= \max\left\{0, v - c_1 + \frac{1}{3v}\int_0^{3v/2} \frac{3}{2}v \, dc_2\right\} \\
&= \max\left\{0, \frac{7v}{4} - c_1\right\} \\
E\left[\pi_1^o(\cdot)\right] &= \frac{1}{3v}\int_0^{\frac{7v}{4}}\left[\frac{7v}{4} - c_1\right] dc_1 = \frac{49}{96}v
\end{aligned}$$

The cost thresholds for the two innovators are

$$\begin{aligned}
c_2 &\leq (3/2)\, v \\
c_1 &\leq (7/4)\, v
\end{aligned}$$

To calculate total industry profit, Π^o, the expected profit of the second innovator must be weighted by the probability that the first innovation is made. The second innovation cannot occur without the first.

$$\Pi^o = E\left[\pi_1^o(\cdot)\right] + \frac{7}{12}E\left[\pi_2^o(\cdot)\right] = \frac{70}{96}v$$

2.2 Openness and Licensing at the Intermediate Stage

An intermediate license is made before the second idea recipient invests his costs. The second innovator must either accept an intermediate-stage license, if offered, or invest in a compatible product and take an ex post license. The latter is more profitable than investing in an incompatible product.

I assume that the second innovation's costs are observable to the first innovator when he offers a license. This is an unrealistic assumption that I relax below.

The bargaining surplus for the intermediate license is

$$\begin{array}{lll} 3v - c_2 & \text{if} & 3v/2 < c_2 < 3v \\ 3v & \text{if} & c_2 < 3v/2 \\ 0 & \text{if} & 3v < c_2 \end{array}$$

In the first line, when $3v/2 < c_2 < 3v$, the second innovator would not invest without the intermediate-stage license, because he would be "held up" ex post for a licensing fee of $3v/2$. In the second line, the first innovator would not offer an intermediate-stage license, because the second innovator will invest, anticipating the ex post license. The ex post license is more profitable for the first innovator, because he does not share the second innovator's (sunk) costs.

The second innovator's profit is then

$$\begin{aligned} \tilde{\pi}_2^o(c_2) &= \begin{cases} 3v/2 - c_2 & \text{if} \quad 0 < c_2 < 3v/2 \\ (1/2)(3v - c_2) & \text{if} \quad 3v/2 < c_2 < 3v \\ 0 & \text{if} \quad 3v < c_2 \end{cases} \\ E[\tilde{\pi}_2^o(\cdot)] &= \frac{1}{3v}\int_0^{3v/2}\left(\frac{3}{2}v - c\right)\,dc + \frac{1}{3v}\int_{3v/2}^{3v}\frac{1}{2}(3v - c)\,dc \\ &= \frac{3}{8}v + \frac{9v}{48} = \frac{9}{16}v \end{aligned}$$

The first innovator's profit and expected profit are

$$\begin{aligned} \tilde{\pi}_1^o(c_1) &= \max\left\{0, v - c_1 + \frac{1}{3v}\int_0^{3v/2}\frac{3}{2}v\,dc + \frac{1}{3v}\frac{1}{2}\int_{3v/2}^{3v}(3v - c)\,dc\right\} \\ &= \max\left\{0, \frac{31v}{16} - c_1\right\} \\ E[\tilde{\pi}_1^o(\cdot)] &= \frac{1}{3v}\int_0^{\frac{31v}{16}}\left[\frac{31v}{16} - c\right]dc = \frac{1}{6}\left(\frac{31}{16}\right)^2 v = 0.6256v \end{aligned}$$

The cost thresholds for the two innovators are

$$\begin{aligned} c_2 &\le 3v \\ c_1 &\le (31/16)\,v \end{aligned}$$

To calculate total industry profit, $\tilde{\Pi}^o$, the expected profit of the second innovator must be weighted by the probability that the first innovation is made:

$$\tilde{\Pi}^o = E[\tilde{\pi}_1^o(\cdot)] + \frac{31}{48}E[\tilde{\pi}_2^o(\cdot)] = .9888v$$

3 The Closed Strategy with Proprietary Licensing

If the first innovator keeps the first innovation closed, the second idea recipient must either seek an intermediate-stage license, or invest in an incompatible product. The bargaining surplus from making the intermediate-stage license is

$$\begin{array}{lll} 2v & \text{if} & 0 < c_2 < v \\ 3v - c_2 & \text{if} & v < c_2 < 3v \\ 0 & \text{if} & 3v < c_2 \end{array}$$

This again assumes that the second innovation's costs are observable to the first innovator when he offers a license. When $c_2 < v$ (the first line), the second innovator could earn $v - c_2$ by investing in an incompatible product. The bargaining surplus for making the product compatible is $2v$. When $v < c_2 < 3v$ (the second line), the second innovation would not be made without a license. Hence the bargaining surplus to divide in the license is $3v - c_2$. When $3v < c_2$ (the third line) the firms will not invest in the second investment because it does not contribute a positive amount to joint profit.

Assuming that the two firms share the bargaining surplus equally, and using the superscript "c" for "closed," the profit of the second innovator is

$$\begin{aligned} \tilde{\pi}_2^c(c_2) &= \begin{cases} (1/2)(3v - c_2) & \text{if} \quad v < c_2 < 3v \\ (1/2)\,2v + v - c_2 & \text{if} \quad c_2 < v \\ 0 & \text{if} \quad 3v < c_2 \end{cases} \\ E\left[\tilde{\pi}_2^c(\cdot)\right] &= \frac{1}{3v}\int_0^v (2v - c)\,dc + \frac{1}{3v}\int_v^{3v} \frac{1}{2}(3v - c)\,dc \\ &= \frac{5v}{6} \end{aligned}$$

The profit of the first innovator with cost c_1 is

$$\begin{aligned} \tilde{\pi}_1^c(c_1) &= v - c_1 + \frac{1}{3v}\int_0^v v\,dc + \frac{1}{3v}\int_v^{3v} \frac{1}{2}(3v - c)\,dc \\ &= \frac{5v}{3} - c_1 \\ E\left[\tilde{\pi}_1^c(\cdot)\right] &= \frac{1}{3v}\int_0^{5v/3} \left(\frac{5v}{3} - c_1\right) = \frac{25v}{54} \end{aligned}$$

Hence the firms with the first and second ideas will invest if the costs c_1 and c_2 satisfy

$$\begin{aligned} c_1 &\leq \frac{5v}{3} \\ c_2 &\leq 3v \end{aligned}$$

Total profit in the industry is

$$\tilde{\Pi}^c = E\left[\tilde{\pi}_1^c(\cdot)\right] + \frac{5}{9}E\left[\tilde{\pi}_2^c(\cdot)\right] = \frac{50}{54}v$$

4 The Open Source (GPL) Framework: Is it more profitable?

Now suppose the industry is governed by a GPL such that each firm has committed to make its innovation open for compatibility, and has renounced its right to collect license fees from the complementary innovator. The revenue to each firm is $2v$ if both innovations are made. The firms' profit functions are the following, where the second innovation's profit is conditional on having the first innovation.

$$
\begin{aligned}
\pi_2^{gpl}(c_2) &= \max\{0, 2v - c_2\} \\
\pi_1^{gpl}(c_1) &= \max\{0, v[1 + F(2v)] - c_1\} \\
&= \max\left\{0, \frac{5v}{3} - c_1\right\}
\end{aligned}
$$

The firms will invest if the costs c_1 and c_2 respectively satisfy

$$
\begin{aligned}
c_1 &\leq \frac{5v}{3} \\
c_2 &\leq 2v
\end{aligned}
$$

The expected profits of the two innovations are

$$
\begin{aligned}
E\left[\pi_2^{gpl}(\cdot)\right] &= \frac{1}{3v}\int_0^{2v}(2v - c)\,dc = \frac{2}{3}v \\
E\left[\pi_1^{gpl}(\cdot)\right] &= \frac{1}{3v}\int_0^{\frac{5v}{3}}\left(\frac{5v}{3} - c\right)dc = \frac{25}{54}v
\end{aligned}
$$

To evaluate industry profit, Π^{gpl}, the expected profit of the second innovator must be weighted by the probability that the first innovation takes place.

$$
\Pi^{gpl} = E\left[\pi_1^{gpl}(\cdot)\right] + \frac{5}{9}E\left[\pi_2^{gpl}(\cdot)\right] = \frac{5}{6}v
$$

None of the three strategies – the open proprietary strategy, the closed proprietary strategy, or the open-source framework – will achieve the level of profit that would be available with cooperation, either when the industry invests according to (1), or when the industry invests according to (2). Industry profit will not be maximized because

- Ex post licensing discourages investments in second innovations, because profit is eroded by license fees. This also erodes the profitability of the first investment.

- Intermediate licensing solves the ex post "holdup" problem, but joint profit nevertheless "leaks" to the second innovator; hence, the first innovator does not internalize the full benefit of the option he creates.

- If the framework is open source, the division of profits is inflexible. Innovations might not take place because one of the innovators might not have enough revenue to cover his own costs, even if total costs are covered by total revenue.

However, the GPL may be an improvement over licensing with fees.

The propositions below are proved from the following relationships. The first two propositions explain what happens when the GPL is not in effect, and the third proposition exposes the circumstances in which the GPL is preferred.

$$\tilde{\pi}_1^o(c_1) > \pi_1^o(c_1) > \tilde{\pi}_1^c(c_1) = \pi_1^{gpl}(c_1) \quad (3)$$

$$\tilde{\Pi}^o > \tilde{\Pi}^c > \Pi^{gpl} > \Pi^o \quad (4)$$

Proposition 1 *The best strategy for the first innovator is to disclose his technology. This is true whether or not intermediate-stage licensing is feasible.*

This is due to (3). The disclosure allows the second idea recipient to invest in a compatible innovation, and to seek a license ex post. He is willing to do this if $c_2 < 3v/2$, and it is best for the first innovator to allow it. The ex post license is more favorable to the first innovator than an intermediate-stage license, because the second innovator's costs are already sunk.

Proposition 2 *Suppose that intermediate-stage licensing is feasible, and that the license fee can depend on the second innovator's cost. Then the most profitable strategy for the first innovator is to disclose his technology, to make intermediate-stage licenses, and in particular, not to commit to the GPL. This is also the most profitable strategy for the industry as a whole.*

This is due to (3) and (4).

Proposition 3 *Suppose that intermediate-stage licenses are not feasible. Then the most profitable strategy for the industry as a whole is to commit to openness and to the GPL. The most profitable strategy for the first innovator, as the decision maker, is to disclose his technology, to make ex post licenses, and in particular, not to commit to the GPL.*

There are two important points here: (1) The attractiveness of the open-source framework (as opposed to mere openness) depends on whether intermediate-stage licenses can be made. The intermediate-stage licenses that dominate the open-source framework are tailored to the costs of the second innovation. However, the costs of the second innovation would not typically be observable, and that changes the feasibility of such licenses. This is developed below.

(2) By Proposition 3, a commitment to open source can be the most profitable for the industry as a whole, but it will only be chosen from behind a veil of ignorance. A firm that finds itself in the privileged position of first innovator will choose to exercise its proprietary rights instead of choosing the GPL. His choice reduces the profitability of second innovations more than it increases his own profit, but that is no longer the innovator's concern, once his position as first innovator is established.

Because the advantages of open-source licensing vanish if intermediate-stage licenses are available to proprietors, I now address the feasibility of such licenses. In the discussion above, I have assumed that everything is observable to everyone. In particular, the first innovator can observe the costs associated with the second innovator's idea, and can make licensing deals that reflect those costs. Since this is unrealistic, assume instead that the costs of the second innovation are unobservable. As a consequence, the first innovator's license fee must be the same for all potential second innovators, say ℓ. In return for paying ℓ, the first technology is disclosed to the second innovator for compatibility, and the second innovator has a right to use the first technology while giving a reciprocal right to use the compatible second technology.

The implication of the following proposition is that, when the costs of the second innovation are unobservable to the first innovator, intermediate-stage licenses no longer have an advantage over ex post licensing, and by Proposition 3, industry profit is maximized by committing to the GPL.

Proposition 4 *Suppose that intermediate-stage licenses cannot be tailored to the second innovation's cost. Then intermediate-stage licensing is equivalent to ex post licensing in the sense that the first and second innovators will obey the same cost thresholds as with ex post licensing.*

Proof: A second idea recipient will license at the intermediate stage if c_2 satisfies $2v - \ell - c_2 \geq 0$. In addition to the profit v that the first innovator gets from the first innovation, he gets additional profit $v + \ell$ with probability $(2v - \ell)/3v$. Thus, the first innovator's profit can be written

$$\hat{\pi}_1(\ell, c_1) = v - c_1 + \frac{(2v - \ell)}{3v}(v + \ell)$$

The licensee fee $\ell = v/2$ maximizes $\hat{\pi}_1(\cdot, c_1)$. Thus, the investment thresholds for the first and second innovators are

$$\begin{aligned} c_2 &\leq 3v/2 \\ c_1 &\leq \frac{7}{4}v \end{aligned}$$

which are the same as with openness and ex post licensing. ■

Of course, this tidy conclusion depends on the special features of the model. Nevertheless, asymmetric information creates a difficulty for intermediate-stage licensing, which pushes firms toward ex post licensing in the proprietary environment, and makes open-source licensing more attractive to the industry as a whole.

5 Conclusion

In the model above, not only is there no conflict between openness and profit, but open source is actually the profit-maximizing strategy.

Open source has two key features: openness (disclosure) and the GPL. Members of the community disclose their code to other members for improvement and commercial use, and at the same time, renounce their right to collect licensing fees in return for reciprocal rights from the other members.

The two features of open source play different roles. Openness allows the members to make compatible contributions, and this contributes to each innovator's profit. This works best if innovators are protected from entry in their core markets, as here, but von Englehardt and Maurer and Henkel show that it can be profitable even if the contributors are rivals.

But why is the GPL more profitable than other types of licensing? Given the inflexibility of the open-source arrangement, why wouldn't other forms of licensing be preferable, such as licenses that allow the firms to share revenues in a way that reflects their different costs?

The answer in this paper is that the more flexible licenses might, in fact be preferable, but they might also be infeasible. Both the first innovator and the industry as a whole are better off if the first innovator can license on more generous terms when the second innovation will be costly. The problem is that the second innovation's costs are not observable to the first innovator. The second innovator will always argue that the innovation is costly, and that he should be given generous terms.

There are two other options. The first innovator can offer licenses at the intermediate stage that are not tailored to the second innovation's cost, or he can restrict himself to ex post licenses. It turns out in the model above that these are equivalent, and not very profitable for second innovators. The problem with ex post licenses is that the second innovator is negotiating after his costs are sunk, and will be held up for high licensing fees (Green and Scotchmer, 1995). The GPL is a solution to the hold-up problem, which leads to a higher probability of achieving second innovations, and increases industry profit as a whole.

The problem, however, is that once a firm finds itself in the position of first innovator, it will want to exploit that position rather than offer a license that favors second innovators, or favors the industry as a whole. The firms must agree to the GPL behind the veil of ignorance, before anyone knows which firm will be in the position of first innovator. This serves them well in expectation, because it leads to higher industry profits than otherwise.

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