Available online at www.sciencedirect.com
ScienceDirect
Research Policy 35 (2006) 1291–1313
research policy
www.elsevier.com/locate/respol

How user innovations become commercial products: A theoretical investigation and case study

Carliss Baldwin [a], Christoph Hienerth [b], Eric von Hippel [c,*]

[a] *Harvard Business School, Boston, MA, United States*
[b] *Copenhagen Business School, Copenhagen, Denmark, and Vienna University of Economics and Business Administration, Vienna, Austria*
[c] *MIT Sloan School of Management, Cambridge, MA, United States*

Received 8 September 2005; received in revised form 10 March 2006; accepted 14 April 2006
Available online 28 August 2006

Abstract

In this paper we model the pathways commonly traversed as user innovations are transformed into commercial products. First, one or more users recognize a new set of design possibilities and begin to innovate. They then join into communities, motivated by the increased efficiency of collective innovation. User-manufacturers then emerge, using high-variable/low-capital cost production methods. Finally, as user innovation slows, the market stabilizes enough for high-capital, low-variable cost manufacturing to enter. We test the model against the history of the rodeo kayak industry and find it supported. We discuss implications for "dominant design" theory and for innovation practice.

Keywords: User innovation; Communities; Dominant design; Industry evolution; Real options

1. Introduction and overview

It has been shown that many users – both individuals and firms – develop new products to serve their own needs. Some of these are later adopted by manufacturers and sold as commercial products. Thus user innovation can greatly influence the rate and direction of innovation in some industries. In this paper we explore the pathways commonly traversed as user innovations are transformed into commercial products. We construct a model, based on design search theory, that explains first, how user innovation is organized and evolves over time, and second, how user innovations become products and affect the evolution of product markets. There is an extensive literature on how changes in product design and production technology affect the organization of industry. This paper brings user innovation into that line of research.

According to the theory developed in this paper, user innovation begins when one or more users of some good recognize a new set of design possibilities – a so-called "design space" – and begin to explore it. In general, one or more communities of *user-innovators* will soon coalesce and begin to exchange innovation-related information. We use the formal theory of design search to model the behavior of user-innovators and the benefits they obtain by forming communities. Some time after user innovation begins, the first *user-purchasers* appear – these are users who want to buy the goods that embody the lead user innovations rather than building them for themselves. Manufacturers emerge in response to this demand. We show that, under quite general conditions,

* Corresponding author. Tel.: +1 617 253 7155.
E-mail addresses: cbaldwin@hbs.edu (C. Baldwin), christoph.hienerth@wu-wien.ac.at (C. Hienerth), evhippel@mit.edu (E. von Hippel).

0048-7333/$ – see front matter © 2006 Elsevier B.V. All rights reserved.
doi:10.1016/j.respol.2006.04.012

the first manufacturers to enter the market are likely to be user-innovators who use the same flexible, high-variable, low-capital cost production technologies they use to build their own prototypes. The relatively high variable costs of these *user-manufacturers* will tend to limit the size of the market.

As information about product designs becomes codified, and as market volumes grow, manufacturers – both existing user-manufacturers and established manufacturers from other fields – can justify investing in higher-volume production processes involving higher capital investments. These processes have lower variable costs, hence their use will tend to drive prices lower and expand the market. User-purchasers then have a choice between lower-cost standardized goods and higher-cost, more advanced models that user-innovators continue to develop. We predict that the market will segment along the lines of consumer preferences: we model that segmentation as a function of design quality, usability, and cost. Finally, as a design space matures, the rate of user innovation within that space tends to decline because the expected returns from further design improvements decrease. We model the effects of this "mining out" of the design space on the manufacturers' choice of technology and capital investment.

We begin this paper with a literature review (Section 2), followed by a case history of rodeo kayaking (Section 3). This case history serves as the "test case" in the development of our theory. In Section 4, we define the basic concepts and terms of our model. In Section 5, we explore the decision-making and organization of *user-innovators*. Next, we consider the economics of *manufacturing* as user innovation and investment in production technologies change the nature of products and demand (Section 6). Section 7 concludes by discussing the theoretical and managerial implications of our findings.

2. Literature review

In this section, we first review research on innovation by users and within user innovation communities. Next, we describe what is known about the role of user-innovators in commercializing the innovations they have developed. Finally, we review prior work on how industry structures change in response to changes in underlying product designs and production technologies.

2.1. Innovation by users

Research has shown that some of the most important and novel products and processes have been developed by users—both user firms and individual end users. Thus, Enos (1962) reported that nearly all the most important innovations in oil refining were developed by user firms (oil refineries). Freeman (1968) found that the most widely licensed chemical production processes were developed by user firms. von Hippel (1988) found that users were the developers of about 80% of the most important scientific instrument innovations, and also the developers of most of the major innovations in semiconductor processing. Pavitt (1984) found that many inventions by British firms were for in-house use. Shah (2000, 2003, 2004) found that the most commercially important equipment innovations in three sporting fields tended to be developed by individual users. It has also been found that commercially attractive products tend to be developed by "lead users" – users that are at the leading edge of important marketplace trends and expect significant benefit from innovating (Urban and von Hippel, 1988; Morrison et al., 2000; Franke et al., 2006; Olson and Bakke, 2001).

Studies have also shown that *many* users engage in developing or modifying products. In studies of five types of industrial products, the fraction of users reporting developing or modifying products for their own use ranged from 19% to 36% (Urban and von Hippel, 1988; Herstatt and von Hippel, 1992; Morrison et al., 2000; Franke and von Hippel, 2003; Lüthje, 2003). Four studies of user innovation in consumer products found from 10% to 38% of sampled users reporting that they had developed or modified products for their own use (Lüthje, 2004; Franke and Shah, 2003; Lüthje et al., 2005). Users with similar interests and needs often form user-innovation communities, where members freely reveal their innovations and assist each other with innovation development (Franke and Shah, 2003; Hienerth, 2006; Tietz et al., 2005).

2.2. Entrepreneurship by users

While it is clear that many users innovate and that user-innovation communities are common, the evidence on the role of user-innovators in the commercialization of their innovations is mixed. On the one hand, von Hippel (1988) found that individual scientists who had developed important scientific instrument innovations seldom founded firms to exploit these. He also found that user firms that had developed new process equipment seldom went into the commercial production of this equipment. In contrast, Shah (2000) found that, in the field of sporting equipment, lead users who developed significant equipment innovations often did become user-manufacturers, producing small volumes