Open Beyond Software

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Teams of employees at firms innovate. Scientists and engineers at universities and research institutions innovate. Individual inventors at private labs innovate. Regular people consume. Wrong! Regular people innovate, too. Users have been the source of many large and small innovations across a wide range of product classes, industries, and even scientific disciplines.

We are accustomed to thinking of firms as the primary engine of innovative activity and industrial progress. The research and development activities of most firms are based on a proprietary model; exclusive property rights provide the basis for capturing value from innovative investments and managerial control is the basic tool for directing and coordinating innovative efforts. The proprietary model does not, however, stand alone.

The "community-based" model has generated many of the innovations we use on a daily basis. The social structure created by this model has cultivated many entrepreneurial ventures and even seeded new industries and product categories. In stark contrast to the proprietary model, the community based model relies neither on exclusive property rights nor hierarchical managerial control. The model is based upon the open, voluntary, and collaborative efforts of users – a term that describes enthusiasts, tinkerers, amateurs, everyday people, and even firms who derive benefit from a product or service by using it.

Open source software development is perhaps the most prominent example of the community-based model. Although often viewed as an anomaly unique to software production, the community-based model extends well beyond the domain of software. Innovative communities have been influential in product categories as diverse as automobiles, sports equipment, and personal computers.

In this chapter, I describe and discuss three elements of the community-based model. First, users and manufacturers generate different sets of information. This allows users to develop innovations distinct from those typically developed within firms. Specifically, innovations embodying novel product functionality tend to be developed by users. Second, users may choose to share their innovations within user communities. The structures of these communities vary, but those observed to date are built on the principles of open product design and open communication. Third, innovations developed by users and freely shared within user communities have provided the basis for successful commercial ventures. Data drawn from the windsurfing, skateboarding, and snowboarding industries illustrate these processes. Four additional examples of the community-based model - spanning fields and centuries - are then presented. I conclude by reframing our view of the innovation process as driven by the activities of firms and research institutions and discussing implications for firms and policy.

Sports Equipment Innovation by Users & Their Communities

Both users and manufacturers contributed to the development of equipment innovations in the windsurfing, skateboarding, and snowboarding industries. *Users* are defined as individuals or firms that expect to directly benefit from a product or service by using it (von Hippel 1988). In contrast, *manufacturers* are those who expect to benefit from manufacturing and selling a product, service, or related knowledge; thus, firms, entrepreneurs, and inventors seeking to sell ideas, products, or services are all examples of manufacturers. To illustrate, snowboarders are users of snowboards. Firms such as Burton and Gnu are manufacturers of snowboards. An inventor who hears that there is a market for improved snowboard bindings and develops a new type of binding with the intent of patenting and licensing it is categorized as a manufacturer.

The User Innovation Process in Three Sports

This section describes the process by which users and their communities develop innovations. I begin with an example that illustrates this process. The following passage describes how Larry Stanley and the community of windsurfing enthusiasts around him innovated in the sport of windsurfing.

Mike Horgan and Larry Stanley began jumping and attempting aerial tricks and turns with their windsurfing boards in 1974. The problem was that they flew off in mid-air because there was no way to keep the board with them. As a result, they hurt their feet and legs, damaged the board, and soon lost interest. In 1978 West German Jurgen Honscheid came to participate in the first Hawaiian World Cup and was introduced to jumping. A renewed enthusiasm for jumping arose and soon a group of windsurfers were all trying to outdo each other. Then Larry Stanley remembered the Chip - a small experimental board that he had equipped with footstraps a year earlier for the purpose of controlling the board at high speeds - and thought:

It's dumb not to use this for jumping.

I could go so much faster than I ever thought and when you hit a wave it was like a motorcycle rider hitting a ramp – you just flew into the air. We had been doing that, but had been falling off in mid-air because you couldn't keep the board under you. All of a sudden not only could you fly into the air, but you could land the thing. And not only that, you could [also] change direction in the air!

The whole sport of high performance windsurfing really started from that. As soon as I did it, there were about 10 of us who sailed all the time together and within one or two days there were various boards out there that had footstraps of various kinds on them and we were all going fast and jumping waves and stuff. It just kind of snowballed from there.

News of the innovation spread quickly and instructions for how to make and attach footstraps to a windsurf board were shared freely. Later, Larry Stanley, Mike Horgan and a small set of windsurfing friends would begin the commercial production and sale of footstraps (and other innovations). Today the footstrap is considered a standard feature on windsurf boards.

This example illustrates three key components of innovation development by users. First, the act of use itself creates new needs and desires among users that lead to the creation of new equipment and techniques. Second, user cooperation in communities is critical to prototyping, improving, and diffusing solutions to those needs. Working jointly allows rapid development and simultaneous experimentation, however working jointly also requires that users openly reveal their ideas and prototypes to others. Third, user innovations – even after they have been freely revealed - are sometimes commercialized. Each of these three key components is discussed in detail below.

Discovery through Use

Users generate and accumulate information based on product use in extreme or novel contexts, the creation of new (unintended) uses for the product or service, and accidental discovery - in addition to intended product use. In contrast, marketing teams at firms generally focus on understanding and improving the *intended* use(s) of a product. For example, until the handles of childrens' scooters accidentally fell off and children experimented with the resulting toy, it is unlikely that manufacturers would have identified skateboarding as a fun activity. These differences in usage and search patterns create an information asymmetry between users and manufacturers. Because users and manufacturers hold different stocks of information, they will tend to develop different types of innovations.

Two complementary sets of information are required for product development activity: (1) Information regarding need and the use context. As discussed in the previous paragraph, this information tends to be generated by users[1]. (2) Solution information. This information may be held by both manufacturers who specialize in a particular solution type and by individuals with expertise in specific areas. It can be a challenge to bring these sets of information together. Both need and solution information can be difficult to communicate between individuals and difficult to transfer from the site where it is generated to other sites, in other words, information is both tacit and sticky (Polanyi 1958; von Hippel 1994; Nonaka and Takeuchi 1995). These difficulties in transferring information, combined with the potential idiosyncratic nature of the request and communication costs, can make it difficult for manufacturers and users to work together.

If information cannot be transferred, users and manufacturers will continue to hold different sets of innovation-related information. Not surprisingly, innovators will develop innovations based upon the information they possess. As a result, users and manufacturers will tend to develop *different types* of innovations. *Functionally novel innovations* will tend to be developed by users. These types of innovations allow users to do qualitatively different things that could not be done previously, that is, they create a new functional capability, e.g. adding footstraps to a windsurfing board so that "jumping" is possible. The development of such innovations requires a great deal of information regarding user needs and use context –

[1] Technique is as important as equipment when it comes to actual use activity. We will focus on innovations in equipment in this chapter, but innovations in technique are equally important, e.g. a surgeon with a new tool must devise a new surgical technique before using the tool. The example at the beginning of this section that describes the development of footstraps provides a particularly vivid illustration of the interplay between equipment and technique innovations.

information that is held by the user; it makes little sense for manufacturers to "guess" what novel functions users might want. *Dimension-of-merit innovations* may be developed by manufacturers or users. Dimension-of-merit innovations improve known product performance parameters, e.g. making a snowboard less expensive, faster, or lighter. Manufacturers, with their dedicated engineering and design staffs, can draw from their specialized expertise to improve dimensions-of-merit known to be of value to customers in order to maximize sales and market share. Users can also draw from what they know to make dimension-of-merit innovations.

Individual users hold limited stocks of information from which to draw when innovating[2]. Even a user who knows exactly what functionality she desires may be unable to independently create a solution that achieves that functionality, let alone create an efficient or elegant solution. Users frequently overcome this barrier by working together.

Communities: Cooperation Between Users

Working together provides users with significant benefits. Working with others allows users to access resources in order to develop their innovations. Working with others also allows more rapid development due to simultaneous experimentation. To illustrate, consider the following description given by windsurfing innovator Larry Stanley:

> *…we were all helping each other and giving each other ideas, and we'd brainstorm and go out and do this and the next day the [other] guy would do it a little better, you know, that's how all these things came about…I would say a lot of it stemmed from Mike Horgan because, if something didn't work, he would just rush home and change it or he'd whip the saw out and cut it right there at the beach.*

Cooperation between users can take many forms. Informal one-to-one cooperation between users is frequent. Semi-structured one-to-many interactions have also been documented (e.g. through publications in newsletters, magazines, and websites). More structured cooperation

[2] Extending the information asymmetry argument one step further, we see that individual users and manufacturers will create and hold different stocks of information. As a result, different users (or manufactures) will develop different solutions and some users (or manufacturers) will be able to more cheaply develop a solution or develop a better a solution than others.

within "innovation communities" is also widespread. Innovation communities provide social structures and, occasionally, tools that facilitate communication and interaction between users and the creation and diffusion of innovations. Open source software development communities are a good example of this.

Innovation communities are composed of loosely-affiliated users with common interests. They are characterized by voluntary participation, the relatively free flow of information, and far less hierarchical control and coordination than seen in firms. These characteristics allow for rich feedback and the potential to match problem with individuals who possess the ideas and means to solve them. Due to the varied needs and skills of the individuals involved, user communities are often well-equipped to identify and solve a wide range of design problems.

Innovation communities may be specifically organized around the development of a particular product or may be organized around a particular activity, with innovation being only one of the community's stated or emergent functions. The term community - rather than network, for example – is used, because these groups often call themselves communities and possess distinct social structures. User innovation communities develop norms and rules, methods for attracting new members, and methods for maintaining their structure and integrity.

Two unique facets of innovation communities are their dedication to open product design and open communication. Open product design means that users are able to modify – "tinker with" – the product or service. Product design can be closed technologically (e.g. by distributing software code only in binary format) or via institutional and contractual mechanisms (e.g. warranties, intellectual property protection, government law and regulation, licensing or usage agreements). For example, proprietary software by its very nature prevents user innovation: the code is closed both institutionally, through copyright protection, and technologically, through distribution in the form of binary code. In contrast, open source software not only allows, but encourages user innovation. This has two consequences: (a) user innovation will only flourish in open source, and (b) users inclined to innovate will gravitate towards open source. More generally speaking, open design is a prerequisite for facilitating user innovation and the formation of innovation communities.

In addition to open design, communities working with complex products or sets of information may choose to adopt modular project architectures. Modular design involves building complex products from smaller subsystems that can be designed independently yet function together as a whole. When a product or process is "modularized," the elements of its design are split up and assigned to modules according to a formal architecture or plan. Modularization makes complexity manageable; enables multiple individuals to work simultaneously and later integrate their work products; and makes it possible to accommodate unforeseen changes to the system, so long as the design rules are obeyed (Baldwin and Clark 2000).

Innovation communities embrace open communication. By making information and innovations accessible to as many interested users as possible in a timely manner, innovation communities increase the diversity of expertise that can be brought to bear on a problem and allow the results of trial-and-error experimentation by multiple parties to be exchanged. Both factors are likely to increase the likelihood that an effective solution will be created and reduce the time required to create such a solution.

User communities utilize a number of communication channels. Today, the Internet is one of the most common – and is being used for much more than open source software development. For example, kite-surfing enthusiasts have created an on-line community where they share innovation-related information on board and sail design. Mailing lists and websites are well-suited communication platforms for communities. They allow many users to be reached very quickly and allow users to both share and record information; they are relatively inexpensive, widely accessible, and easily scalable. However, free and open diffusion of ideas and innovations occurred even before the advent of the Internet. Users have historically and continue to share ideas through word-of-mouth; at club meetings, conferences and competitions; and in newsletters and magazines. For example, Newman Darby, who is credited with the invention of the windsurfer, published blueprints and instructions for making a windsurfer in *Popular Science* magazine.

The open revelation of information and innovations is a necessary input into cooperative work. Communities provide several innovation-related benefits that might lead an innovator to develop an innovation within or share a completed innovation with the community. First, community members work with innovators and provide innovation-related ideas and assistance (Franke and Shah 2003; Harhoff, Henkel et al. 2003). In order to get assistance, one must reveal the problem and possible solutions. Given that user-innovators are also enthusiasts who enjoy practicing their activity, much of the "reward" for innovation lay in future improvements and continued use. It thus makes sense to reveal the innovation (unless the innovator believes the design is ideal), since revealing opens the door to getting feedback and improvements ideas from others. Interviews with innovators indicate that a desire to advance the technology motivate collaborate work:

> *We knew that we were just scratching the surface… The more we worked together, the sooner we'd go faster or do new things.*

Second, innovators may share simply because they enjoy the innovation development process and working with others. This pattern emerged in this study, and in research examining the activities and motives of software, radio, and automobile enthusiasts (Weizenbaum 1976; Gelernter 1998; Torvalds 1998; Haring 2002).

> *If you did not share… [others] would not be able to keep up with you. To do or experience something new and fantastic or go another step faster isn't much fun when you shout 'Wow! Did you see that!' and nobody is there to hear you.*

Third, user-innovators willing to share their work with others generally want to prevent third-parties from appropriating their work. Third-party appropriation would prevent users from further modifying, improving, and producing the innovation. Communities take a variety of precautions to protect their work and make sure that it will remain available for others to use and modify. For example, public exhibition and documentation acts to prevent appropriation by the manufacturer and encourages development by others. Protecting the innovation via available intellectual property protection mechanisms and then allowing others to use and modify it freely can have a similar effect. The sports enthusiasts described here engage in such practices, as do communities of open source software developers (O'Mahony 2003).

Finally, a generally unintended consequence of sharing the innovation in the community is the potential development of a market for the innovative product or product feature - and the opportunity to build a business to satisfy and further grow this market. Sharing the innovation with others can result in both improvement and widespread adoption of the innovation. While some adopters will be willing to construct the innovation for themselves, others will prefer to purchase the innovation, thereby paving the way for firm entry. The process by which user innovations were commercialized in the windsurfing, skateboarding, and snowboarding industries is described in the next section.

Commercialization

Conventional wisdom argues that the open revelation of innovations and the commercialization of those same innovations for profit are antithetical. Yet a number of innovating users both freely revealed their innovations and started firms that produced those innovations for sale to others. The actions of snowboarding innovator Dimitrije Milovich show how a user-innovator can both profit from an innovation and contribute to community development and market growth. Milovich, granted a patent for his snowboard design in 1971, made it known that he would not enforce his patent against users and other firms in the industry. His actions encouraged experimentation by users and the founding of new firms; both of which are likely to have contributed to market development and growth. He also started his own snowboard manufacturing firm, called Winterstick. Many other user-innovators in these sports did not patent their innovations – purposefully or because they did not recognize the potential commercial value of the innovations – but later started companies that produced the innovations for sale to others[3].

Not only can free revealing and commercial activity coexist, but free-revealing can actually set the stage for profitable commercial production. As the innovation diffuses through the community, the reactions of community members to the innovation can be observed. Information regarding improvement ideas, usefulness, and new uses is openly communicated and discussed, making the community a rich source of information for innovating users, users, entrepreneurs, and existing firms seeking to make investment decisions. This is especially true

[3] A small handful of user-innovators responsible for key innovations patented their innovations. Their experiences suggest that the enforcement of intellectual property rights – i.e. the decisions of courts in upholding patents which have been granted - is worthy of further examination. In the few cases where the windsurfing, skateboarding, and snowboarding innovations studied were patented and then challenged in court by firms wishing to profit from the manufacture of the innovation without paying licensing fees to the innovator, courts tended to overturn the patents. It was argued that these patents did not meet the "non-obviousness" criteria required to be granted a patent: if a layperson could develop the innovation, how could it be non-obvious? In contrast, firms tended not to challenge patents granted to users who were also professionally trained engineers. The legal system is reliant on the knowledge held by society and is influenced by society's assumptions, norms, and biases. It is possible that user-innovators will not be afforded the same rights as inventors, formally-trained scientists and engineers, and firms until the importance of innovation by users is more widely recognized.

in the context of new or emerging product categories where price and quantity information are not available and where it is difficult or impossible to engage in market research; recall that at this stage many users are building their own products, distribution chains do not exist, and overall awareness of the product has not penetrated to the mainstream.

As user-innovators observed interest in their innovations, many chose to commercialize the product. This process is straightforward in some cases, and highly emergent in others. Some user-innovators did not think to produce their innovation for sale to others until after receiving a series of requests from enthusiasts - who had heard of the equipment from other enthusiasts or in newsletters and magazines – interested in purchasing a copy of the innovation. Handmade copies of the equipment were initially constructed for free or at-cost. Eventually, some user-innovators realized that they could sell the equipment at a profit and began to manufacture and market the product.

Firms founded by users in these industries functioned as lifestyle firms for many years. By lifestyle firm, I mean a firm with ten or fewer employees that generates modest revenues for innovating users while they continue to innovate and advance their skills in a sport. These firms were initially operated out of garages or spare rooms. In their early years, these firms generally had no capital equipment beyond portable power tools and produced products one-by-one or in small lots. User-innovators who founded firms typically worked full-time at other jobs and often had low opportunity costs for their time.

The activities of users who founded firms highlights the multiplicity of motives at play, and cautions us to not think of entrepreneurial motivation in purely material terms. First, the innovative activity observed does not appear to be driven by pecuniary motives as is commonly thought; rather it was driven by motives such as use, enjoyment, challenge, and a desire to build the sport. Second, for many user-innovators, the benefits of starting a firm were not merely financial. Starting a firm also allowed them to spend more time practicing and building the sport they enjoyed and, as the business became more profitable, they could afford to give up other forms of employment and focus fully on the sport.

Over time, many of these firms became leaders in their fields and many were regarded as makers of exceptionally high-quality equipment. Several continue to operate independently, while the brands established by others have been acquired by larger manufacturers. Many of today's well-known brands in the windsurfing, skateboarding, and snowboarding industries –

including Windsurfing Hawaii, Gnu, Winterstick, and Dogtown Skates - were created by innovative enthusiasts who later became entrepreneurs.

How Important is Community-Based Innovation in These Sports?

In 2000, I conducted a longitudinal study of the development and commercialization histories of 57 key equipment innovations in the windsurfing, skateboarding, and snowboarding industries (Shah 2000)[4]. The aim of the study was to understand the extent to which users did or did not contribute to innovative and commercial activity in these sports. The study found that users and their communities were critical to the emergence and development of these sports.

Sports equipment users developed the first-of-type innovation in each of the three sports studied, that is, users developed the first skateboard, the first snowboard, and the first windsurfer. Users also developed 57% of all major improvement innovations in the sample, while manufacturers developed 27% of the major improvement innovations. The remaining 16% were developed by other functional sources of innovation, such as joint user-manufacturer teams or professional athletes[5].

Product Origins: First-of-Type Innovations

In each of the three sports studied, users developed the initial first-of-type innovation. In each instance, the innovator(s) engaged in the process of bricolage, using the skills and materials at hand to create the innovation.

For example, skateboarding began in the early 1900s. At that time, children played and rode on wooden scooters, often homemade, consisting of a board with roller skate wheels and a handle attached for control. Over the next five decades, adventurous users removed or did without the handle (it often broke off), thereby creating the first skateboards.

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[4] The innovations were identified with the assistance of multiple experts in each industry. Detailed information on each innovation was gathered through one-on-one interviews with a variety of actors - innovators, designers, early manufacturers, current manufacturers, magazine editors, book authors, friends and acquaintances of the innovator who were involved in the innovation process, and occasionally professional competitors in the sport. Whenever possible, the innovator was interviewed to get a better understanding for the local information employed and the specific circumstances, needs, and problem solving methods surrounding the innovative activity. *Innovator* is defined as the individual or set of individuals who first develop a working prototype of an equipment innovation.

[5] In the study, users and professional athletes are treated as distinct. Users benefit directly through product use. In contrast, professional athletes derive financial and career-related benefits from activities such as winning or placing well at competitions and being awarded advertising contracts.

In the case of snowboards, people have been trying to stand up on their sleds for ages. Experts agree, however, that the "formal" history of the snowboard began with Sherman Poppen's Snurfer (Howe 1998; Stevens 1998). In 1965 Poppen noticed his daughter and a friend standing up on their sleds as they slid down a hill. He went to his workshop and used the materials available to create the first prototype – two skis bound together with a string attached at the nose for stability – of what would later become known as the "Snurfer" (a name created by combining the words snow and surfing)[6].

In the case of windsurfing, an individual user, Newman Darby, was the initial innovator. In 1964 Darby, a Pennsylvania sailboat enthusiast and amateur boat builder, created the first windsurfer by fixing a universal joint to the base of a mast on a floating platform. The universal joint – a fundamental feature of the windsurfer - allowed the board and mast to move relative to one another. This in turn meant that the sailor could directly manage the direction of sail by standing up and holding the boom and tipping the mast. Darby recollects his experience:

> *I first designed the universal joint back in 1948 to use, but I was afraid it would be too dangerous…But [with designs lacking the universal joint] every time the wind blew too strong, it blew the sail out of the socket. So I decided, "Well I'm going to have to use the universal joint." I was a little afraid it would break your legs if you went over. Then I started developing one using rubber hoses… I even tried a metal universal joint, and I finally devised one using ropes (Darby 1997).*

Major Improvement Innovations

Manufacturers developed 27% (n=12) of the major improvement innovations in the sample; users developed 57% (n=26)[7]. Major improvement innovations are an important subset of overall innovative activity in the sport. They are those equipment innovations identified by multiple experts as being most critical to the development of the sport.

Existing manufacturers developed a total of three major improvement innovations in the sample. For example, an engineer at Shimano (a bicycle manufacturer) designed the first step-in

[6] Whether or not Poppen was a user is not clear, however his activities were first inspired and appreciated by a group of users important to him – his daughter and her friends!

[7] Percentage calculations throughout the paper exclude nine innovations for which the innovator is not known.

binding for snowboards. He initially designed the device for bicyclers and realized that the design could also be used for snowboarding. Shimano then worked with the snowboard company K2 to develop the Clicker, the first functional step-in bindings.

Manufacturers organized specifically to produce for the sport in question developed three major improvement innovations in the sample. For example, F2, which was initially organized to distribute and manufacture windsurfers for the European market, is believed to have pioneered the use of polyester film as a sail material.

Sports equipment component suppliers developed six major improvement innovations in the sample. These innovations generally involved transferring specific technology and know-how from an existing sport to the novel one. For example, a maker of fins for surfboards was asked to design a fin to solve some windsurfer-specific problems. Similarly, a producer of sailboat sails worked to improve the design of windsurfing sails and made several innovations. Interestingly, in all cases, the innovative components suppliers were small craft shops run by their founder-owners.

Users and *user-manufacturers* developed 58% of all improvement innovations in the sports studied. The term user-manufacturer describes innovative users who founded firms *after* prototyping and beginning to refine an innovation(s) – and, in most cases, also after sharing the innovation(s) with others[8]. These individuals benefited from their innovation(s) both through use and financially. As discussed earlier, the firms they founded are generally best characterized as small, lifestyle firms rather than mass market producers.

Community-Based Innovation & Development: An Even Broader Phenomenon

We've seen how users and their communities shaped the windsurfing, skateboarding, and snowboarding industries and we observe that open source software communities have and continue to shape the software industry. Are these unique cases or are they representative of a broader phenomenon? It appears that users will innovate whenever they have the means and interest to do so. The following four examples show that community-based innovation has been

[8] The first innovation produced by user-manufacturers was made prior to the creation of a firm. Subsequent innovations made by user-manufacturers with ten or fewer employees are included in this category. Innovations developed by user-founded firms that grew beyond ten employees are classified as manufacturer innovations in order to conservatively estimate innovative activity by users.

influential in shaping product classes, industries, and even scientific disciplines for hundreds of years.

The Automobile

Franz (1999) describes innovations in automotive accessories made by middle-class American leisure travelers during the early 1900s. She reports that users built and added such features as radiator hoods, safety devices, interior heaters, automobile tops, trunks, reclining seats, and electric ignitions to their cars. Some even replaced the standard body altogether. “The rewards of tinkering lay… in the cultural space of leisure where amateurs produced their own narratives of ingenuity and claimed knowledge of the new machine (Franz 1999, pg. 149).”

Many of these innovators shouldered the cost of disseminating news of their innovations to other automobile enthusiasts. In the early 1900s a high number of journals for automobile enthusiasts - “written by and for devotees of the new “sport” (Franz 1999, pg. 198) - published innovator-written “how-to” articles. Existing manufacturers often learned of innovations via the innovators themselves, through requests for repairs, phone calls suggesting that the manufacturer adopt the innovations, and articles in the hobbyist journals (one of the journals was sponsored by Ford). Despite these avenues for information transfer and the fact that many innovating users did <u>not</u> patent their innovations, substantial time lags existed between the time an innovation was made and communicated to other users and when manufacturers incorporated it into commercial products.

The Personal Computer

As is well known, the personal computer revolution was not instigated by R&D scientists and engineers toiling in well-equipped labs. The personal computer was initially developed by hobbyists working after hours in garages, warehouses, basements, and bedrooms (Freiberger and Swaine 2000). These individuals triggered a revolution through their own fascination with technology and willingness to openly share hard-won technical insights with fellow enthusiasts through local computer clubs (such as the Homebrew Computer Club) and hobbyist electronics magazines such as *Popular Electronics* and *Radio Electronics*. Over time many hobbyists started companies to sell copies of their work to those unwilling or unable to construct their own.

In fact, many well-known names in the computer and software industry today, including Bill Gates, Paul Allen, and Steve Wozniak, were active hobbyists before they became entrepreneurs.

User Firms in the 18th Century Iron Industry

We've seen many examples of individual users working together, but there are also examples of *user firms* working together. All firms use products that they do not sell to consumers, e.g. the information technology activities of investment banks. Allen's (1983) study of the 18th century iron industry found that firms cooperated and shared information pertaining to the design and construction of blast furnaces. Improved blast furnace design increased the temperature of the blast and significantly reduced fuel consumption. According to Allen, the science behind blast furnace technology was not well understood. No one could predict how design changes would affect furnace performance, so development took the form of trial-and-error learning. Firms were limited in their ability to independently experiment as construction costs were high. By sharing experiences with different designs, firms could multiply the number of experiments from which to learn and collectively improve the technology.

Amateur Astronomy

Users also contributed innovations and discoveries to the scientific disciplines. For example, amateurs played a significant role in the development of astronomy equipment (Lankford 1981). They pioneered the use of reflecting telescopes and applied photographic techniques to the study of the stars. Amateurs published papers in journals alongside professionals, received the same awards, and attended the same meetings. The activities of professionals and amateurs were similar, but because amateurs were allowed to take greater risks than professionals (who were concerned about their careers), the two groups often came into conflict. By the early 1900s amateurs were unable to compete with the activities of trained astrophysicists, largely because only those with specialized training were allowed to access the increasingly sophisticated and expensive technologies housed within universities and research institutions. By restricting access to tools and technology, professionals effectively limited the ability of amateurs to contribute to and challenge the field.

Today, thousands of amateurs are once again making meaningful contributions to the field of astronomy. A revolution triggered by three new and inexpensive technologies has reignited amateur astronomy over the past two decades (Ferris 2002). First, there was the creation of the “Dobsonian,” a powerful telescope built from inexpensive materials.

> In the early 1950s, John Dobson spied a 12-inch piece of porthole glass on a friend's table and realized that it could be polished with sand into a reflecting telescope mirror. As an ascetic monk with no money, he was forced to scrounge for materials, cobbling the mount from such humble objects as a plywood box, the cardboard cores of garden hose reels, and roof shingles. Then he pointed his homemade contraption at the moon -- and was astonished by how much detail he could see. Craters, mountains, crags leapt to life. "It was like I was coming in for a landing," he says. His eventual design for an affordable Newtonian reflecting telescope would later be named the Dobsonian (Campbell 2004).

Dobson actively reached out to other enthusiasts and provided them with instructions for building the telescopes. Enthusiasts willing to forego shortcuts can build a Dobsonian for about $20; for a few hundred dollars they can assemble one using materials available at most hardware stores or from a kit. Then came the creation of the CCD, a highly light-sensitive chip able to record very faint starlight with far greater accuracy than a photograph. Finally, the Internet multiplied the power of individual efforts by enabling rapid collaborative work.

Armed with Dobsonian telescopes and CCD sensors, thousands of amateurs are exploring space and recording events that might otherwise go unnoticed by professionals. This community of globally linked amateurs share their observations and expertise within minutes via email, community websites, and mailing lists as they as they race to document, understand, and corroborate their findings. They also meet from time to time at meetings and conferences, and keep abreast of developments through magazines.

In these examples, we see the importance of use <u>and</u> community. Use drives the emergence and recognition of heterogeneous needs and desires. Community allows rapid experimentation and allows individuals with differing expertise to bring their skills and knowledge to bear on a particular problem. Users in a wide variety of fields work within communities where the open exchange of ideas, prototypes, and resources is commonplace.

Although communities are rarely created for the express purpose of encouraging and supporting innovation, many communities fulfill this function. The social structure provided by communities facilitates the development of user innovations by making resources – ideas, expertise, skills, and physical resources – more easily accessible and by creating incentives that support the sharing of resources and the creation and diffusion of innovation.

Reframing: Where Does Innovation Come From?

Why have we overlooked the fact that so much creative and innovative activity stems from the everyday behavior of regular people? Three factors that are likely to have played a role: Schumpeter's legacy, the low visibility of user innovators outside their own community, and the deliberate creation of a consumer culture.

Firms and entrepreneurs are generally recognized as the primary agents of product change and economic progress (Schumpeter 1934; Nelson and Winter 1977; Dosi 1982). Firms are motivated by profits and invest in research and development in order to create new products for consumers. As the instigators of change, it is incumbent upon firms to either educate the consumer to want what they produce or identify and satisfy consumer needs. The consumer's role is a passive one: producers, not consumers, innovate and consumer preferences do not change without producer influence. The consumer merely chooses to make or not make a purchase based on price and comparison with other products and services. In broad and oversimplified terms, this is what is taught to students in management, marketing, economics, and engineering. There is no simple term by which to refer to the "everyday" person who also innovates. Enthusiast, hobbyist, tinkerer, and developer are all possibilities; but they all carry distinct connotations. The term user-innovator is better, but is neither perfect nor widely used.

The relatively low visibility of user-innovators may have also prevented us from noticing their activities or viewing them as more than mere anomalies: while firms are likely to heavily promote their innovations to the mass market, consumer innovations are more likely to be diffused through word of mouth or be written up in small, specialist newsletters, journals, or, more recently, websites. Although it appears that users have always innovated, the advent of the Internet made their activities more visible to those outside of innovation communities and the success of some open source software development provided an extreme example of the power and effectiveness of user communities.

Nobel (1977) argues that the rise of the corporation and the engineer in the 1900s led to "the deliberate creation of a consumer culture, through advertising, to absorb and diffuse potential revolutionary energies." Institutions, namely corporations, sought to identify themselves with innovation, and relegate the consumer to a passive role (recall that historically individuals were anything but passive, producing much of what they used and consumed themselves). Corporations worked to inhibit innovation by consumers through a variety of means, including advertising and creating closed designs (i.e. product designs that made it difficult for a consumer to alter or tinker with the product).

As a result, two characters dominate the landscape of managerial, economic and sociological thought in the area of innovation: firms and consumers. Firms produce. Consumers consume. As we have seen, however, users have played and continue to play a dramatic role in the development, diffusion, and commercialization of innovations. What does this mean for government policy and firm strategy?

Building & Preserving the Intellectual Commons

The commons are a crucial resource for fostering innovation. Keeping a resource in the commons both allows others to draw upon the resource and mitigates the number of strategic games played by those seeking to influence the innovative and commercial activities of competitors and potential competitors (Lessig 2001a, p. 72. For additional data and analysis regarding the strategic uses of patents and copyrights, see Parr and Sullivan 1996, Hall and Ziedonis 2001, and Shapiro 2001). Government policy plays an important role in developing and maintaining these commons.

The goal of intellectual property policy is to promote technological and cultural progress for the benefit of society. One of the underlying assumptions of these policies is that investment in innovative and creative activities is highly contingent on the ability to derive pecuniary profits from that investment. To that end, government policy in much of the world seeks to strike a balance between granting temporary control rights over innovative and creative work to originators of the work and allowing others to access and build upon that work. These temporary control rights take the form of patent and copyright protection; patents generally offer protection for 14-20 years, copyrights for 95 years.

From the perspective of community-based innovation, however, benefit is derived primarily through use rather than pecuniary profit. As the examples in this chapter illustrate, users working within communities actively choose to partake of the benefits derived from allowing others to freely use their work rather than pursue benefits derived from control. Thus, protecting the ability of users to tinker and share their work is critical for fostering community-based innovation; the provision and exercise of exclusionary control rights, in contrast, might do little more than act to deter community-based innovation.

Both patent and copyright laws affect the users' "right" to tinker. Here, I will focus on some issues around fair use to show how these laws might influence community-based innovation. Fair use makes copyrighted work available to the public as raw material without the need for permission or clearance, so long as such use promotes progress. What activities do and do not constitute fair use? The answer to this question is unclear in many instances, providing users with little guidance regarding the legality of their actions. Law in this area is complicated and continuously evolving through legislative and judicial action. These decisions, however, do not move in lock-step. From the perspective of protecting fair use, the Digital Millenium Copyright Act (DMCA) is a setback and *Sony v. Connectix* (2000) is a victory.

Many are concerned that the DMCA has gone too far in restricting fair use in the digital domain (see, for example: Samuelson 1999; Nimmer 2000). The DMCA was intended to prevent consumers from illegally making *copies* of protected works. Unfortunately the DMCA can also have a number of unintended side effects, one of which is preventing users from *modifying* the products that they purchase. Specifically, the DMCA outlaws technologies designed to circumvent technologies that protect copyrighted material. "The trouble, however, is that technologies that protect copyrighted material are never as subtle as the law of copyright. Copyright law permits fair use of copyrighted material; technologies that protect copyrighted material need not. Copyright law protects for a limited time; technologies have no such limit. Thus when the DMCA protects technology that in turn protects copyrighted material, it often protects much more broadly than copyright law does. It makes criminal what copyright law would forgive (Lessig 2001b)."

The judgment of the Ninth Circuit Court of Appeals in *Sony vs. Connectix* upheld and extended the limits of fair use. In the case, Sony alleged that Connectix illegally reverse engineered the Sony BIOS in order to develop their Virtual Game Station, which played Sony

Playstation games on Windows. The court concluded that "Connectix's reverse engineering of the Sony BIOS extracted from a Sony PlayStation console purchased by Connectix's engineers is protected as a fair use. Other intermediate copies of the Sony BIOS made by Connectix, if they infringed Sony's copyright, do not justify injunctive relief." The court determined that it was acceptable for Connectix to not just copy and study Sony's code, but to actively use that code in the process of developing a non-infringing product and make multiple copies of the code. The judgment established new precedents in fair use law, opening up some areas for fair use that were previously risky from a legal perspective.

Restricting the ability of others to build upon ideas may slow the overall rate of innovation; the modification of existing ideas, products, and artistic work is the source of much creative and innovative production by firms, researchers, and users. Evidence of this can be found in many areas. Consider for example the development of Linux versus Minix (DiBona, Ockman et al. 1999, Appendix A: The Tanenbaum-Torvalds Debate). Software developers were free to tinker with Linux and adapt it to suit their own needs and desires. They were also able to share what they had learned with one another and build upon each others' efforts. In contrast, enhancements were generally not accepted to Minix in order to preserve its integrity as a teaching tool. As a result, disgruntled Minix users chose to adopt – and work to improve – Linux. Also consider the "anti-commons" effect. The anti-commons effect is a side-effect of patent protection in fields where innovation is cumulative. A commons is a resource that everyone has the right to use. In contrast, an "anti-commons" is a resource where many have the right to prevent others from using the resource (Heller 1998; Buchanan and Yoon 2000). In such a context, innovation may be stifled as innovators become reluctant to innovate because too many others have the right to prevent or raise the costs of use and commercialization (see Heller and Eisenberg 1998 for evidence from biomedical research). Finally, recall the importance of tinkering and bricolage in the examples of community-based innovation presented in this chapter.

The impact of intellectual property policy on the activities of innovation communities deserves careful consideration. As a society, there are important decisions to be made regarding intellectual property protection that will influence not only the rate of technological progress, but also control over its direction, our own ability to "tinker" with and adapt those products to suit our own desires, and the variety of commercial products that are available to us.

Firm Strategy

Not all firms are choosing to enclose their intellectual property inside hermetically sealed black boxes. Some firms - ranging from video-game makers to manufacturers of airplane kits to Lego – have found that it is in their self-interest to permit and even encourage innovation by user communities. Contributions by user communities can complement a firm's own R&D and marketing efforts, extend a product's life, and cater to market niches not targeted by the firm's marketing department. As discussed, user communities often generate a variety of functionally novel and incremental, dimension-of-merit innovations; firms can observe which of these innovations are adopted by community members. Firms, with their specialized engineering, design, manufacturing, and marketing departments, can then streamline, promote, and produce these innovations for the many consumers who are unable or unwilling to construct the product or service themselves. Firms may choose to incorporate these innovations into the core product or service, sell these features as optional modules, or allow a third-party to freely distribute or sell the modules.

User groups often form and operate independently of firms. Many groups, however, are open to participation by firms so long as firms support the general goals of the community and abide by the community's rules, norms, and practices. Businesses seeking to encourage user activity around their products have found it useful to open all or part of their product design and establish or support forums where users can congregate and share information.

Building a business around freely-revealed user innovations is more straightforward when the product is physical rather than virtual. In the case of physical products, a fraction of users will build their own, but many will prefer the convenience of purchasing a copy. In other words, even if product development by users displaces that of manufacturers, manufacturers can still profit from manufacturing activities and product innovation. Manufacturers may compete against each other for customers based on complementary assets such as brand name, and distribution and production capabilities. Firms may also choose to provide services that go with the product, e.g. in the case of sports equipment, lessons, facilities, or equipment maintenance.

The case of virtual products is more complicated for manufacturers, because many more users will be able to access and deploy the product themselves. One option is to sell services that support the product. A second option is to build and sell proprietary platforms on which users can develop and build their own products.

There are two general approaches to platforms - the “walled garden” and the “open range.” Walled gardens place limits around the ability of others to build on and use the platform. For example, this may mean that outside vendors are restricted in their ability to offer commercial products based on the platform or that the platform owner controls the content available to users. While users and outside vendors may have considerable latitude within the walled garden, the platform owner often retains ultimate control rights and establishes both the boundaries and rules of the garden. Open ranges, in contrast, allow users and other firms to build on and use the platform in limitless ways. The platform owner typically retains few, if any, control rights. NTT DoCoMo explicitly created a walled garden within a larger open range, with respect to content, when setting up its i-mode wireless internet service. “Official” content partners – subject to strong editorial and usability rules - populate the walled-garden, however users are also allowed open internet-access to “unofficial” sites. There is a long standing debate between proponents of the walled garden and open range approaches. However, from the perspective of the platform owner, it is not yet clear which of these approaches will yield greater profits.

Conclusion

Community-based innovation has contributed to technological and industrial advance in many fields. Users are at the center of this model: they discover new needs and desires, cooperate with other users within innovation communities, and sometimes even commercialize their innovations. The community-based innovation model is pervasive across time and context, contributing to the development of physical and virtual products and shaping products, industries, and scientific disciplines. Yet, for a number of reasons, communities of users often go unnoticed by firms, policy makers, and society at large. Some firms have, however, recognized the contributions of users and their communities and actively work alongside them, providing consumers with novel and improved products and services and creating a revenue stream that contributes to the firms’ profits. As intellectual property policy evolves, policymakers ought to consider the impact of proposed policy changes on the ability of users to innovate. Preserving the ability of users to collectively tinker and modify is necessary for continued innovation of the type that has provided us with many of the products and tools, and a substantial amount of the knowledge and know-how that we rely upon and enjoy on a daily basis. In short, the principle that Richard Stallman succinctly defined in the GNU General Public License – that people must be free to use, modify, and distribute – applies to creative and innovative activity in many fields, not just software.

Bio

Sonali K. Shah is an Assistant Professor in the Organization Behavior Group at the University of Illinois at Urbana-Champaign. Her research examines the social structures that support innovation and entrepreneurship. Her current work examines the creation and maintenance of "innovation communities" that support the development and diffusion of new technologies in fields ranging from software to sports equipment to medical imaging devices. She is also currently investigating the processes underlying the formation of new industries and product markets. Previously, she worked at Morgan Stanley & Co. in the Technology Investment Banking Group. She holds undergraduate degrees in biomedical engineering and finance from the University of Pennsylvania. She received her PhD in management from the Massachusetts Institute of Technology.

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