Free revealing and the private-collective model for innovation incentives

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A central tenant of open innovation is free revealing of the detailed workings of novel products and services, so that others may use them, learn from them, and perhaps improve them as well. We explain that innovators frequently do freely reveal proprietary information and knowledge regarding both information-based products and physical products they have developed. We explain why free revealing can make good economic sense for innovators and for society as well. The article develops the case for free revealing in terms of a 'private collective' model of innovation incentives.

1. Introduction

Free revealing of findings, discoveries, and knowledge is a defining characteristic of what Paul David and colleagues call 'open science' (David, 1992, 1998; Dasgupta and David, 1994). Similarly, in our view, free revealing of product and process designs is a defining characteristic of 'open innovation.'[1] Free revealing is the feature that makes it possible to have collaborative design in which all can participate – as is famously the case in open source software projects (Raymond, 1999).

Empirical research shows that free revealing of product and service designs is practiced far beyond software. In this article, we first review evidence that this is the case. Next, we discuss the case for free revealing from an innovators' perspective, and argue that it often can be the best *practical* route for innovators to increase profit from their innovations. Finally, we discuss the implications of free revealing for innovation theory. We show that free revealing can be understood in terms of a 'private-collective' model of innovation incentives (von Hippel and von Krogh, 2003). This model occupies a fertile middle ground between the traditional private and collective action models of innovation incentive.

2. Evidence of free revealing

When we suggest that an innovator – be it an individual or a firm – 'freely reveals' proprietary information, we mean that all intellectual property rights to that information are voluntarily given up by that innovator and all parties are given equal access to it – the information becomes a public good (Harhoff et al., 2003). A public good is characterized by non-excludability and non-rivalry: if any one consumes it, it cannot be feasibly withheld from others (Olson, 1967, p. 14). Intellectual property may be freely revealed whether or not it is first protected by patents or copyrights. All that is required is that the owners of the protected information elect to do this. For example, in the case of copyrighted software 'writings,' authors may freely reveal their code by placing it under a software license that conveys all rights granted to the author under copyright law to all parties without charge and on a non-discriminatory basis. Of course, authors that freely reveal information are not necessarily able to convey legal rights to others to freely *use* the information they have revealed. Property rights held by others – for example, rights to other patents also needed to 'practice' an innovation that has been freely revealed – may still stand in the way.

Free revealing as we define it does not mean that recipients necessarily acquire and utilize the revealed information at no cost to themselves. Nor does it mean that the benefits of acquiring and applying freely-revealed information will necessarily outweigh the costs. Recipients may, for example, have to pay for a subscription to a journal or a website and/or cover the expenses for a field trip to an innovation site to acquire the information being freely revealed. Also, in order to understand or make use of freely revealed information to solve problems, the recipient must already possess or create necessary complementary knowledge (Cohen and Levinthal, 1990; MacKenzie and Spinardi, 1995). However, if the possessor of the information does not profit from any such expenditures made by the information adopters, the information itself is still freely revealed, according to our definition. This definition of free revealing is rather extreme in that revealing with some small constraints, as is sometimes done, would achieve largely the same economic outcome. Still, it is useful to discover that innovations are often freely revealed even in terms of this stringent definition.

Intentional and routine free revealing among profit-seeking firms was first reported by Allen (1983). He noticed the phenomenon, which he called 'collective invention,' in historical records from the 19th-century English iron industry. In that industry, ore was processed into iron by means of large furnaces heated to very high temperatures. Two attributes of the furnaces used had been steadily improved during the period 1850–1875: chimney height had been increased and the temperature of the combustion air pumped into the furnace during operation had been raised. These two technical changes significantly and progressively improved the energy efficiency of iron production – a very important matter for producers. Allen noted the surprising fact that employees of competing firms publicly revealed information on their furnace design improvements and related performance data in meetings of professional societies and in published material.

After Allen's initial observation, a number of other authors searched for free revealing among profit-seeking firms and frequently found it. Nuvolari (2004) studied a topic and historical period akin to that studied by Allen and found a similar pattern of free revealing in the case of improvements made to steam engines used to pump out mines in the 1800s. At that time, mining activities were severely hampered by water that tended to flood into mines of any depth, and so an early and important application of steam engines was for the removal of water from mines. Nuvolari explored the technical history of steam engines used to drain copper and tin mines in Cornwall, England. Here, patented steam engines developed by James Watt were widely deployed in the 1700s. After the expiration of the Watt patent, an engineer named Richard Trevithick developed a new type of high-pressure engine in 1812. Instead of patenting his invention, he made his design available to all for use without charge. The engine soon became the basic design used in Cornwall. Many mine engineers improved Trevithick's design further and published what they had done in a monthly journal, *Leans Engine Reporter*. This journal had been founded by a group of mine managers with the explicit intention of aiding the rapid diffusion of best practices among these competing firms.

Free revealing has also been documented in the case of more recent industrial equipment innovations developed by equipment users. Lim (2000) reports that IBM was first to develop a process to manufacture semiconductors that incorporated copper interconnections among circuit elements instead of the traditionally used aluminum ones. After some delay, IBM revealed increasing amounts of proprietary information about the manufacturing process to rival users and to equipment suppliers.

Free revealing was widespread in the case of innovations developed by users for use on automated clinical chemistry analyzers manufactured by the Technicon Corporation for use in medical diagnosis. After commercial introduction of the basic analyzer, many users developed major improvements to both the analyzer and to the clinical tests processed on that equipment. These users, generally medical personnel, freely revealed their improvements via publication, and at company-sponsored seminars (von Hippel and Finkelstein, 1979). Mishina (1989) found free, or at least selective no-cost revealing in the lithographic equipment industry. He reported that innovating equipment users would sometimes reveal what they had done to machine manufacturers. Morrison et al. (2000), in a study of library IT search software found that innovating users freely revealed 56% of the software modifications they had developed. Reasons given for not revealing the remainder had nothing to do with considerations of intellectual property protection. Rather, users said they had no convenient users' group forum for doing so, and/or they thought their innovation was too specialized to be of interest to others.

Innovating users of sports equipment also have been found to freely reveal their new products and product modifications. Franke and Shah (2003), in their study of four communities of serious sports enthusiasts found that innovating users uniformly agreed with the statement that they freely revealed their innovation to their entire community free of charge – and strongly disagreed with the statement that they sold their innovations ($P<0.001$, *t*-test for dependent samples). Interestingly, two of the four communities they studied engaged in activities involving significant competition among community members. Innovators in these two communities reported high but significantly less willingness to freely reveal, as one might expect in view of the potentially higher level of competitive loss such conduct would entail.

Contributors to the many open source software projects (more than 90,000 were listed on SourceForge.net in 2004) routinely make the new code they have written public under a license granted by authors based upon their rights in copyright law. Many copyright owners decide to license their work under terms prescribed by the GNU General Public License (GPL). Basic rights transferred to those possessing a copy of software licensed under the GPL include the right to use it at no cost, the right to study its source code, the right to modify it, and the right to distribute modified or unmodified versions to others at no cost. Open source software licenses do not grant downloaders the full rights associated with free revealing as that term was defined earlier. For example, the GPL license prohibits anyone from incorporating software covered by that license into proprietary software that they then sell.

While it may seem reasonable that free revealing is practiced among innovators that face low rivalry, at first glance it would seem less likely that direct competitors would freely reveal much information and share knowledge. Interestingly Henkel (2003) showed that free revealing is sometimes practiced by directly competing manufacturers. He studied manufacturers that were competitors and that had all built improvements and extensions to a type of software known as embedded Linux. (Such software is 'embedded in' and used to operate equipment ranging from cameras to chemical plants.) These manufacturers freely revealed improvements to the common software platform that they all shared and, with a lag, also revealed much of the equipment-specific code they had written. Even under adverse competitive conditions, there may be practical reasons why innovators want to freely reveal information. Next, we explore some of these reasons.

3. Practical case for free revealing

The 'private investment model' of innovation incentives assumes that innovation will be supported by private investment if and as innovators can incur profits from doing so. In this model, any free revealing or uncompensated spillovers of proprietary knowledge developed by private investment directly reduce the innovator's profits. It is therefore assumed that innovators will strive to avoid spillovers of innovation-related information. From the perspective of this model, then, free revealing is an enigma: it seems to make no sense that innovators would intentionally give away information and knowledge for free that they had invested money to develop (von Hippel and von Krogh, 2003). In this section we offer an explanation by pointing out that free revealing is often the *best practical* option available to innovators.

Harhoff et al. (2003) found that it is in practice very difficult for most innovators to protect their innovations from direct or approximate imitation. This means that the practical choice is typically *not* the one posited by the private investment model of innovation incentives: should innovators voluntarily freely reveal their innovations, or should they protect them? Instead, the real choice facing innovators often is whether to voluntarily freely reveal or to arrive at the same end state, perhaps with a bit of a lag, via involuntary spillovers. The practical case for voluntary free revealing is further strengthened because it can often be accomplished at low cost, and often yields significant private benefits to the innovators. When benefits from free revealing exceed the benefits that are *practically* obtainable from holding an innovation secret or licensing it, free revealing should be the preferred course of action for a profit-seeking firm or individual. This decision might be contingent on what others know, the profits that ensue from patenting, and the incentives from free revealing.

3.1. When others know something close to 'your' secret

Innovators seeking to protect innovations they have developed as their intellectual property must establish monopoly control over the innovation-related information and knowledge (Arrow, 1962, Granstrand, 1999). In practice, this can be done either by intentionally and effectively hiding the information or knowledge as a trade secret, or by obtaining effective legal protection by patents or copyrights (Liebeskind, 1996). (Trademarks also fall under the heading of intellectual property, but we do not consider those here.) In addition, however, information must be unequally distributed amongst innovators, and it must be the case that *others* do not hold substitute information and knowledge that skirt these protections and that they *are* willing to reveal. If multiple individuals or firms have substitutable information or knowledge, they are likely to vary with respect to the competitive circumstances they face. A specific innovator's ability to protect 'its' innovation as proprietary will then be determined for all holders of such information or knowledge by the decision of the one having the *least* to lose by free revealing. If one or more information holders expect no loss or even a gain from a decision to freely reveal, then the secret will probably be revealed despite other innovators' best efforts to avoid this fate (von Hippel, 2005). For those innovators whose preference is to keep information, the challenge then becomes how to compete with free (Levin and von Krogh, 2004).

Commonly, many firms and individuals have information that would be valuable to firms or individuals seeking to imitate a particular innovation. This is because innovators and imitators seldom need equal access to a specific version of an innovation. Indeed, engineers seldom even want to see a solution exactly as their competitors have designed it: specific circumstances differ even among close competitors, and solutions must in any case be adapted to each adopter's precise circumstances. The cost of doing so may offset the rewards from imitation. Therefore, what an engineer often wants to extract from the work of others is the algorithms, principles and the general outline of a possible improvement, rather than the details easy to redevelop. Interestingly, this information is likely to be available from many sources – because a single innovation type is likely to be applied to many different problems and markets.

For example, suppose you are a system developer at a bank and you are tasked with improving in-house software for checking customers' credit online. On the face of it, it might seem that you would gain most by studying the details of the systems that competing banks have developed to handle that same task. It is certainly true that competing banks may face market conditions very similar to your bank, and they may well not want to reveal the valuable innovations they have developed to a competitor. However, the situation is still by no means bleak for an imitator. There are also many non-bank users of online credit checking systems in the world – probably millions. Some will have innovated and have the information you need. Of this group, in turn, some may be willing to reveal. The likelihood that the information you seek will be freely revealed by some individual or firm is further enhanced by the fact that your search for novel basic improvements may profitably extend far beyond the specific application of online credit checking. Other fields will also have information on *aspects* of the solution you need. For example, many applications in addition to online credit checking use software designed to determine whether persons seeking information are authorized to receive it. Any can potentially be a provider of information for this element of your improved system.

A finding by Lakhani and von Hippel (2003) illustrates the possibility that many firms and individuals may have similar information. They studied Apache help-line websites – sites that enable those having problems with Apache software to post questions, and others to respond with answers. The authors asked those who provided answers how many other help-line participants they thought also knew a solution to specific and often obscure problems they had answered on the Apache online forum. Information providers generally were of the opinion that some or many other help-line participants also knew a solution, and could have provided an answer if they themselves had not done so (Table 1).

Even in the unlikely event that a secret is held by one individual, that information holder will not find it easy to keep a secret for long. Mans-

Table 1. Others may also know 'your' information.

How many others do you think knew the answer to the question you answered?	Frequent providers ($n=21$)	Other providers ($n=67$)
Many (%)	38	61
A few with good Apache knowledge (%)	38	18
A few with specific problem experience (%)	24	21

Source: Lakhani and von Hippel (2003, Table 10).

field (1985) studied 100 American firms and found that 'information concerning development decisions is generally in the hands of rivals within about 12–18 months, on the average, and information concerning the detailed nature and operation of a new product or process generally leaks out within about a year.' This observation is supported by Allen's (1983) analysis of free revealing in the 19th-century English iron industry. Allen notes that developers of improved blast furnace designs were unlikely to be able to keep their valuable innovations secret because 'in the case of blast furnaces and steelworks, the construction would have been done by contractors who would know the design.' Also, 'the designs themselves were often created by consulting engineers who shifted from firm to firm.'

3.2. When profits from patenting are low

Next, suppose that a single innovator *is* the only holder of a particular innovation-related information, and that for some reason there are no easy substitutes for that information. Under these conditions an information-holder actually does have a real choice with respect to disposing of its intellectual property: it can keep the innovation secret and profit from in-house use only, it can license it, or it can choose to freely reveal the innovation. We have just seen that the practical likelihood of keeping a secret is low, especially when there are multiple potential providers of very similar secrets. But if one legally protects an innovation by means of a patent or a copyright, one need not keep an innovation secret in order to control it. Thus, a firm or an individual that freely reveals is forgoing any chance to get a profit via licensing of intellectual property for a fee. What, in practical terms, is the likelihood of succeeding at this and so of forgoing profit by choosing to freely reveal?

In most subject matters, the relevant form of legal protection for intellectual property is the patent, generally the 'utility' patent. (The notable exception is the software industry, where material to be licensed is often protected by copyright and sometimes by patent.) In the United States, utility patents may be granted for inventions related to composition of matter and/or a method and/or a use. They may not be granted for ideas *per se*, mathematical formulas, laws of nature, and anything repugnant to morals and public policy. Within subject matters possible to protect by patent, protection will be granted only when the intellectual property claimed meets additional criteria of usefulness, novelty, and non-obviousness to those skilled in the relevant art.

The real-world value of patent protection has been studied for more than 40 years. Various researchers have found that, with a few exceptions, innovators do *not* believe that patents are very useful either for excluding imitators or for capturing royalties in most industries (Fields generally cited as exceptions include pharmaceuticals, chemicals, and chemical processes, where patents do enable markets for technical information, see Arora et al. 2001.) Moreover, a majority of respondents state that the availability of patent protection does not induce them to invest more in research and development than they would if patent protection did not exist. Taylor and Silberston (1973) reported that for 24 of 32 firms, only 5% or less of the R&D expenditures were dependent on the availability of patent protection. Levin et al. (1987) surveyed 650 R&D executives in 130 different industries and found that all except respondents from the chemical and pharmaceutical industries judged patents to be 'relatively ineffective' compared with other measures such as secrecy or lead time advantages. Similar findings have been reported by Mansfield (1968, 1985), by Cohen et al. (2000, 2002), by Arundel (2001), and by Sattler (2003).

Despite recent governmental efforts to strengthen patent enforcement in the United States, a comparison of survey results indicates only a modest increase between 1983 and 1994 in large firms' evaluations of the patents' effectiveness in protecting innovations or promoting innovation-related investments. Of course, there are notable exceptions: some firms, including IBM and Texas Instruments, report significant income from the licensing of their patented technologies. Moreover, patents are often used as 'bargaining chips' for trading technologies or licensing them, and as means to prevent competitors from creating new technologies in areas of importance to the firm.

Obtaining a patent typically costs thousands of dollars, and it can take years to get the necessary approval (Harhoff et al., 2003). This makes patents especially impractical for many individual innovators, and also for small and medium-size firms of limited means. As a stark example, it is hard to imagine that an individual who has developed an innovation in sports equipment would find it appealing to invest in a patent and in follow-on efforts to find and prosecute imitators and/or find a licensee and enforce payment. Indeed, Shah (2000), in a study of sports equipment innovations developed mostly by individuals, found that few patented their inventions – and that those who did seldom gained any return from licensees as payment for their time and expenditures.

Copyright is a low-cost and immediate form of legal protection that applies to original writings and images ranging from software code to music and movies. Authors do not have to apply for copyright protection; it 'follows the author's pen across the page.' Licensing of copyrighted works is common, and it is widely practiced by commercial software firms. When one buys a copy of a non-custom software product, one is typically buying only a license to use the software for a certain period of time, not buying the intellectual property itself. However, in the case of intellectual property protected by copyright only the specific original writing itself is protected, not the underlying invention or ideas. As a consequence, those who wish to imitate the *function* of a copyrighted software program can do so by writing new software code to implement that same function. As seen in the case of the operating system GNU/Linux, innovators will do so if copyrighted software programs are too costly to license or if they lack the appropriate quality.

To summarize, in many practical situations little profit is being sacrificed by firms or individuals that choose to forgo the possibility of legally protecting their innovations in favor of free revealing.

3.3. When incentives for free revealing are positive

As was noted earlier, when we say that an innovator 'freely reveals' proprietary information we mean that all existing and potential intellectual property rights to that information are voluntarily given up by that innovator and that all interested parties are given access to it – the information becomes a public good. These conditions can often be met at a very low cost. For example, an innovator can simply post information about the innovation on a website without publicity, so those potentially interested must discover it. Or a firm that has developed a novel process machine can agree to give a factory tour to any firm or individual that thinks to ask for one, without attempting to publicize the invention or the availability of such tours in any way. However, it is clear that many innovators go beyond such basic, low-cost forms of free revealing. Often, innovators spend significant money and time to ensure that their innovations are seen in a favorable light, and that information about them is effectively and widely diffused. Writers of computer code may work hard to eliminate all bugs in the code they contribute to an open source community, and perhaps strive to document it in a way that is very easy for potential adopters to understand before freely revealing it. Plant owners may repaint their plant, announce the availability of tours at a general industry meeting, and then provide a free lunch for their visitors.

Innovators' *active* efforts to create awareness about their freely revealed innovations suggest that there are positive, private rewards to be obtained from free revealing. A number of authors have considered what these might be. Foray (2004) discusses implications of the distributed nature of knowledge production among users and others, and notes that the increased capabilities of the computing and communication technologies tend to reduce innovators' ability to control the knowledge they create. He proposes that the most effective knowledge-management policies and practices will be biased toward knowledge sharing. Allen (1983) and Nuvolari (2004) both suggest that an important private reward is that free revealing of new designs and their performances may significantly increase the rate of collective learning, leading to a more rapid development of better performing designs. This has also been modeled and shown to be an important factor rewarding the formation of innovation communities within which innovations are freely revealed (Baldwin et al., 2005; Baldwin and Clark, 2006).

Allen (1983) also proposed that reputation gained for a firm or for its managers might offset a reduction in profits for the firm caused by free revealing. Raymond (1999) and Lerner and Tirole (2002) elaborated on this idea when explaining free revealing by contributors to open source software development projects. Free revealing of high-quality code, they noted, can increase a programmer's reputation with his peers. This benefit can lead to other benefits, such as an increase in the programmer's value on the job market.

Free revealing may also increase an innovator's profit in other ways. When an innovator freely reveals an innovation, the direct result is to increase the extent and pace of diffusion of that innovation relative to what it would be if the innovation were either licensed at a fee or held secret. The innovator may then benefit from the increase in diffusion via a number of effects. Among these are network effects. (The classic illustration of a network effect is that the value of each telephone goes up as more are sold, because the value of a phone is strongly affected by the number of others who can be contacted in the network.) In addition, and very importantly, an innovation that is freely revealed and adopted by others can quickly become a 'dominant design' or even an 'open standard' that may preempt the development and/or commercialization of other versions of the innovation. If, as Allen has suggested, the innovation that is revealed is designed in a way that is especially appropriate to conditions unique to the innovator, this may result in creating a permanent source of competitive advantage for that innovator.

Being first to reveal a certain type of innovation increases a firm's chances of having its innovation widely adopted, other things being equal. This may induce innovators to race to reveal first. Firms engaged in a patent race may disclose information voluntarily if the profits from success do not go only to the winner of the race. If being second to the market quickly is preferable to being first to the market relatively late, there will be an incentive for voluntary revealing in order to accelerate the race (de Fraja, 1993).

Positive incentives to freely reveal have been most deeply explored in the context of open source software projects. Research on the open source software development process report that innovators have a number of motives for freely revealing their code. If they freely reveal, others can debug and improve upon the modules they have contributed, to everyone's benefit. Code that is freely revealed in open source projects has been found to be extensively reused. von Krogh et al. (2005) studied software reuse in 15 open source software projects. They report that *most* of the lines of software code in the majority of open source projects investigated were taken from the commons of other open source software projects and software libraries and reused. In addition, the developers interviewed stated that they were being motivated by 'giving back' to those whose freely revealed code has been of value to them. Many developers therefore developed software specifically for others to reuse. They also enjoyed being part of a community of developers where learning through feedback from peers is very effective. The latter finding supports the earlier work by Hertel et al. (2003).

Software code developers are also motivated to have their improvement incorporated into the standard version of the open source software that is generally distributed by the volunteer open source organization, because it will then be updated and maintained without further effort on the innovator's part. It must be noted that an improvement will be assured of inclusion in new 'official' software releases only if it is approved and adopted by the coordinating group of the software project, sometimes called 'core developers.' To become a core developer on a software project, a software project participant must expend considerable resources to identify and fix bugs or competently perform other tasks useful to the community (von Krogh et al., 2003).

By freely revealing information about an innovative product or process, a user makes it possible for manufacturers to learn about that innovation. Manufacturers may then improve upon it and/or, assuming economies of scale in production, offer it at a price lower than users' in-house production costs (Kotha, 1995; von Krogh et al., 2000; Harhoff et al., 2003). When the improved version is offered for sale to the general market, the original user-innovator (and others) can buy it and gain from in-house use of the improvements. For example, consider that manufacturers often convert user-developed innovations ('home-builts') into a much more robust and reliable form when preparing them for sale on the commercial market. Also, manufacturers may offer related services, such as field maintenance and repair programs, that innovating users must otherwise provide for themselves.

A variation of this argument applies to the free revealing among competing manufacturers documented by Henkel (2003). Competing developers of embedded Linux systems were creating software that was specifically designed to run the hardware products of their specific clients. Each manufacturer could freely reveal this equipment-specific code without fear of direct competitive repercussions: it was applicable mainly to specific products made by a manufacturer's client, and it was less valuable to others. At the same time, all would jointly benefit from free revealing of improvements to the underlying embedded Linux code base, upon which they all build their proprietary products. After all, the competitive advantages of all their products depended on this code base's being equal to or better than the proprietary software code used by other manufacturers of similar products. Additionally, Linux software was a complement to the computer hardware that many of the manufacturers in Henkel's sample also sold. Improved Linux software would likely increase sales of their complementary hardware products. (Complement suppliers' incentives to innovate have been modeled by Harhoff (1996)).

4. Private-collective model for innovation incentives

Free revealing may often be the best practical course of action for innovators. How can we tie these observations back to theory, and perhaps improve theory as a result? Recall that at present there are two major models that characterize how innovation gets rewarded in industry and society (von Hippel and von Krogh, 2003). The private investment model, discussed earlier, is based on the assumption that innovation will be supported by private investors expecting to make a profit. To encourage private investment in innovation, society grants innovators some limited rights to the innovations they generate via patents, copyrights, and trade secrecy laws. These rights assist innovators in getting private returns from their innovation-related investments. At the same time, the monopoly control that society grants to innovators create a loss to society relative to the free and unfettered use by all of the knowledge that the innovators have created. Traditionally, society elects to suffer this social loss in order to increase innovators' incentives to invest in the creation of new knowledge (Arrow, 1962; Dam, 1995).

The second major model for inducing innovation is the collective action model for innovation incentives. This model is applied to the provision of public goods, where a public good is defined by its non-excludability and non-rivalry as explained above (Olson, 1967). The collective action model assumes that innovators relinquish control of knowledge or other assets they have developed to a project and so make them a public good. This requirement enables collective action projects to avoid the social loss associated with the restricted access to knowledge of the private investment model. At the same time, it creates problems with respect to recruiting and motivating potential contributors. As contributions to a collective action project are a public good, those who will benefit from that good have the option of waiting for others to contribute and then free riding on what they have done (Olson, 1967).

The literature on collective action deals with the problem of recruiting contributors to a task in a number of ways. Oliver and Marwell (1988) and Taylor and Singleton (1993) predict that the description of a project's goals and the nature of recruiting efforts should matter a great deal. Researchers also argue that the creation and deployment of selective incentives punishing or rewarding contributors for their contributions is essential to the success of collective action projects. However, the importance of selective incentives suggests that small groups will be most successful at executing collective action projects (Oliver, 1980; Friedmann and McAdam, 1992). In small groups, selective incentives can be carefully tailored for each group member and the individual contributions can be more effectively monitored (Olson, 1967; Ostrom, 1998). Science is often mentioned as an example of the collective action model. Incentives to create good science include targeted funding of research, and reputation awarded to those who make significant and recognized contributions to the field (Stephan, 1996). However, additional incentives in the form of public subsidies may also be required to generate adequate contributions. Thus, it is common to provide university scientists with research grants from public funds to induce them to create and freely reveal scientific research findings (David, 1992, 1998; Dasgupta and David, 1994).

Open source projects create a public good and so would seem to naturally fall within the province of the collective action model. Interestingly, however, open source software projects deviate significantly from the guidelines for successful collective action projects just described. With respect to project recruitment, goal statements provided by successful innovation projects vary from technical and narrow to ideological and broad, and from precise to vague and emergent. (For examples of goal statements in open source projects, see the websites of projects hosted on Sourceforge.net.) Further, such projects may engage in no active recruiting beyond simply posting their intended goals and access address on a general public repository, like a website customarily used for this purpose (e.g. see the Freshmeat.net website). Also, projects have shown by example that they can be successful even if large groups – perhaps thousands – of contributors are involved. Finally, projects that thrive on free revealing such as open source software projects seem to expend no effort to discourage free riding. In open source software, anyone is free to download code or seek help from project websites, and no apparent form of moral pressure is applied to make a compensating contribution (e.g. 'If you benefit from this code, please also contribute . . .').

What can explain these deviations from expected practice? In other words, what can explain free revealing of privately funded innovations and enthusiastic participation in projects to produce a public good? From the theoretical perspective, we think the answer involves revisiting and easing some of the basic assumptions and constraints conventionally applied to the private investment and collective action models for innovation incentives. Both, in an effort to offer 'clean' and simple models for research, have excluded from consideration a very rich and fertile middle ground where incentives for private investment and collective action can coexist, and where a 'private-collective' model for innovation incentives can flourish. More specifically, a private-collective model occupies the middle ground between the private investment model and the collective action model in two ways. First, based on the empirical evidence discussed above regarding the private rewards associated with free revealing, we should review the assumption in private investment models that free revealing of innovations developed with private funds will represent a loss of private profit for the innovator. Indeed, the private-collective model of innovation incentives incorporates quite a different assumption: under common conditions, free revealing of proprietary innovations will increase rather than decrease innovators' private profit.

Second, a private-collective innovation incentive model modifies the assumption in collective action models that a free rider obtains benefits from the public good that are equal to those a contributor obtains. Instead, it assumes that private benefit to innovators from innovations freely contributed as a public good will yield *higher* private benefits to innovators than to free riders. This is realistic because contributors to a public good can obtain private rewards tied to the *development* of that good. Consider that the problem solving process and effort used to produce the public good yield private benefits that innovators have been shown to value, such as learning, enjoyment, and a sense of ownership of the user's work product. (In open source software and other software projects the technical learning opportunities have been found to be substantial (Hertel et al., 2003).) Previous coding and learning, in turn, can increase the user's returns on learning in future activity (Arthur, 1997).

In addition, individual benefits in open source software projects have been tied to *participation* in communities surrounding the projects as opposed to simple free riding (Raymond, 1999; Moon and Sproull, 2000; Wayner, 2000; O' Mahoney, 2003; von Krogh et al., 2003). Hertel et al. (2003) support this view in a test of two extant models in the social psychology and sociology literatures. The first model is by Klandermanns (1997) and explains the incentives for people to participate in social movements. The second model deals with motivational processes in small work teams, particularly 'virtual teams' with members working in different places and coordinating their work mainly via electronic media (Hertel, 2002; Hertel et al., 2004). The researchers found a good fit between both models and data derived from a survey of 141 contributors to the Linux kernel. That is, they found that contributors' identify with the Linux developer community. They are also motivated by pragmatic motives to improve their own software, and by group-related factors such as their perceived indispensability for the team with which they are working.

Finally, it seems reasonable that if the cooperation among innovators is intense and sustainable, the social rewards might even outweigh individual rewards from the collective good being jointly developed. Typically, innovators that expend considerable resources in the project develop feelings of solidarity, fairness, and altruism. Interestingly, such 'transformation of individual psychology' (Elster, 1986) can make the innovator voluntary contribute to the project beyond a level that would correspond to the individual benefits derived from the public good and its production. Therefore the analysis of the nature of the community of cooperating innovators must complement the analysis of individual rewards in the free revealing of innovation: Many rewards are tied to entry into, contribution to, and exit from the community.

Table 2 summarizes the line of argumentation in this section by distinguishing and comparing the private investment, collective action, and private-collective model with respect to incentives to innovate, and the social implications of each

Table 2. Three models of innovation incentives.

Private investment model	Collective action model	Private–collective model
Applies to: Provision of private goods Key assumption: Innovators will gain higher profits than free riders only if innovations *are not* freely revealed as public goods Impact on social welfare: Monopoly control granted to innovators represents a loss to society relative to free use by all of knowledge created	Applies to: Provision of public goods Key assumption: Innovators and free riders profit equally from innovations contributed as public goods Impact on social welfare: Free revealing by participants in collective action projects avoids social loss problem, but public subsidy may be required to reward contributors	Applies to: Provision of public goods Key assumption: Innovators gain higher profits than free riders from freely-revealed innovations because some sources of profit remain private Impact on social welfare: 'Best of both worlds' in which public goods are produced at private expense. Innovators relinquish control of knowledge produced, but at the same time gain private profits, so public subsidy not required

model. The private-collective model of innovation incentives explains conditions under which an innovation created by private funding may be offered freely to all. When these conditions are met, society appears to have the best of both worlds – new knowledge is created by private funding and then freely offered to all.

5. Conclusion

We have argued that free revealing of the detailed workings of novel products and services is a central feature of 'open innovation.' We have also shown that innovators frequently freely reveal proprietary information and knowledge regarding both the information-based products and the physical products they have developed. Such free revealing can make good economic sense for innovators and for society as well, and there are several incentives, some weak and other strong, that promote this behavior. The phenomenon of free revealing suggests that an alternative exists to the private and collective action models of innovation incentives. A 'private-collective' model of innovation incentives combines elements of the private model with elements of the collective action model. It occupies a middle ground that appears to offer society 'the best of both worlds' – public goods created by private funding.

We suggest further research to develop a better understanding of this intriguing middle ground. In particular, research should investigate how the incentives proposed in the private-collective model interact to produce or prevent free revealing as an outcome of innovation. In addition, future empirical research is needed on free-revealing as a competitive strategy. As mentioned above, innovators often reveal information and knowledge with a time lag. There is a need to better understand the nature of this lag, and the costs or benefits it incurs for the innovators and the adopters of the innovation.

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Notes

1. Please note that definitions of open innovation may take a less restrictive view on 'openness.' See for example a key contribution by Chesbrough (2003), or the editors' introduction to this special issue.