Title

Openness, Open Source, and the Veil of Ignorance

Author

Scotchmer, Suzanne

Publication Date

2010

Openness, Open Source, and the Veil of Ignorance

By SUZANNE SCOTCHMER*

In the 1990's, open-source collaborations emerged as a new way to organize 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.

The open source movement evolved in the one industrial context where openness is not required by intellectual property law.[1] 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.[2]

Early commentators explained this new development model by focussing on the motives of the programmer, such as to demonstrate skills. See the survey by Stephen M. Maurer and Suzanne Scotchmer (2006). But firms also participate in open-source collaborations, sometimes contributing significant resources (Joachim Henkel, 2006, Dirk Riehle, 2009). Doing so can be profitable even if the contributors are rivals in the market. The quality improvements or cost reductions 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. Yet another reason that a profit-seeking firm may participate is that participation gives it access to network effects created by the open source community (Mikko Mustonen, 2005). A less benign consequence is that sharing can increase profit by allowing firms to commit against costly competition on quality (Sebastian von Englehardt and Stephen Maurer (2009)).

In all these models, the GPL can sustain software development, provided the shared code is an input to some product whose market is protected. However, 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 investigates this question, by comparing a type of proprietary licensing with the GPL. He focuses on the fact that proprietary licensing leads to a hold-up problem, which can end a sequence of innovations prematurely. He shows that sometimes this problem can be overcome with the GPL, and characterizes circumstances when the first innovator will choose the GPL as an industry licensing standard rather than proprietary licensing.

Like Polansky, I consider sequential innovations, although only two. Instead of assuming that the order of innovators is given, I imagine that it is not known in advance who will be the first innovator. Once a firm is in the position of first innovator, he will choose proprietary licensing rather than the GPL, because he can then share in the profit of the next innovation.

However, proprietary licensing is not the best thing for the industry as a whole. Industry profit is higher if the industry uses the GPL than if the first innovator

* Department of Economics, MC 3880, University of California, Berkeley, CA 94720-3880, scotch@berkeley.edu. I thank Stephen Maurer, Joachim Henkel and Sebastian von Englehardt for comments. I thank NSF Grant 08-0830186 and the Sloan Foundation for financial support.

[1] 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.

[2] 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.

sets in motion a sequence of proprietary licenses. The proprietary license is more profitable for the first innovator, but creates a larger loss in profit to potential second innovators than the gain in profit it secures for the first innovator himself. 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 in expectation. 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.

I. Complements: A Model

I consider two sequentially created products that do not compete in the market, but use technologies that can be complements. Each product has a standalone commercial value υ if it uses only its own core technology. Each product has commercial value 2υ if it is compatible with the other product. The second product is only possible if the first has been introduced. This is similar to the model of Jerry Green and Suzanne Scotchmer (1995), except that I introduce the compatibility issue. The second technology cannot be made compatible unless the first technology is "open." As in the Green and Scotchmer model, and also in the models of Ted O'Donoghue, Scotchmer and Jacques Thisse (1998), Scotchmer (1999), and Nisvan Erkal and 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 create the innovation, 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 $[0, 3\upsilon]$. 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.[3] These costs are private information of the idea recipients.

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.

[3]The scarcity of ideas explains why second innovators do not compete for a license, and implies that second innovators retain some profit. This impinges on the first innovator's incentive to innovate.

Investing in the first idea creates value υ in its own right, but also creates a valuable option on the second investment. If compatible, the second investment provides incremental value 3υ.

If the costs c_1 and c_2 could be revealed before making the investments, the profit-maximizing strategy would be to invest in both ideas if

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

and otherwise to invest in the first idea if $\upsilon \geq c_1$. The problem is that, if c_1 is high, these investments might not take place, even when (1) will eventually be satisfied.

For clarity, I assume that the entire social value is appropriable by the innovators, so that profit and social value coincide. Efficient strategies are investment decisions that maximize industry profits under the restriction that the second idea is only received if the first innovation materializes. The optimum is achieved by the cost thresholds $\left(c_1^*, c_2^*\right)$ that maximize

$$\frac{1}{3\upsilon}\int_0^{c_1^*}\left[\upsilon - c_1 + \frac{1}{3\upsilon}\int_0^{c_2^*}(3\upsilon - c_2)\,dc_2\right]dc_1$$

Thus, investment should take place if

$$\begin{aligned} c_1 &\leq c_1^* = (5/2)\,\upsilon \\ c_2 &\leq c_2^* = 3\upsilon \end{aligned} \tag{2}$$

This optimum entails two inefficiencies relative to an unachievable first best where c_1 and c_2 are observed before making the investment decisions. First, investments might be made even when $c_1 + c_2 > 4\upsilon$, which means that the investments together are unprofitable. This is because the first investment must be made before the cost of the second investment is known. Second, the investments might not occur even when they would be profitable, that is, even when $c_1 + c_2 < 4\upsilon$. 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 (2). My objective is to understand whether the open-source framework is more profitable than proprietary licensing.

Without the open-source commitment, licenses can be made 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 than proprietary licensing. This conclusion depends on the premise that an intermediate-stage license cannot depend on the second innovation's cost.

II. Proprietary licensing

A. Ex post licensing

If the firms can only make licenses ex post, 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 commercialize the second product, 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 υ to the first innovator and 2υ to the second innovator, for a total of 3υ. Thus, each firm gets $3\upsilon/2$ in the ex post license. The license fee is $\upsilon/2$, while the value υ is received "in kind" by giving access to the compatible second product. If the second innovator chooses incompatibility, he only gets value υ ex post, so he will always choose compatibility, in anticipation of licensing. The second innovation will take place if and only if $c_2 \leq 3\upsilon/2$.

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

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

The first innovator's profit and expected profit are

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

The firms' equilibrium strategies are to invest when

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

(Compare with the efficient thresholds given in (2).)

To calculate total industry profit, Π^p, the expected profit of the second innovator must be weighted by the probability that the first innovation is made.

$$
\Pi^p = E\left[\pi_1^p(\cdot)\right] + \frac{1}{3\upsilon}\frac{7\upsilon}{4}E\left[\pi_2^p(\cdot)\right] = \frac{35}{48}\upsilon
$$

B. Intermediate stage licensing

An intermediate license is made before the second idea recipient invests c_2, but after he knows c_2. In addition to the profit υ that the first innovator gets from the first innovation, he gets additional profit υ from compatibility plus the license fee ℓ, both with some probability, namely, the probability that there is a second innovator who takes the license.

Second innovators have the option to invest without a license, but I will first ignore that possibility, and assume that the second innovator takes the license at the intermediate stage if $2\upsilon - \ell \geq c_2$. The cost c_2 satisfies this condition with probability $(2\upsilon - \ell)/3\upsilon$. Thus, the first innovator's profit can be written

$$
\upsilon - c_1 + \frac{(2\upsilon - \ell)}{3\upsilon}(\upsilon + \ell)
$$

Profit is maximized by the license fee $\ell = \upsilon/2$. The first innovator's profit is $(7/4)\,\upsilon - c_1$, and the profit of the second innovator is $2\upsilon - \ell - c_1$. Hence, the investment thresholds are

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

which are the same as with openness and ex post licensing, and less conducive to innovation than (2).

I now show that $\ell = \upsilon/2$ remains the optimum when second innovators might decline the intermediate license and invest without it. This is regardless of whether the first innovation is open or closed.

With openness, if the second innovator invests in a compatible product, he pays $\upsilon/2$ in the ex post license, and gets revenue $2\upsilon - (\upsilon/2) - c_2$. This is the same as he gets by accepting the intermediate license at fee $\ell = \upsilon/2$. With closedness, the second innovator would have to invest in an incompatible product, and get $\upsilon - c_2$, which is less than $2\upsilon - \ell - c_2$ when $\ell = \upsilon/2$.

Let $\pi_1^I(c_1)$ be the profit available to firm 1 with intermediate-stage licensing, and let Π^I be expected industry profits. I have shown that $\pi_1^I(c_1) = \pi_1^p(c_1)$ for each c_1, and $\Pi^I = \Pi^p$.

Of course, the tidy conclusion that intermediate licensing is equivalent to ex post licensing depends on the special features of the model. The robust point is that the unobservability of c_2 cripples the firms' ability to divide revenue in a way that reflects their costs. As a consequence, intermediate-stage license might not have much advantage over ex post licensing. I now show that asymmetric information is crucial to the equivalence of ex post licensing and intermediate-stage licensing.

III. What if c_2 is observable?

If c_2 is observable, the first innovator will make the innovation open for compatibility before negotiating at the intermediate stage. The intuitive reason is that the first innovator is in a better bargaining position if he can negotiate a license after the second innovator has sunk his costs, especially if the second innovator has invested in a compatible product. Openness facilitates this. I thus assume that the first innovation is open when the intermediate license is negotiated.

The bargaining surplus for the intermediate-stage license is

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

When $0 < c_2 < 3\upsilon/2$ (the first line), a compatible second innovation would be made without a license, and the bargaining surplus ex post would be 3υ. When $3\upsilon/2 < c_2 < 3\upsilon$ (the second line), a second innovation would not be made without an intermediate-stage license because the ex post licensing fee would be $\upsilon/2$, and the second innovator would make negative profit, $2\upsilon - (\upsilon/2) - c_2 < 0$. Hence the bargaining surplus is $3\upsilon - c_2$, which implies that the first innovator shares the second innovator's costs. When $3\upsilon < c_2$ (the third line) the firms will not invest in the second investment because it does not contribute a positive amount to joint profit.

With equal division of the bargaining surplus, the profit of the second innovator is

$$\tilde{\pi}_2^I(c_2) = \begin{cases} (3\upsilon/2) - c_2 & \text{if} \quad 0 \le c_2 \le 3\upsilon/2 \\ (1/2)(3\upsilon - c_2) & \text{if} \quad 3\upsilon/2 < c_2 \le 3\upsilon \\ 0 & \text{if} \quad 3\upsilon < c_2 \end{cases}$$

$$E\left[\tilde{\pi}_2^I(\cdot)\right] = (9/16)\,\upsilon$$

The revenue of the first innovator is

$$\upsilon + \frac{1}{3\upsilon}\int_0^{3\upsilon/2} \frac{3\upsilon}{2} dc_2 + \frac{1}{3\upsilon}\int_{3\upsilon/2}^{\upsilon} \frac{1}{2}(3\upsilon - c_2)\, dc_2$$

$$= \upsilon + (15/16)\,\upsilon$$

Hence the first innovator's profit is

$$\begin{aligned} \tilde{\pi}_1^I(c_1) &= \max\left\{0, \frac{31}{16}\upsilon - c_1\right\} \\ E\left[\tilde{\pi}_1^I(\cdot)\right] &= \frac{\upsilon}{6}\left(\frac{31}{16}\right)^2 \end{aligned}$$

The firms' equilibrium strategies are to invest if

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

and expected industry profit is

$$\tilde{\Pi}^I = E\left[\tilde{\pi}_1^I(\cdot)\right] + \frac{1}{3\upsilon}\frac{31\upsilon}{16} E\left[\tilde{\pi}_2^I(\cdot)\right] = 0.9888\upsilon$$

IV. Is GPL 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 2υ if both innovations are made. The firms' profit functions are

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

In the expression for $\pi_1^{gpl}(c_1)$, $F(2\upsilon)$ is the probability that the second innovation materializes.

The firms' equilibrium strategies are to invest if

$$\begin{aligned} c_1 &\leq (5/3)\,v \\ c_2 &\leq 2v \end{aligned}$$

The expected profits of the two innovations are the following

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

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.

$$\Pi^{gpl} = E\left[\pi_1^{gpl}(\cdot)\right] + \frac{1}{3v}\frac{5v}{3}E\left[\pi_2^{gpl}(\cdot)\right] = \frac{5}{6}v$$

The following summarizes what we have learned from these calculations.

$$\begin{aligned} &(3) & \pi_1^{gpl}(c_1) &< \pi_1^{p}(c_1) = \pi_1^{I}(c_1) \\ & & &< \tilde{\pi}_1^{I}(c_1) \\ &(4) & \Pi^{p} &= \Pi^{I} < \Pi^{gpl} < \tilde{\Pi}^{I} \end{aligned}$$

The inequalities (3) imply that if a firm can choose the style of licensing once it finds itself in the position of first innovator, it will always choose proprietary licensing rather than the GPL, and if it can observe the costs of the second innovation before the investment is made, the first innovator will strictly prefer to license at the intermediate stage. If the cost of the second innovation is not observable, there is no advantage to licensing at the intermediate stage.

The inequalities (4), however, imply that if the firms could commit in advance to the GPL, before knowing which firm will innovate first, they would prefer the GPL over proprietary licensing. This is because the proprietary license hurts the second innovator more than it helps the first innovator. Again, this result is overturned if the cost of the second innovation is observable at at the intermediate stage, and the negotiated license can be tailored to c_2.

V. Conclusion

Neither proprietary licensing nor the open-source framework will achieve the level of profit or social benefits that would be available with cooperation, either when the industry invests according to (1), or when the industry invests according to (2). This is because

- Licensing of either type is a burden on second innovators, and therefore inhibits some second investments that would be efficient.
- Because ideas for investments are scarce, second investors make positive profit on average, which implies that first innovators are not fully rewarded for the options they create.
- The division of profit is inflexible in both licensing regimes, with the consequence that at least one of the innovators might not cover costs, even if total profit exceeds total costs.

The key strategy for social welfare and industry profit is openness. Without openness, the innovations cannot be compatible, which reduces the value of the innovations to half. Because openness is so valuable, the first innovator will provide it under either licensing regime. What the above analysis adds is the timing. The first innovator will open his innovation for compatibility *before negotiating*. This is for a subtle reason. Openness may encourage the second innovator to invest without a license, so the firms are negotiating after the second innovator has sunk his costs. This helps the first innovator extract profit from the second innovator.

The other key insight of this paper is that the licensing choice of the first innovator is not the choice he would make from behind the "veil of ignorance," that is, not knowing whether he will be first or second. The firm that finds itself in the position of first innovator will choose proprietary licensing because it is the most profitable choice once it is in that privileged position. However, proprietary licensing is so onerous for the second innovator that the industry as a whole earns less than with the GPL. Thus, from behind the veil of ignorance, the firms should favor the GPL, rather than leaving the choice to a first innovator, whoever it is.

Finally, I would like to draw attention to two limitations of this argument.

First, if the second innovation's cost is observable to both firms, the firms can use the second innovator's prospective cost as a basis for negotiation. Then the industry as a whole will be more profitable with intermediate-stage licensing than with the GPL.

This is because the intermediate stage license provides enough flexibility in dividing profit to ensure investment in the second innovation whenever it adds something positive to joint profit (whenever $c_2 \leq 3v$). See Green and Scotchmer (1995). Nevertheless, intermediate stage licensing will not achieve full efficiency. Because the idea for the second innovation is only available to a single firm, second innovators retain some bargaining surplus and make positive profit. (This is where it matters that "ideas are scarce".) As a consequence, the first innovator does not collect the full value of the option that its investment creates, and will not always invest when investment would be efficient.

Second, it is not always possible to commit to the GPL before innovating. If not, the benefits of this commitment strategy may not be available. One way to commit is to join a community that is founded on a core open-source technology with a viral GPL license. Each of the two innovators discussed above would be using that core technology to make compatible products.

REFERENCES

von Engelhardt, Sebastian and Stephen Maurer. 2009. "The New (Commercial) Open Source: Does it Really Improve Welfare?" Paper presented at the January 14, 2010, conference on "Open Source, Innovation, and Entrepreneurship", Friedrich-Schiller Universitaet, Jena.

Erkal, Nisvan and Suzanne Scotchmer. 2009. "Scarcity of Ideas and R&D Options: Use it, Lose it, or Bank it." National Bureau of Economic Research Working Paper 09-14940.

Henkel, Joachim. 2006. "Software Development in Embedded Linux – Informal Collaboration of Competing Firms." *Wirtschaftinformatik Proceedings 2003.* http://aisel.aisnet.org/cgi/viewcontent.cgi?article=1057&context=wi2003

Henkel, J. 2006. "Software Development in Embedded Linux – Informal Collaboration of Competing Firms." *Wirtschaftinformatik Proceedings 2003.*

Henkel, Joachim. 2008. "The Jukebox Mode of Innovation." Unpublished paper. TUM Business School, Technische Universitaet Muenchen.

Green, Jerry, and Suzanne Scotchmer. 1995. "On the Division of Profit in Sequential Innovation." *RAND Journal of Economics,* 26(1):20-33.

Johnson, Justin P. 2002. "Open Source Software: Private Provision of a Public Good," *Journal of Economics and Management Strategy*, 24(4):637-662.

Lemley, Mark, Peter Menell, Robert Merges and Pamela Samuelson. 2002. *Software and Internet Law* (2d ed.). New York: Aspen Law and Business.

Maurer, Stephen and Suzanne Scotchmer. 2006. "Open Source Software: The New IP Paradigm." In *Handbook of Economics and Information Systems*, ed. T. Hendershott, 285-319. Amsterdam: Elsevier

Mustonen Mikko. 2005. "When do firms support the development of substitute copyleft programs?" *Journal of Economics and Management Strategy,* 14(1):121-139.

O'Donoghue, Ted, Scotchmer, Suzanne and Thisse, Jacques-Francois. 1998. "Patent Breadth, Patent Life and the Pace of Technological Progress," *Journal of Economics and Management Strategy*, 7(1):1-32.

Polansky, Arnold. 2007. "Is the General Public License a Rational Choice?" *Journal of Industrial Economics,* 55(4): 691-714.

Raymond, Eric S. 1999. *The Cathedral and the Bazaar: Musings on Linux and Open Source by an Accidental Revolutionary*. Sebastopol, CA: O'Reilly & Associates, Inc.

Riele, Dirk. 2009. "The Commercial Open Source Business Model." *Americas Conference on Information Systems 2009 Proceedings.*

Scotchmer, Suzanne. 2004. *Innovation and Incentives*. Cambridge, MA: MIT Press.

Scotchmer, Suzanne. 1999. "On the Optimality of the Patent Renewal System." *RAND Journal of Economics,* 30(2):181-196.

Scotchmer, Suzanne and Green, Jerry. 1990. "Novelty and Disclosure in Patent Law," *RAND Journal of Economics*, 27(2):322-331.