INNOVATION COMMUNITIES: A PATH FROM INNOVATION TO FIRM & MARKET FORMATION

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Abstract

Academics and practitioners have long been interested in understanding the sources and causes of innovative activity and the relationship between innovation and industrial change. Existing theory assumes innovative activity to be the domain of firms and research institutions, and commercial activity to be the domain of firms and entrepreneurially-minded individuals. This paper suggests and provides evidence for the idea that, in some industries, social activity may precede and heavily influence both firm and market formation via the innovative activities that take place within *innovation communities*.

Based on an inductive study of the innovation and commercialization histories of 57 key skateboarding, snowboarding, and windsurfing equipment innovations, this paper finds that (1) the majority of innovative activity in these industries was conducted by hobbyists and enthusiasts. (2) Innovation communities, in which ideas and prototypes are freely shared, serve as an innovation development and selection mechanism. (3) Many of these innovators start firms in order to appropriate financial benefit from their innovation. Based on these findings, I derive a conceptual model that shows how innovation and social interactions among users can lead to the formation of firms and markets. This model complements existing models that focus on the role of firms, markets, and research institutions in industry formation.

INTRODUCTION

The idea that firms, motivated by profit and supported by strong intellectual property right regimes, drive product innovation is one of the central notions in the technological innovation literature (Schumpeter, 1934; Arrow, 1962; Demsetz, 1967; Nelson and Winter, 1977; Nelson and Winter, 1982; Dosi, 1988). This view of firms has produced many important theoretical insights into the formative years of industry development (Figure 1). Two main streams of research exist in this area: the economics influenced "product life cycle view" and the sociological literature on organizational fields and populations. The product life cycle view posits that technological innovations, often in the form of spillovers from research institutions or existing firms, give rise to new industries: firms enter the emerging industry, despite high technological and market uncertainty (see, for example, Mueller and Tilton, 1969; Abernathy and Utterback, 1978; Gort and Klepper, 1982; Abernathy and Clark, 1985; Clark, 1985; Utterback, 1994; Klepper, 1997; Agarwal and Bayus, 2002). These firms experiment with various product designs and features to attract and satisfy customers. The combined efforts of these firms lead to subsequent market development. The literature on organizational fields and populations has produced a wealth of information regarding the mechanisms used by firms to establish legitimacy in order to reduce the negative effects of various sources of uncertainty during the formative years of industry development (see, for example, DiMaggio and Powell, 1983; Hannan and Carroll, 1992; Aldrich and Fiol, 1994; Rao, 1994). In both views, the firm is the central actor and is motivated to engage in innovative activities by profit or a desire to survive.

INSERT FIGURE 1 HERE

Empirical and theoretical work in both areas begins with the firms that initially populate an industry, leaving the question of why these firms enter a highly uncertain context unaddressed (Astley, 1985). Our existing theories do not explain how managers and entrepreneurs came to conceptualize a market-that-does-not-yet-exist and believe that it could be created and found profitable (McKelvey, 1982; Venkataraman, 1997; Schoonhoven and Romanelli, 2001). Thus, a critical question remains unanswered: how do new product markets and industries emerge (White, 1981; Astley, 1985; Fligstein, 2001; Schoonhoven and Romanelli, 2001; Beckert, 2002; Helfat and Lieberman, 2002)? This paper presents evidence suggesting one possible mechanism for industry emergence: users and user communities.

There is growing anecdotal evidence that many commercially important innovations – even innovations that eventually spawn new industries or industry segments – are developed not by firms, but by individuals or groups of individuals seeking to fulfill their own needs and interests with little, if any, regard for the commercial viability of their ideas. These individuals derive benefit directly from the *use* of the innovation. Innovation is a by-product of "everyday" activities and interests. The case of the personal computer is one such example.

Contrary to the firm-centric notion of industry emergence that would indicate that the personal computer revolution was instigated by R&D scientists and engineers toiling in well-equipped labs, the development of the personal computer is a history of 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 and hobbyist electronics magazines such as *Popular Electronics* and *Radio Electronics*. 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.

Existing models that rely solely on firms and research institutions to explain innovation fail to provide insight into the activities of user innovators and the commercial consequences of their activities. Von Hippel (1976; 1988), Bijker (1987), Kline & Pinch (1996) and others introduced and examined the influential idea that individual users are the source of many important innovations in *existing* industries. This study complements and extends that work.

Based on data from three industries, I derive a conceptual model that shows how everyday innovations and social interactions among users can lead to the formation of firms and markets (Figure 2). I suggest and provide evidence for the idea that innovation communities provide a social structure – independent of the visible hand of firms and the invisible hand of markets – that supports innovation development and selection and can lead to the emergence of new industries.

INSERT FIGURE 2 HERE

This model begins with "discovery through use." As users of products and services encounter new needs, wants, or use contexts, they are motivated to seek out solutions. Some users may work alone, but many users seek out like-minded individuals with whom to collaborate, forming an innovation community. These communities are characterized by voluntary participation, the 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 skills and needs of the individuals involved, user communities are often well-equipped to identify and solve a wide range of product design problems. As innovations are developed, refined, and freely shared within the user community, innovators often receive requests for copies of their innovations from community participants who do not want to build their own copy of the innovation. As innovators (and others) observe the value of the innovation to others and the extent to which there is widespread interest in the innovation, firms are founded.

I begin by describing the research sample and inductive methods. I then present my findings and a complementary conceptual model outlining the process by which new firms and industries emerge. I then discuss implications of the model for theory and firm strategy. I conclude by discussing the limitations of this study and suggesting avenues for future research.

RESEARCH METHOD

Since the primary focus of the study was to understand the *process* by which innovations, firms and industries are created, I chose qualitative data collection procedures. Qualitative approaches are preferred in areas that defy existing theoretical categorization and explanation, because they "make room for the discovery of the unanticipated (Van Maanen, 1988)." Over 75 interviews were conducted and data on 57 innovations across three industries – windsurfing, skateboarding, and snowboarding – were collected. Individual equipment innovations were chosen as the unit of analysis to structure data collection. By tracing the development and commercialization histories of all key innovations in an industry, my aim was to develop a better understanding of where the initial ideas that sparked the industry were created and the process by which businesses, and ultimately industries, were built around those ideas. Data for multiple industries was collected to facilitate the making of comparisons over time and stage of industry development. The research methodology is described in detail below.

Study Setting

The general context of sports equipment was chosen for two reasons. First, new sports emerge relatively frequently. Hence, it is possible to study the economic and social history of new sports via primary data collection methods, including discussions with early innovators and other actors. Second, these industries are largely free of government regulation, a factor that could shift activity towards firms and institutions able to bear legal and financial risk.

This study examines the development and commercialization histories of equipment innovations in three sports: skateboarding, snowboarding and windsurfing (Table 1). These sports were chosen based on two criteria: (1) they were developed relatively recently. Almost all of the innovations for each sport were developed within the last 40 years. (2) They have grown to significant size, each having at least a million participants and equipment sales in the range of $100 million annually by the late 1990s.

INSERT TABLE 1 HERE

Recent development of key innovations allowed for the collection of rich, detailed, and accurate data: information about the histories of the innovations could typically be obtained by interviewing the innovators and others present when the innovation was being developed or commercialized. Significant market size was important because it meant that both users and manufacturers should, in principle, have an incentive to innovate: users because of the attractiveness of the activity; manufacturers because of the commercial attractiveness of the market. Each sport studied has a group of serious enthusiasts and a contingent of professional racers, as well as mass-market recreational participants.

Identification of Key Innovations

The set of equipment innovations - defined as a new piece of equipment that is actually used - for each of the three sports was identified by first constructing a list of experts in each field and then having each expert nominate key equipment innovations[1]. Experts were identified through a technique known as snowball sampling. Snowball sampling occurs when interviewees are identified based on the recommendations of past interviewees (Denzin and Lincoln, 2000). I first compiled a preliminary list of knowledgeable individuals in each sport. These include editors of well-known sport-specific magazines, authors of books that discussed the history of each sport, and experts at leading equipment manufacturers. Each of these individuals was asked to identify others who he or she judged to have excellent knowledge of the innovation history of each sport. These experts were contacted in turn and asked the same question. Eventually between five to seven experts with information on the histories of important equipment innovations in each sport were identified.

[1] Manufacturing process innovations were purposefully not chosen as a subject for study, because the topic of interest here is the process by which new product markets are built. Process innovations are almost always made by firms seeking to reduce product costs *after* an initial product market has been established (Utterback, 1994).

Next, each of these experts was asked to list "the key equipment innovations in the history of the sport." The lists of innovations independently generated by these experts were then compared. All innovations nominated by three or more experts (not including the innovator if he was also a nominator) were included in the sample. Via this process, 10 key equipment innovations for snowboarding, 7 for skateboarding, and 40 for windsurfing were identified (Table 2 lists all innovations in the sample). The greater number of innovations in windsurfing reflects the greater number of parts on a windsurfer. Whereas snowboards and skateboards consist primarily of a board, a windsurfer consists of a board with a fin (and often also a dagger board), a sail, a mast, and a boom. Each of these parts, as well as the interface between parts, can be the object of design work and improvement.

INSERT TABLE 2 HERE

Data Sources

I collected data primarily through one-on-one interviews with a variety of actors who had insight into the innovation, how it was developed and commercialized, and the state of the industry and market at that time. 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. An *innovator* is defined as the individual or set of individuals who first develops a working prototype of an equipment innovation. All individuals are credited for developing an innovation in cases where more than one individual(s) independently developed an innovation contemporaneously. Interviews with 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 were also conducted.

Interviewees were asked a series of open-ended questions, augmented by follow-up and clarifying questions (Spradley, 1979). Interview questions were designed to solicit detailed information about the development and commercialization history of each innovation from the perspective of the interviewee. Interviews ranged in length from 30 minutes to over five hours (broken into several sessions), with most lasting between 70 and 90 minutes. Interviews were conducted by telephone and recorded to facilitate data analysis. Detailed notes were also taken during interviews. Information used in tables was verified using either a second interview source, published magazine articles, patent applications, old equipment catalogues, or dated photographs, drafts, and sketches whenever possible. In-text quotes relating to specific innovations have been attributed to particular innovators (particularly when previously published materials also document the same story); quotes relating to process, beliefs, and motives have been kept anonymous.

Data Analysis

The analytical method of grounded theory building was chosen to guide data analysis. Grounded theory building is particularly useful in situations where the phenomenon does not fit existing categories or is not readily explained by existing theory (Glaser and Strauss, 1967). Such an approach avoids layering preconceived theoretical concepts onto a novel social structure. In this area, there exists little theory to guide us: the existing literature tells us a great deal about what happens after many firms have entered a particular product market, but tells us little about the events that precede and trigger industry emergence.

Grounded theory building is an iterative process that begins with the construction of a category (Strauss, 1987; Eisenhardt, 1991; King, Keohane, and Verba, 1994; Locke, 2001; Dougherty, 2002). Constructing categories involves creating a common meaning that captures the essence of multiple observations (Locke, 2001). For example, I found that a number of innovators sought help from fellow enthusiasts in developing their innovations and subsequently shared their innovations with those individuals. I therefore created a category, “innovation shared with those who provided assistance” to describe this process. After a category was named, I studied the data again and looked for other fragments of data (like interview quotes) that supported or refuted the category or suggested the existence of a mutually exclusive category. If revisited data did not support a category, the category was abandoned or revised. Continuing with the same example, I realized that many innovators shared their innovations freely not only with those who assisted them, but actively sought to let all interested others know about the innovation. I then created an additional category under which to classify those innovations. The variance inherent in the data and the use of various sources of data enlivened and fed the process of constant comparison and the development of categories.

After identifying a number of categories, I tried to understand how the different categories fit together into a coherent picture. In addition, I made a series of comparisons at *two* levels: between innovations and between industries. This allowed me to draw insights into both the innovation development process and variations in this process over time.

Key Definitions

Several definitions are required to understand the grouping of innovations in this study. The *functional source* of each innovation describes the primary means used by an innovator to derive benefit from the innovations at the time the innovation was made (von Hippel, 1988). I distinguish between three functional sources of innovations, defined below.

> *Manufacturer innovator:* An innovator who, at the time the innovation was developed, benefits primarily from selling a product, service, or related knowledge. Firms, entrepreneurs, and independent inventors are generally included in this category.

> *User innovator*: An innovator who, at the time the innovation was developed, benefits primarily from using the innovation. Hobbyists, enthusiasts, and amateurs are generally included in this category.

User-manufacturer innovator: An innovator(s) who benefits both from use and from participation in a small lifestyle firm (10 full time employees or less at the time of innovation) that produces and sells equipment for the sport. Innovations made at lifestyle firms that have grown beyond the ten employee threshold at the time the innovation was made are classified as manufacturer innovations; this is a conservative cut-off with respect to the conceptual model, intended to accommodate the possibility that as firms grow, the founders and employees may come to act more like profit-driven manufacturer" and less like enthusiastic users. The user-manufacturer category has not been used before in studies of innovation. It is employed here because it accurately characterizes the nature of the benefit obtained by innovators in the sample who (1) were early and avid practitioners of their sport, and (2) subsequently made and sold equipment to others in order to support their sport-centered lifestyle.

Other innovator: Instances where an innovator does not belong in any of the categories listed above. For example, innovations developed by members of two or more of the categories described above working jointly or by professional athletes are included in this category.

NA: Instances where the identity of the innovator could not be determined were coded as not available.

FINDINGS & CONCEPTUAL DEVELOPMENT: SPORTS EQUIPMENT INNOVATIONS BY USERS & THEIR COMMUNITIES

The findings section is divided into two parts. In the first part, I position the activities of users in the larger industrial context. I compare and contrast the innovative activities and contributions of users to those of manufacturers over time, showing that users and their communities play a significant role in creating and shaping these products and industries. In the second part, I describe the *process* by which users develop and commercialize their innovations, focusing on three key concepts: discovery through use, collaborative work in innovation communities, and commercialization. These data provide the empirical basis for the conceptualization presented in Figure 2.

User vs. Manufacturer Innovations in the Context of Industry Emergence & Development

User innovations were critical to the emergence and development of the snowboarding, windsurfing, and skateboarding industries. In fact, the origins of each of these three products began with users and users – not manufacturers – were the dominant source of major improvement innovation in these industries.

Product Origins: First-of-Type Innovations

Users developed the first-of-type innovation in each of the three industries studied, that is, users developed the first skateboard, the first snowboard, and the first windsurfer. In each instance, the innovator(s) engaged in the process of bricolage, using the skills and materials at hand to create the innovation (Lévi-Strauss, 1967; Miner, Bassoff, and Moorman, 2001; Garud and Karnøe, 2003).

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 (Brooke, 1999).

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, a chemical gases engineer in Muskegon, Michigan, 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).

In the case of windsurfing, an individual user, Newman Darby, was the initial innovator (Bruce, 2000). In 1964 Darby, a sailboat enthusiast and amateur boat builder living in the Pocono Mountains of Pennsylvania, 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

In addition to seeding these product categories, users and user-manufacturers developed 57% (n=26) of all major improvement innovations in the sample (Table 3). Manufacturers developed only 27% (n=12). The remaining 16% were developed by other functional sources of innovation, such as joint user-manufacturer teams

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INSERT TABLE 3 HERE

A binomial distribution is used to test the conservative hypothesis that *manufacturers in general* (existing manufacturers, component suppliers, and manufacturers organized to produce specifically for the sport in question) will develop greater than or equal to 50% of the innovations in novel sports. With only 12 of 48 innovations being developed by various types of manufacturers, this hypothesis is rejected at the 0.05 level of significance.

An even more conservative test was conducted by assuming that each innovator rather than each innovation is a statistically independent event. Table 4 shows the sample constructed by including only the first innovation developed by each innovator. Manufacturers in general developed 7 of 25 innovations. Based on these data, the hypothesis that manufacturers will be the dominant developers of innovations in these sports can be rejected at the 0.05 level of significance.

INSERT TABLE 4 HERE

Figure 3 depicts a stylized chart plotting the number of key innovations by source relative to the time of initial consumer market growth. The pattern that emerges is striking. The majority of key equipment innovations made prior to the growth of the mass market are made by users and user-manufacturers. An increase in innovative activity by manufacturers occurs only after the mass market begins to grow rapidly. Much of this manufacturer activity is devoted to solving known problems for users (e.g. creating "step-in" bindings for snowboards that allow users to more easily gear up), rather than creating new product uses or truly novel new features.

INSERT FIGURE 3 HERE

This finding suggests that, in some industries, innovation by users and their communities – not innovation by manufacturers – sets the stage for mass market emergence.

Innovating Manufacturers

Here, I distinguish between three types of innovating manufacturers and describe their contributions to the sports studied. In several cases, these manufacturers have "user roots" – albeit in other fields of sports. Innovations made by manufacturers often apply a solution concept that the manufacturer already has in stock to a new sport and/or improve performance along a known product performance parameter, 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 performance parameters known to be of value to customers in order to maximize sales and market share (Van de Ven and Garud, 1989).

An *existing manufacturer* developed two major improvement innovations in the sample. Existing manufacturers that enter a new industry might logically be of two types: those in closely related product categories (e.g. sailing, skiing, surfing) and those with production or design capabilities useful in producing the product. The existing manufacturer observed in this study – NHS – was a small, Northern California firm founded by three surfing buddies to design and build surfboards. A surplus of fiberglass and a deficit of customers led the trio to begin designing skateboards. NHS ultimately developed two key skateboarding innovations: the use of precision ball bearings and skateboard truck modifications that allowed each wheel to move independently of the others.

Existing sports equipment component suppliers developed seven 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 designed 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. In most cases, the innovative components suppliers were small craft shops run by their founder-owners.

Manufacturers organized specifically to produce for the sport in question developed three major improvement innovations in the sample. The firm F2, initially organized to distribute and manufacture windsurfers for the European market, is credited with having pioneered the use of polyester film as a sail material. R&D engineers at Burton snowboards developed two innovations aimed at making the process of gearing up faster and easier.

Several of the companies discussed above have "user roots" in either one of the three focal industries or in a related industry. These firms were conservatively coded as manufactures, rather than as user-manufacturers, in order to account for the possibility that while they were users in the early part of their life-cycle, their motives for innovating may morph as the firms mature and hire employees, invest in capital equipment and other assets, etc.

The User Innovation Process in Three Sports

This section describes the process by which users and their communities develop and diffuse innovations. I begin with an example that illustrates the innovation development process:

> Mike Horgan and Larry Stanley began jumping and attempting aerial tricks and turns with their windsurfing boards in 1974. The problem was that they kept losing their board in mid-air. 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

User-innovators were generally young sports enthusiasts in their twenties who spent many hours practicing their sport and often chose to live a sport-centric lifestyle. Most had carpentry or basic woodworking skills and often described themselves as self-taught or "seat-of-the-pants" engineers.

I was probably the best [chuckle] carpenter in the group. The others had some skills in carpentry that they developed over the years, but we were all pretty much generalists. We all came from backgrounds where we had motorcycles or cars or, you know, model airplanes or whatever so we were good at making pieces that fit and shaving them down to make them fit and adapting this piece of wire and that piece of plastic to make this part that we needed that we couldn't buy.

Many acquired these skills as a normal part of growing up - in the Boy Scouts, woodshop, or in the garages of family and friends. Several learned woodworking and mechanical arts skills on military bases as children or as adults. Only a few user-innovators had college degrees and only three of fifteen user innovators are known to have received formal engineering training. Newman Darby, inventor of the windsurfer, made the following comment at the Smithsonian Institute in April 1999:

> *You have to keep trying...You don't have to have a college degree to be an inventor. Kids invent things in their bedrooms (Bruce, 2000).*

Many eagerly pushed the limits of their sport, thus discovering the limitations of existing equipment and creating a need for equipment innovations and improvements[2]. As a result, they often experienced a need or desire not satisfied by existing products (Alexander, 1964; Clark, 1985; Norman, 1990)[3]. These users generated and accumulated information based on product use in extreme or novel contexts; the creation of new (and often unintended) uses for the product or service, such as new riding techniques or tricks; and mindful experimentation – conducted just to see what will happen; and accidental discovery.

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 is often generated and held by users[4]. (2) Solution information. Solution information may be held by individual users with expertise in specific areas. Not surprisingly, users will develop innovations based upon the information, skills, and material resources that

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[2] In addition to creating innovative equipment and companies, many of the user- and user-manufacturer-innovators contributed to the growth and development of their sports in other ways. For example, some introduced new riding tricks and techniques, some worked to organize early (often highly informal) contests, many worked to increase interest in the sport by teaching others and writing "how-to" articles, and others strove to create venues were enthusiasts could practice the sport (in the case of skateboarding, users developed early skateboard parks and skateboarding ramps such as half-pipes and lobbied that municipalities not disallow the use of skateboards on public property. In the case of snowboarding, many lobbied for ski-slopes to allow the use of snowboards).

[3] Frustration with the inadequacy of products is a common and universal experience that many readers are likely to have shared. Innovation by individual users has been documented in a variety of settings, including chemical and petroleum processing (Enos, 1962; Freeman, 1968), industrial computing (Knight, 1963), scientific instruments (Riggs and von Hippel, 1994), semiconductors (von Hippel, 1988), and sports equipment (Lüthje, 2004).

[4] 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 modify or 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.

they possess. As a result, different users develop different solutions and some users are able to more cheaply develop a solution or develop a better a solution than other users (Shane, 2000; Lüthje, Herstatt, and von Hippel, 2005).

However, individual users hold limited stocks of information from which to draw when innovating. 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

It is not unusual for individuals to voluntarily aggregate based on common interests (Brown and Duguid, 1991; Wellman and Gulia, 1999; Putnam, 2000). Working together provides users with significant benefits. First, working with others allows users to access additional resources to develop and improve their innovations and also allows more rapid development due to simultaneous experimentation. Second, communities may serve as an effective selection mechanism since rich information (e.g. the reactions of other enthusiasts) can be fed back to innovators and overall interest in the innovation can be used to screen ideas for possible commercialization.

All but two user-innovators in the sample worked closely with others as they developed their innovation(s) and only 22% of the user-innovations studied were patented (Table 5). Participants were competitive with each other in a collegial way and willing to share their equipment and what they had learned with others. 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.*

Ideas and prototypes were shared not only with those who gave assistance, but also with any and all interested enthusiasts. Information exchanged hands through word-of-mouth, at club meetings, at conferences and competitions, and in newsletters and magazines[5]. In fact, many "how-to" articles related to equipment and technique were written by the user-innovators and published in magazines. For example, Newman Darby, founding father of the sport of windsurfing, published blueprints and instructions for making a windsurfer in *Popular Science* magazine. Even when racing or competing, innovations were shared:

> *The timing was just a little different in those cases… right after the race, not before.*

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.

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 (see also Franke and Shah, 2003; Harhoff, Henkel, and von Hippel, 2003). 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.*

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[5] Across all three sports, only developments and refinements made to windsurfing sails did not readily diffuse, possibly because changes to sail shape and design are particularly difficult for an untrained eye to see. Also, very few of the innovators – and we can assume very few enthusiasts in general - knew how to sew. In the case of the Hawaiians, only one member of the group knew how to sew and friends who were professional sailmakers (skilled at designing sailboat sails, a highly competitive field) typically designed and made sails for them. Limited information about sailmaking likely hindered rapid diffusion of windsurfing sail innovations.

In order to get assistance, one must reveal the problem. 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 improvement ideas from others (Harhoff, Henkel, and von Hippel, 2003).

Second, innovators may share simply because they enjoy the activity, innovation development process and working with others.

> *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.*

This pattern also emerged in studies examining the activities and motives of software, radio, and automobile enthusiasts, as well as professional engineers (Weizenbaum, 1976; Bailyn and Lynch, 1983; Gelernter, 1998; Torvalds, 1998; Levy, 2001; Moody, 2001; Haring, 2002).

Third, user-innovators willing to share their work with others generally want to prevent a third-party (e.g. a firm or an entrepreneur) from appropriating that work and preventing 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 ideally act to prevent appropriation by any one actor and encourage 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 occasionally engaged in such practices, and communities of open source software developers regularly engage in such practices (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. 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 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 shared 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[6]. 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 (Table 5), but later started companies that produced the innovations for sale to others. Table 6 shows that 71% of the users who innovated sought to profit financially from their innovations by forming firms.

[6] Interview data suggest that the enforcement of intellectual property rights – specifically, the decisions of courts in upholding patents which have been granted - is worthy of further examination. In the few cases where an innovation was 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 (for example, Milovich holds an engineering degree from Cornell University). 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.

INSERT TABLES 5 & 6 HERE

Not only can such sharing and commercial activity coexist, but sharing 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 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 (71%) chose to commercialize the product (Table 6). 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 highlight the multiplicity of motives at play, and caution 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.

> *The motivation was control, definitely not to get rich, but the motivation was control of the craft at speed… I was involved in four or five other, some major, some not so major developments, and they all were pretty much for the same reason. Just trying to make the craft more efficient and more fun to sail. When it got really windy and really rough it was hard to sail. You fell off all the time, you crashed at high speeds and you always felt that this thing has the potential to do so much more and you couldn't make it do more with what you had.*

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.

The case of "the Hawaiians" illustrates how innovation, fun, and competition intermixed with small-scale production for most user-manufacturers. The Hawaiians were a group of seven men in their early 20s living in Kailua, Hawaii in the 1970s. Five of the seven shared a house and all seven windsurfed daily off a nearby beach. New needs emerged when high winds and wave conditions and unique use patterns challenged the existing equipment. The Hawaiians adapted the equipment to meet these conditions. Requests from enthusiasts interested in purchasing the equipment began to come in as people saw or heard about the Hawaiians' innovative equipment. The Hawaiians initially made and sold handmade copies of their innovative equipment from their house and opened a small store three or four years later. Eventually, their brand became one of the most popular in windsurfing industry.

> *Our model was we build it for ourselves. I didn't want this stuff to break when I was out sailing in 15-foot waves or from Molokai to Oahu when you can't see land in either direction… Built to last and the people who used our stuff understood.*

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[7].

IMPLICATIONS OF THE CONCEPTUAL FRAMEWORK

This paper develops a conceptual framework (Figure 2) of the innovation and commercialization process that highlights the role of users and their communities, in addition to firms and profit-driven entrepreneurs. The data presented here suggest that user preferences often change independent of firm action. Some users create prototypes of altogether new products or product features that satisfy their wants, either independently or with the help of others. Some innovators will keep their innovations to themselves, while others will make their idea known through patenting and/or by communicating with like-minded others, often within innovation communities. The benefits of sharing the idea with others are two-fold: others may help improve or refine the prototype and they let others know about the innovation, thereby

[7] The longevity of the brands established by user-manufacturers and the use of these brands as complementary assets in the face of weak intellectual property protection is worthy of further consideration (Teece, 1986). Two factors are likely to be particularly relevant: reputation and deep knowledge of user requirements. Firms founded by user-innovators had several reputation building advantages over others. The names of the innovators were often well-known within the community because of their innovative ability and general expertise (some well-financed entrants sought to leverage the reputation of user innovators for promotional materials. One innovator even recalled a manufacturer's request to place a decal with the manufacturer's name on a self-made board produced and ridden during a photo-shoot). User-manufacturers also possess a competitive advantage due to their intimate understanding of how a product would be used. Copycat entrants often produced equipment unable to withstand even moderate use conditions. This drove demanding consumers to purchase from user-manufacturers, who were known for producing high quality, reliable products that often carried a steeper price tag.

generating interest in the innovation and the activity. That is to say, sharing the idea seeds and grows the market for the innovation; absent sharing, market emergence might occur at a slower pace, not occur, or require significant investment by firms. Potential entrepreneurs can observe the growing market and decide whether or not to build businesses around the innovation and invest resources in building and attracting a broader consumer market for the innovation.

This framework departs from existing explanations of innovation and industry emergence in three primary ways. First, the development of the innovations seeding the industry is endogenous. The needs and wants igniting and fueling the innovation process are developed in the course of user's day-to-day activities. Second, this framework recognizes the importance of both individual agency and collective action in problem identification, problem solving (e.g. prototype creation and refinement) and sensemaking (e.g. commercialization decisions). The innovator and entrepreneur remain key players, but the *innovation community* stands with them. Third, user innovations can seed new firms and new industries. Based on feedback from fellow enthusiasts, these *user-entrepreneurs* founded firms to manufacture their innovations.

These findings also serve to deepen our understanding and appreciation of the user innovation process. Past studies of user innovation focus largely on the innovative activity of industrial users in refining existing products (von Hippel, 1988). These users often worked independently, drawing knowledge and material resources from the firm or university with which they were affiliated. These users did not commercialize their own innovations; instead manufacturers found out about these innovations and incorporated them into existing products. In contrast, this study finds that individual users – enthusiasts, tinkerers, amateurs, consumer, and everyday people - innovate and their efforts can lead to the emergence of new industries. These users draw knowledge and resources from innovation communities. These communities are an effective social structure supporting innovation; however they function quite differently from the support systems found in commercial, university, and government settings.

Implications for Existing Theory: Complementarities & Tensions Between Communities & Mass Market Firms

When we think of the social structures and actors that support innovation development and diffusion, we focus on firms, public and private research institutions, and entrepreneurially minded individuals; innovation communities should be added to the list. This study shows that the innovation development and commercialization activities of users matter in the context of *industry emergence*: in some industries, the very existence of firms and markets may depend upon innovation taking place in *user communities*. The task now is to theoretically reconcile the role of users with existing literature and theory on industry emergence and development.

As a market develops, distinct groups are likely to appear: those users and firms with strong community ties (e.g. firms started by user-innovators or dedicated community members), and mass-market consumers and firms. Users and firms with ties to the community are likely to prioritize issues such as innovation and quality, while mass-market firms and consumers may be more likely to prioritize price and ease of use. Mass market firms will aim to build a large and, ideally, homogeneous customer base. This difference in outlook and priorities is likely to be the source of both complementarities and tensions.

Complementary Roles: Refinement, Production & Visibility

Firms may bring with them the skills to refine the design and manufacture of a product innovation, potentially benefiting both community users and mass market consumers. User communities and early firms may also share the goal of generating interest and recognition in the product and its uses and establishing legitimacy within a broader market context; investments in advertising, newsletters and journals, and competitions generally benefit both communities and firms.

Complementary Roles: Innovation & Market Segmentation

Users and firms are both likely to innovate in ways that best serve their own interests, with users dedicating resources to fulfilling their own wants and needs, whatever they may be, and with manufacturers dedicating resources to well-known and often experienced problems. One effect of these behaviors is market segmentation. The mass-produced product will not satisfy the needs of at least some subset of users, who may choose to either produce for themselves or purchase from a specialty or custom producer. Specialty firms may be more likely to be part of or emerge from the user-community, since they serve more sophisticated and demanding users.

Tensions: Open Design vs. Mass Production

Users in a wide variety of product areas value the ability to change, alter or customize their products to best suit their own wants and needs. Open design is critical to enabling innovation and product alterations by users. To illustrate, several key windsurfing innovators rode Snurfers as kids. As they got older, they tinkered with and redesigned the Snurfer until eventually starting to make boards from scratch (Howe, 1998)[8].

In contrast, mass manufacturers are likely to be interested in creating and promoting standardized products designed for specific uses. They need to develop a relatively homogenous mass market to which they can sell a product that can be produced cheaply and efficiently. To illustrate, tension between a community's desire for innovation and mass manufacturers' desires for standardization in technique manifested itself in early skateboarding and windsurfing competitions (Stecyk and Friedman, 2000). Sponsoring manufacturers wanted participants to compete using the same equipment and perform identical maneuvers, while a number of enthusiasts wanted to bring their own equipment and show-off their latest tricks. Some of these enthusiasts, more interested in skill and innovation than winning a prize, chose to do their own

[8] Additional examples include the car racing enthusiasts often work on Honda cars because of their simple design (and price point); and early 1900s farmers who purchased automobiles and routinely used the engines for household chores (Kline and Pinch, 1996).

thing, scandalizing the event judges. Manufacturers focused on the mass market may quickly begin to view communities, with their new ideas and innovations, as threatening: by altering perceptions around overall product design, the importance of various features, usage, and culture, communities may disrupt the mass-manufacturer's strategy and production planning (and thus profits).

When mass-manufacturers make it difficult for users to alter products, they gain power over the product: only approved product changes will be introduced and the timing of the introduction will be controlled by the manufacturer, thereby protecting the manufacturer's investments. Mass manufacturers may try to achieve power over product changes in several ways, including: (1) manipulating the public's perceptions of innovative ability by suggesting that innovative ability lies in the hands of firms (Nobel, 1977; Franz, 2005), (2) invoking property rights, government protection, and warranty provisions to disrupt or threaten to disrupt a variety of user and community activities (Nobel, 1977; Kline and Pinch, 1996), and (3) adopting a closed product design that prevents users from altering the product on their own (Franz, 2005)[9]. In addition, increased product complexity or specialized requirements (e.g. tools, materials, or knowledge) may also decrease the ability of users to improve the mass-produced product. By raising design and legal barriers, mass-manufacturers may not only limit user actions, but also decrease competition from firms that might otherwise emerge organically or enter the industry.

[9] Franz (2005) provides detailed evidence describing how the one-piece metal body severely limited the ability of the average car owner to tinker with their car in the 1930s. "Streamlining provided the perfect solution in the mid-1930s because it conflated style with notions of improved engineering… Streamlining privileged the machine, the designer's vision, and the corporate image over the practical needs of the user… The harder rounder bodies of the streamlined decade proved tinker-resistant, especially after the development of all-steel bodies in the mid-1920's. Unlike the earlier and more pliable metal-covered wooden bodies, steel bodies were virtually impervious to the average car owner's tools." Car companies followed up with advertising and propaganda aimed at communicating the efficiency and power of science and the American corporation at the expense of the user: "Science discovers, genius invents, industry applies, and man adapts himself to or is molded by new things."

Intellectual Property Policy

One might wonder why only a small handful of user-innovators patented their innovations – surely obtaining a patent and licensing the innovation must be easier than starting a firm? Several possible explanations exist: the user innovators did not recognize the potential commercial value of the novel innovations, public disclosure made patenting legally impossible, patents are expensive to obtain, had no interest in starting a firm or faced high opportunity costs, and/or realized that they are were creating something new and hoped to improve the field and create additional value by working with others rather than by working independently[10].

In Table 3 we see that only eight non-manufacturer innovations in the sample were patented and, of these, only three were licensed. These licensing activities were not always successful. To my knowledge, there is only one case in which a patent was successfully licensed by an innovator to a manufacturing firm for the life of the patent: that of the Snurfer developed by Sherman Poppen, a chemical gases engineer. In other cases, the user-innovators faced difficulty when working and negotiating with firms possessing significant financial and legal resources, suggesting that even when user innovators take steps to protect their intellectual property through patents, they may be better off starting their own firm than licensing the innovation.

Their experiences suggest that the enforcement of intellectual property rights held by users – i.e. the decisions of courts in upholding patents which have been granted - is worthy of further examination. In the few cases where an innovation was 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

[10] Public display and use of an innovation can make patenting legally impossible. United States patent law requires that an innovator has one year from the date an "enabling disclosure" is made to file a patent application. An enabling disclosure is one that enables an expert in the same field to use the innovation. An offer for sale is equivalent to an enabling public disclosure in the United States. Patent law in virtually every developed country other than the United States is not so lenient, dictating that an innovator may not apply for a patent after an enabling disclosure has been made. Because innovations are openly displayed during use, innovators did not have the ability to protect their innovations as trade secrets.

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?[11] In this way, patent law acts to discourage the protection of user innovations. In contrast, firms and courts appeared more respectful of 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 should not be that a patent for the same innovation is enforced if the innovator is a firm or an educated user and not enforced if the innovator is a user with a high-school education. Until the importance of innovation by users is more widely recognized, users may be at a distinct disadvantage when it comes to appropriating the value of their innovative work through intellectual property protection.

Taking another tack, it may be that innovation by users should, in fact, not be protected and that the patent law – even if accidentally – recognizes this: community development coupled with subsequent commercial activity, may improve social welfare more quickly than might a stronger intellectual property regime by allowing and encouraging rapid and high variance experimentation with the innovation and encouraging the development of complementary technological and institutional innovations. As Rosenberg (1982) and others have observed, the process by which breakthrough technologies develop and are commercialized takes considerable time and often occurs through the accumulation of many small improvements and the efforts of many. When a market is new and highly uncertain, proprietary development may lead to expensive and irreversible investments that become inertial forces and hinder subsequent technological and commercial development (Van de Ven and Garud, 1993, p. 28-29, 41).

[11] Patent law requires that the innovation be non-obvious to a person having ordinary skill in the area of technology related to the invention. Many user innovations are not technologically complex and, once created, may be relatively simple to understand; however, as shown, the innovations may also be far from obvious to create, requiring considerable time to uncover the need.

Limitations

This study is grounded in data from a set of industries chosen for their young age and relative freedom from government intervention. In addition, these industries are all consumer products industries with products exhibiting relatively simple and open design. Each of these factors constitutes a potential factor limiting the generalizability of the framework. However the framework appears applicable to a range of industries; user communities were also instrumental in the emergence of the personal computer, atomic force microscopy, and software industries (Salus, 1994; Freiberger and Swaine, 2000; Levy, 2001; 2005; Mody, 2006). The early development of the Internet was also characterized by discovery through use and a desire to freely share the technology and ensure its availability to all (Berners-Lee, 1999)[12]. Future research, however, may unearth examples where the processes described in Figure 2 fail to spark firm and industry development for a variety of reasons (e.g. because there is not wide-spread interest in the product, manufacture is not profitable, users' opportunity costs are high). Additional, detailed studies are required to fully assess the generalizability of the framework and develop it further.

Users will not be instrumental in the emergence of all industries. First, users are likely to be most active in industries where there is an immediate benefit from their innovation activity, such as satisfaction of a need or enjoyment derived from the innovation or innovative activity and where they have information regarding what to do and capabilities for how to do it. For the latter reason, closed product design will inhibit user innovation. 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 regulation, licensing or usage agreements, access to raw materials and tools)[13]. Second, user communities

[12] Evidence also suggests that user communities contribute to the refinement of products in a number of *existing* industries, including automobiles, electronic components, industrial equipment, software, sports equipment, and video games (Allen, 1983; Langlois and Robinson, 1992; Kline and Pinch, 1996; Raymond, 1999; Haring, 2002; von Krogh and von Hippel, 2003; Nuvolari, 2004; Franz, 2005; Jeppesen and Frederiksen, 2006)

[13] 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

may be more prevalent when it is difficult to garner and enforce intellectual property protection and/or amongst users who are not interested in securing proprietary control over the innovation[14]. Third, user communities may be more prevalent when innovations are cumulative, as this characteristic increases the benefits of sharing and community development to user innovators. Fourth, opportunity costs are likely to affect the propensity of users to found firms (Amit, Glosten, and Mueller, 1995). Hence, we may see fewer user innovators founding firms in industries where users have relatively high opportunity costs, although users will continue to innovate. Such user innovators may instead patent and license their ideas or allow others to commercialize their ideas.

The emergence of the magnetic resonance imaging (MRI) industry provides a counter-example in which academic research institutions and firms were the primary actors (Blume, 1992; Mattson and Simon, 1996; Kevles, 1997). This example illustrates our dominant conceptualization of the process by which new industries emerge (Figure 1). Both the science and the technology supporting MRI are complex and government permission must be obtained prior to diffusion. Nuclear magnetic resonance (NMR), the science underlying MRI was uncovered independently in 1945 by Felix Bloch at Stanford and Edward Purcell at Harvard; they shared the 1952 Nobel Prize in physics for their work. It took more than fifteen years before the notion of NMR as the basis for a medical imaging technique emerged, instigated by

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only allows, but encourages user innovation. This has two consequences: (a) user innovation will be more likely to flourish in the open source context, 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).

[14] In the context of this sample, one might ask whether the inability to enforce patents encouraged community development processes, that is led users to share and form communities. It is difficult to know for certain, however it seems more appropriate to conclude that communities are a viable and independent social structure supporting innovation and that some user innovators will choose to work within communities, while others will choose a more proprietary route. Specifically, it should be noted that users appear to have the ability to patent, although they do not appear to have the ability to enforce their patents. It is unlikely that users in this sample thought through potential enforcement issues if and when they considered applying for a patent, and the USPTO database contains many patents for skateboarding, snowboarding, and windsurfing innovations, many of which appear to have been granted to individuals. Hence those who shared the innovation freely likely did so regardless of issues pertaining to patent enforceability.

the work of Raymond Damadian and later John Mallard, both medical physicists located in academic medical centers. It was in 1973 that chemist Paul Lauterbur successfully transformed NMR signals into images; work for which he and Peter Mansfield shared the 2003 Nobel Prize in Physiology or Medicine. Physicists Peter Mansfield, Edward Andrew, and Waldo Hinshaw subsequently refined the technique further.

By the late 1970s, physicians and surgeons, whose appetites for novel imaging techniques had been whetted by CT scanning, became excited by the promise of MRI and firms competing in the CT and x-ray markets began to focus on MRI as a new commercial opportunity. These firms forged strong ties with academic researchers and industry and academia were intertwined to an extraordinary degree (Kevles, 1997). Although most of the basic ideas underlying MRI were in the public domain by the time firms entered the picture, firms developed the ideas further by subsidizing advanced research and hiring away experts from academic labs. This wave of development focused on transforming prototypes into functional and reliable machines that would attract the interest and dollars of radiologists and hospital administrators, but was complicated by high levels of uncertainty regarding trade-offs in design and likely uses (Blume, 1992). In 1984 the FDA granted market approval to four firms. It was within hospitals that initially adopted the technology that physicians – users of the equipment – devised how the imaging modality would actually be used, developing techniques and training physicians that would support the further diffusion of MRI.

Future Research Directions

Innovation communities are a distinct organizational form, worthy of future study because of their impact on innovation and industry. In addition to their role in the formative years of industries, innovation communities may also play a role in initiating discontinuous or competence-destroying innovations later in the industry life-cycle. Several novel *processes* for innovation discovery and the coordination of innovative activities that warrant further examination surfaced during this study. These include the process by which user actions are coordinated within communities, methods by which firms and communities can work together, and the interplay between technique and equipment innovation.

In some cases, community-based and proprietary models coexist and even complement one another. In other cases, one model may dominate. The question of which model – community vs. proprietary – will dominate under what conditions has yet to be investigated. In either case, the presence of communities will affect the competitive dynamics of an industry and affect the strategies of for-profit firms. We see this today as some open source software development communities produce software that rivals or exceeds that produced by for-profit firms in terms of both quality and functionality and affects the strategic direction taken by software firms (See, for example, Valloppillil, 1998; Raymond, 1999). Anecdotal evidence suggests that community-based models produce highly competitive products. Examples include the adoption of the Apache web server over proprietary products, and the growing use of Wikepedia. An article in the journal *Nature* concludes that Wikepedia is almost as accurate as Enclopaedia Brittanica, and had the added benefit of being freely and easily accessible on-line and easily updatable, although it may lag somewhat behind in readability (Giles, 2005).

Another research direction involves tracking the evolution and activities of user-founded firms and user communities longitudinally, as the mass-market grows and the industry matures. The effect of the community on the long-term profitability and survival of user-founded firms could be investigated: while ties to the community increase access to innovation, are likely to help support brand, and may provide the entrepreneur with personal benefits (reputation, status, enjoyment), they may also lead a firm to neglect the mass market consumer, leading to reduced profitability. In addition to providing support for innovation, product customization, use, and maintenance activities, user communities might also play a role in lobbying manufacturers for open design and new features and in monitoring manufacturer quality and safety. For example, owners of BMW's Z8 sports car can participate in one of several online forums dedicated to discussion about the car and related topics. A structural issue with the car's chassis was first discovered by members of the Z8 Club of Munich and quickly became a concern amongst Z8 owners in the United States. Convinced that BMW was dismissing individual owner concerns, the owners collectively pressured BMW into launching an inquiry (Walczak, 2006).

Use is just one method by which individuals may gain knowledge of a particular product and market. Scientists and employees of existing firms also possess unique knowledge and social networks (see, for example Audretsch and Feldman, 1996; Agarwal, et al., 2004). Many industries are likely to be shaped by the activities and contributions of users, scientists at research institutions, and employees of existing firms. Future research might investigate the contributions and competitive strategies of firms founded by user, employee, and scientists entrepreneurs over the course of the industry life-cycle.

Finally, some of the concepts of community-based innovation may be useful for structuring innovative activities among *communities of firms* as well as *communities of users.* Allen (1983), Nuvolari (2004), Van de Ven & Garud (1993), and Garud & Karnøe (2003) provide examples of firms engaged in collective innovation processes to varying degrees. These examples highlight processes such as trial-and-error learning, the sharing of select information, and building upon the efforts of many. Several researchers have argued that intra-firm research consortia – the sharing of information between firms – can be both beneficial and effective under certain conditions (Spence, 1984; Katz, 1986; Branstetter and Sakakibara, 2002). If we expect such sharing and joint development to promote innovation, experimentation, and market development, we might expect higher levels of alliance activity – between firms, users, and research institutions – to precede product introduction and sales growth as new industries and product markets emerge.

CONCLUSION

This paper provides one answer to an important, yet under-researched question: how do new product markets and industries emerge? Rather than focusing exclusively on firms, I identify an alternative source of market and industry creation: users and user communities. I develop a conceptual model that highlights their role as agents of technological and industrial change, delineates the process by which innovation happens in user communities, and identifies the complementarities and tensions between firms and user communities as agents of change. The paper highlights the fact that motives other than profit can drive investment in innovative activity and that innovative activity may in fact precede the existence of both firms and markets in some industries.

FIGURES & TABLES

FIGURE 1:
DOMINANT VIEW CHARACTERIZING THE EMERGENCE OF A NEW MARKET

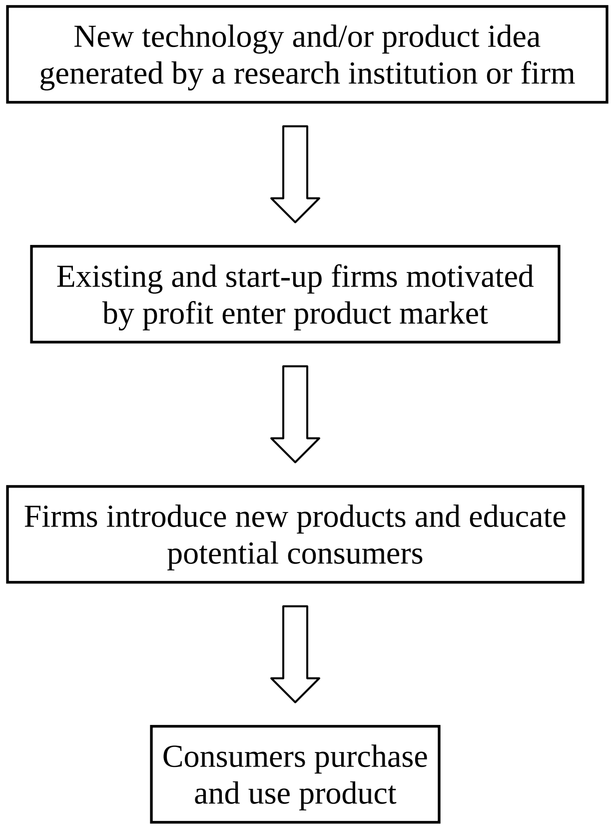


FIGURE 2:
COMPLEMENTARY VIEW CHARACTERIZING THE EMERGENCE OF A NEW MARKET

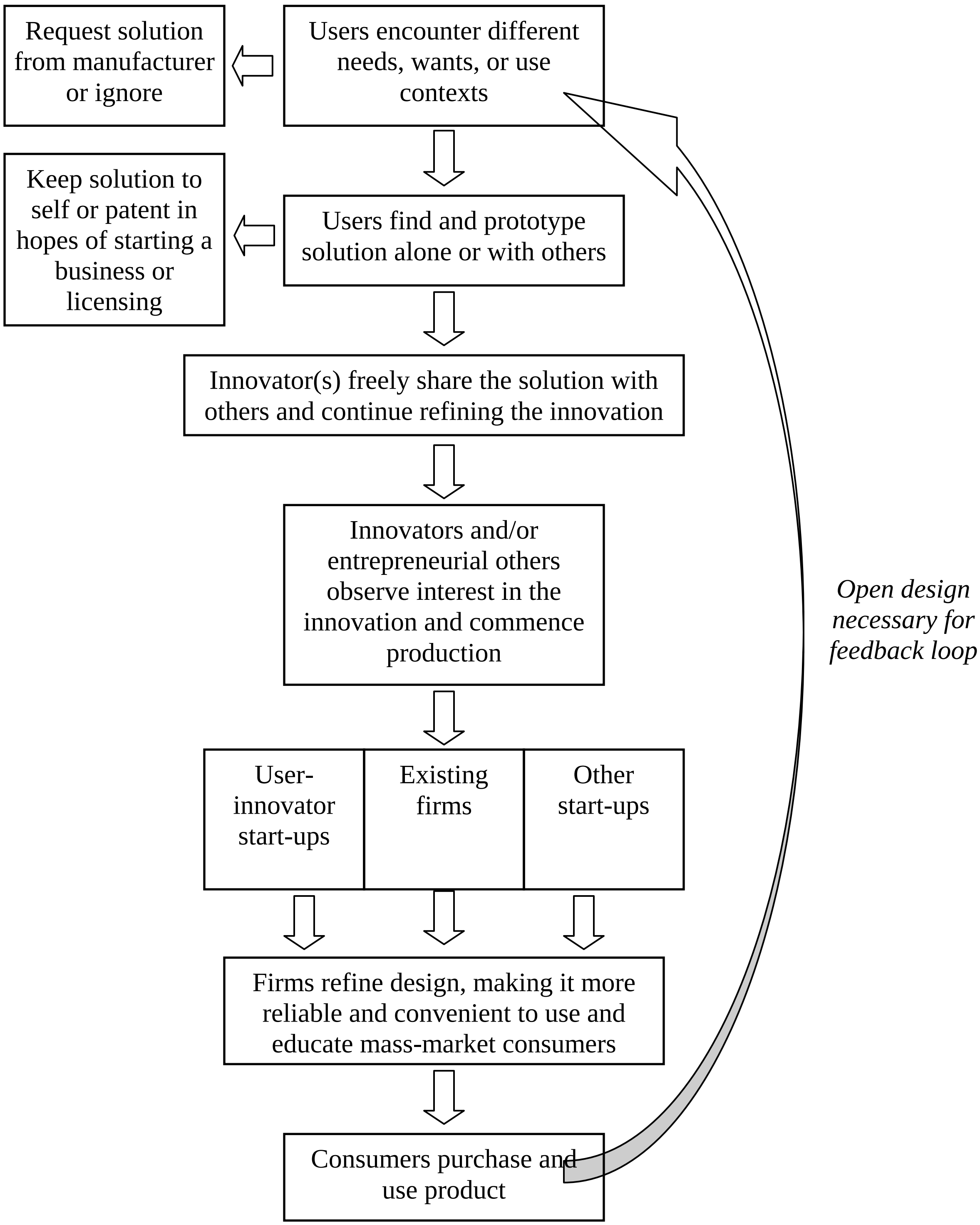
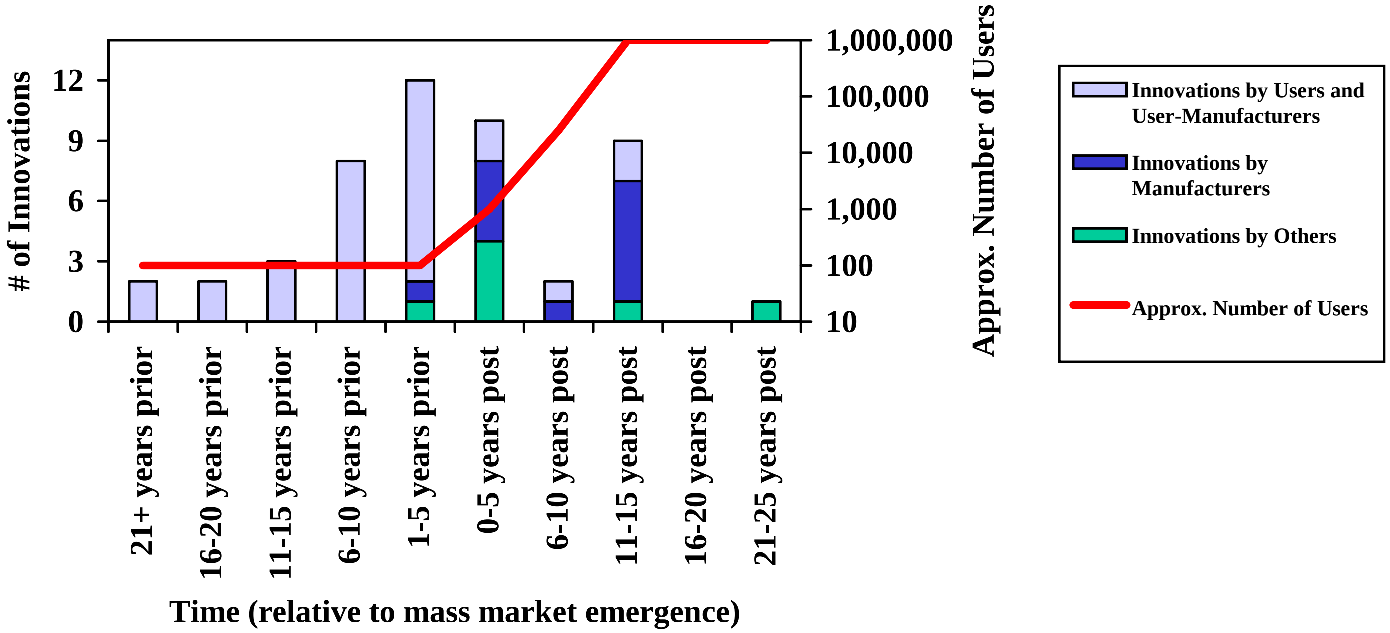


FIGURE 3: INNOVATIONS AND MARKET GROWTH OVER TIME[15, 16]



[15] According to industry experts, mass consumer market participation in "standard" windsurfing begins in 1973; in high performance windsurfing in 1981; in snowboarding in 1986; and in skateboarding in 1963.

[16] Data based on interviews with expert manufacturers and users active in the field at the time. Published market data estimates do not appear to be available for the early phases of these markets.

TABLE 1:
MILESTONES AND 1998 U.S. EXPENDITURES & PARTICIPATION STATISTICS FOR SKATEBOARDING, SNOWBOARDING & WINDSURFING

Sport	Founding Date	Year included in Olympic Competition	U.S. Consumer Expenditures	Participants
Skateboarding	Between 1900-1910	Not an Olympic sport	$72.5 million	5.8 million
Snowboarding	1965	1998	$240.9 million	3.6 million
Windsurfing	1964	1984 (called boardsailing)	*minimum* of $46 million [b]	1.2 million

Source: National Sporting Goods Association (NSGA) or American Windsurfing Industries Association. Note: these sources collect data approximately once every five years, so 1998 data is the most recent collected prior to the start of the study.
[a] 1997 data (1998 data unavailable)
[b] Conservative estimate based on unit sales data. Actual consumer expenditures are likely to be two to three times higher.

Table 2: Innovations in Snowboarding, Windsurfing & Skateboarding

Sport	Year	Innovation	Innovator	Affiliation	Locus of Innovation
Snowboarding	1965	Snurfer	Sherman Poppen	None	User
	1970	Metal/Steel Edges	Dimitrije Milovich	Winterstick	User-Founded Firm
	Mid-1970s	Huge Side Cuts	Chris Sanders; Mike Olsen; Dimitrije Milovich	Gnu Snowboards; Avalanche; Winterstick	User-Founded Firms
	1978	Rubber Bindings/ Footstraps	Jake Burton; Willi Winkel	Burton Snowboards; Wee Willi Winkel Skateboards	User-Founded Firms
	Pre-1980	Polyethylene Base	Burton Snowboards; Dimitrije Milovich	Burton; Winterstick	User-Founded firms
	1983	Hybak	Jeff Grell	None (bindings first used on Flite snowboards and later developed for Sims snowboards)	User
	1995	Central attachment of the binding/central disk system	Burton employees; F2 employees	Burton Snowboards; F2	Manufacturer (for the sport of snowboarding) and existing manufacturer
	Approx. 1995	Flap Ratchet	Burton employee – David Dodge	Burton Snowboards	Manufacturer (for the sport of snowboarding)
	Mid-1990s	Step-in Binding	Engineer at Shimano & K2 employees	Shimano & K2	Existing Manufacturers

Sport	Year	Innovation	Innovator	Affiliation	Locus of Innovation
Windsurfing	1964	First of Type Windsurfer (the Universal Joint)	Newman Darby	None (later Darby Industries)	User
	1967	Wishbone booms used for windsurfing	Jim Drake	None (later Windsurfing International)	User
	Early 1970s	Eliminating the Dagger board	The Hawaiians	Windsurfing Hawaii	User-Founded Firm
	1975	Retractable Dagger board	Mike Horgan	Windsurfing Hawaii	User-Founded Firm
	1975	Full View Windows in Sails	Pat Love & Mike Horgan	Windsurfing Hawaii	User-Founded Firm
	1975	Volcano Pads	The Hawaiians	Windsurfing Hawaii	User-Founded Firm

Sport	Year	Innovation	Innovator	Affiliation	Locus of Innovation
Windsurfing (Cont')	1976	Shoulder and Chest Harness	Ken Kleid, Pat Love & Larry Stanley	Windsurfing Hawaii	User-Founded Firm
	1976	Bungeed Uphaul	Mike Horgan	Windsurfing Hawaii	User-Founded Firm
	1976; 1987	Boomstraps (Powerstraps Boom Straps – 1976; For N' Aft Adjustable Boom Straps – 1987)	Dennis Davidson & Pat Love – 1976; Larry Stanley & Pat Love – 1987	Windsurfing Hawaii	User-Founded Firm
	1977	Footstraps	Larry Stanley	Windsurfing Hawaii	User-Founded Firm
	1977	High Clew Surf Sails/High Wind Sails	Pat Love & Larry Stanley & Mike Horgan	Windsurfing Hawaii	User-Founded Firm
	1979	Higher Aspect Sails	Barry Spanier & Jeff Bourne	Maui Sails	Existing Manufacturer
	1979	Adjustable Booms	Larry Stanley & Ken Winner	Windsurfing Hawaii & Pro-windsurfer (affiliated with multiple manufacturers)	Other (user-founded firm & pro)
	1979	Spreader Bar, Stainless Steel and Plastic	Mike Horgan	Windsurfing Hawaii	User-Founded Firm
	Late 1970s	Fully Battened Sails (NS)	Pat Love	Windsurfing Hawaii	User-Founded Firm
	1980	Polyurethane Universal	Dave Dominy	Streamlined	User
	1980	Forefin	Larry Stanley	Windsurfing Hawaii	User-Founded Firm
	1980	Adjustable Mast Base	Larry Stanley & Mike Horgan	Windsurfing Hawaii	User-Founded Firm
	1981	Adjustable Mast Track	Ken Winner; unnamed North shore boardshaper on Oahu	Pro-windsurfer (affiliated with multiple manufacturers); Independent board shapers	Other (pro; user-founded firm)
	Approx. 1981	Cutaway Fin	Graham Allen	None	User
	1981-2	"Hybrid" Harness	Barry Spanier (pure hip harness); Larry Stanley ("Add-On Speedseat/Chest Harness Combo - a combination of hip, waist and chest harnesses to create the hybrid type of harness that is used today)	Maui Sails; Windsurfing Hawaii	Other (existing manufacturer; user-founded firm)
	1982	Sail Materials: Laminated Fibers	Barry Spanier & Jeff Bourne	Both with Maui Sails and Neil Pryde	Existing Manufacturer

Sport	Year	Innovation	Innovator	Affiliation	Locus of Innovation
Windsurfing (Cont')	1984	Clamp-on Boom Front End	Barry Spanier	Maui Sails and Neil Pryde	Existing Manufacturer
	1984	RAF Sails	Barry Spanier & Jeff Bourne	Both with Maui Sails and Neil Pryde	Existing Manufacturer
	1984	Camber Inducers	Jeff Magnan; Thomas Nishimura; Jeff Belvedere	Gaastra; NA; NA	Other; NA; NA
	1985	ADTR	Jeff Magnan & Chuck Stahl	Consultants for Gaastra	Other (consulting for an existing manufacturer)
	1985	Fin Boxes	Larry Tuttle	FinWorks	Existing Manufacturer
	1985	Carbon-Fiber Masts	Peter Quigley & Nevin Sayre	Fiberspar	NA
	1986	Boom Materials – Carbon Fiber	Peter Quigley & Nevin Sayre	FiberSpar	NA
	Approx. 1988	Sail Materials: Polyester Film	Peter Brockhaus	F2	Manufacturer (for the sport of windsurfing)
	1980s (verify with notes)	Flapper/Anti-Ventilation Device	Ken Winner	Pro-windsurfer (affiliated with multiple manufacturers)	Other (Pro)
	late 1990s	Beginner Board/Windglider	Ken Winner & Dave Johnson	Pro-windsurfer & North Sports (verify)	Other (in-industry manufacturer & a pro)
	Approx. 1998	Sheer-Tip Rigs/Flex Top Sail	NA	NA	NA
	NA	High Performance Fins	Bill Bahne & Curtis Hesselgrave	Bahne	Existing Manufacturer
	NA	Wingmast	Dimitrije Milovich; Ernst Meyer (Swiss)	NA	NA
	NA	Lighter Boards/Sandwich Construction	John Parton & Ian Pitkairn	ProTech	NA
	NA	Boom Materials & Design – Aluminum	NA	NA	NA
	NA	Blade Fin	NA	NA	NA
	NA	Short High Performance Boards	NA	NA	NA
	NA	Kitesurfing	NA	NA	NA

Sport	Year	Innovation	Innovator	Affiliation	Locus of Innovation
Skateboarding	Early 1900s	Putting skates on a 2x4	Many children	None	Users
	Late 1960s	Kicktail	Larry Stevenson	Makaha Skateboards	User-Founded Firm
	1970	Urethane Wheels	Frank Nasworthy	None	User
	Between 1974-1975	Precision Ball Bearings	Jay Shuirman	NHS	Existing Manufacturer
	1973; 1976	Wider Boards/Laminated Plywood	Lonnie Toft & Willie Winkel	Pro-skater for Sims & Wee Willi Winkel Skateboards	User-Founded Firm
	Between 1975-78	Lighter Boards/Laminated Plywood	Wes Humpston and Jim Muir	Dogtown Skates	User-Founded Firm
	1978	Developments in Skateboard Trucks	John Hutson, Jay Shuirman, Rich Novak	NHS (marketed as "Independent")	Existing Manufacturer

TABLE 3:
FUNCTIONAL SOURCE OF INNOVATION

Sport	Innovation Type	Percentage of Innovations Developed by Users and User-Mfrs	Number of Innovations Developed by: Users	User-Mfrs	Mfrs [a]	Other	Unknown	*Total*
Skateboarding	First of Type	100%	1	0	0	0	0	*1*
	Major Improvement	67%	1	3	2	0	0	*6*
Snowboarding	First of Type	100%	1	0	0	0	0	*1*
	Major Improvement	67%	2	4	3	0	0	*9*
Windsurfing	First of Type	100%	1	0	0	0	0	*1*
	Major Improvement	53%	3	13 [b]	7	7 [c]	9	*39*
Total			*9*	*20*	*12*	*7*	*9*	*57*
Percent of First of Type		100%	100%	0%	0%	0%		
Percent of Major Improvement [d]		57%	13%	44%	27%	16%		

[a] Two of these are attributable to existing manufacturers, seven to components suppliers, and three to manufacturers organized to produce specifically for the sport in question.
[b] Thirteen of these innovations are attributed to the firm Windsurfing Hawaii.
[c] Two of these are partially attributable to the firm Windsurfing Hawaii.
[d] The nine innovations for which the developer is unknown have been excluded from percentage calculations, leaving 45 major improvement innovations.

Statistics:

- Null hypothesis: *manufacturers in general* will develop greater than or equal to 50% of the innovations in novel sports.
- Using a binomial distribution with n=48, x=12, and p=0.5, the null hypothesis can be rejected at the 0.05 level of significance. Put another way, if in fact the probability of manufacturer innovations is greater than or equal to 50%, the realized value of only 12 of 48 innovations being developed by manufacturers has only a 0.02% probability of occurring.

TABLE 4:
FUNCTIONAL SOURCE OF INNOVATION – FIRST INNOVATION BY EACH INNOVATOR ONLY

Sport	Innovation Type	Percentage of Innovations Developed by Users and User-Mfrs	Number of Innovations Developed by: Users	User-Mfrs	Mfrs [a]	Other	Unknown	*Total*
Skateboarding	First of Type	100%	1	0	0	0	0	*1*
	Major Improvement	67%	1	3	1	0	0	*5*
Snowboarding	First of Type	100%	1	0	0	0	0	*1*
	Major Improvement	67%	2	2	2	0	0	*6*
Windsurfing	First of Type	100%	1	0	0	0	0	*1*
	Major Improvement	36%	3	1	4	3	8	*19*
Total			*9*	*6*	*7*	*3*	*8*	*33*
Percent of First of Type		100%	100%	0%	0%	0%		
Percent of Major Improvement [b]		55%	27%	28%	32%	14%		

[a] Two of these are attributable to existing manufacturers, three to components suppliers, and two to manufacturers organized to produce specifically for the sport in question.

[b] Innovations for which the developer is unknown have been excluded from percentage calculations, leaving 22 major improvement innovations.

Statistics:

- Null hypothesis: *manufacturers in general* will develop greater than or equal to 50% of the innovations in novel sports.
- Using a binomial distribution with n=25, x=7, and p=0.5, the null hypothesis can be rejected at the 0.05 level of significance. Put another way, if in fact the probability of manufacturer innovations is greater than or equal to 50%, the realized value of only 7 of 25 innovations being developed by manufacturers has only a 1.4% probability of occurring.

TABLE 5:
PATENTING AND LICENSING OF NON-MANUFACTURER INNOVATIONS

Sport	Non Manufacturer Innovations[a]	Patented Innovations[b]		Licensed Innovations[b]	
		Number	*Percent*	*Number*	*Percent*
Skateboarding	5	1	20%	0	0%
Snowboarding	7	1	14%	1	14%
Windsurfing	24	6	25%	2	8%

[a] Excludes the nine windsurfing innovations for which the innovator is unknown.
[b] Percentages based on the number of non-manufacturer innovations in the entire sample (column 2).

Table 6: Methods By Which Non-Manufacturers Appropriated Benefits

Sport	**Locus**	**Method by Which Financial Benefit Appropriated** [a]			
		Profits from User-Manufacturing Firm	*Consulting, Patent Licensing, Patent Sales Fees, or No Benefit*	*Unknown*	*Total*
Skateboarding	Users & Other	0	1	0	1
	User-Manufacturer	4	0	0	4
Snowboarding	Users & Other	0	3	0	3
	User-Manufacturer	4	0	0	4
Windsurfing	Users & Other	2	6	2	10
	User-Manufacturer	14	0	0	14
Total		24 (71%)	10 (29%)	2	36

a Explanation of coding categories:
No Benefit - innovators received no known financial benefits from their innovation
Consulting Fees - innovators in this category were often professional competitors with strong ties to manufacturers or innovators who were hired for product design consulting by manufacturers.
Patent Licensing Fees - innovators who patented their innovations and then licensed them to manufacturers.
Profits from Own Manufacturing firm – user-manufacturers engaged in the sale and production of their innovation – they often established a firm to produce and sell their equipment innovations.

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