J. Eng. Technol. Manage. 32 (2014) 1–25

Contents lists available at ScienceDirect

Journal of Engineering and Technology Management

journal homepage: www.elsevier.com/locate/jengtecman

Radical innovation from the confluence of technologies: Innovation management strategies for the emerging nanobiotechnology industry

Elicia Maine [a,*], V.J. Thomas [a], James Utterback [b]

[a] Beedie School of Business, Simon Fraser University, Canada
[b] Sloan School of Management, Massachusetts Institute of Technology, USA

ARTICLE INFO

Article history:
Received 22 February 2013
Received in revised form 1 October 2013
Accepted 17 October 2013

Keywords:
Opportunity creation
Radical innovation
Confluence of technologies
Nanotechnology/biotechnology commercialization
Technology convergence

ABSTRACT

We investigate how the confluence of technologies can lead to radical innovation, thus creating opportunities at the firm and industry levels. To do so, we conduct a detailed examination of the development of the transistor and of two nanobiotechnology drugs — Doxil® and Zevalin® — from an innovation management perspective. We argue that three innovation management strategies are central to the development of radical innovation from the confluence of technologies, namely: importing ideas from broad networks, creating environments which allow for deep collaboration, and technology-market matching.

Introduction

There is enormous potential for innovation from the confluence of technologies (Sharp et al., 2011), but little is known about how the confluence of technologies can lead to the creation of radical innovation and subsequently the emergence of new industries. A confluence of technologies is defined as a new combination of previously distinct technologies, and evolves when researchers begin to work at the intersection of two or more technology streams, and when products based on this intersection of technology begin to emerge. Radical innovation dramatically improves existing product attributes, enables entirely new functionality, or reduces product cost very significantly (Foster, 1986; Leifer

* Corresponding author. Tel.: +1 778 782 5260.
E-mail address: emaine@sfu.ca (E. Maine).

0923-4748/$ – see front matter © 2013 Elsevier B.V. All rights reserved.
http://dx.doi.org/10.1016/j.jengtecman.2013.10.007

et al., 2000). An often cited example of radical innovation is that of the transistor (Morton, 1971; Riordan and Hoddeson, 1999; Gertner, 2012), which was enabled by technological advances and knowledge integration across the fields of advanced materials, physics, electronics and instrumentation (Globe et al., 1973a,b). Several radical innovations have already been enabled by the confluence of biotechnology and nanotechnology streams, including effectively targeted drug delivery, rapid diagnostics, and nanoscale tissue engineering. Many firms have already been formed around these innovations (Maine et al., 2012a; Wagner et al., 2006). Further radical innovation is anticipated, from both ambitious and uncertain multidisciplinary research programs and from serendipitous discoveries (Sharp et al., 2011). Although the development and exploitation of radical innovation is an important and enduring research theme (Foster, 1986; Utterback, 1994; Leifer et al., 2000), scholars have not yet adequately explored how radical innovation is enabled by the confluence of technologies.

In this paper, we explore the innovation management strategies that connect the confluence of technologies to radical innovation by developing and analyzing a series of case studies. By innovation management strategies, we mean the purposeful actions that company founders and technology managers take to influence the productivity and impact of their scientists and product development teams. We focus on innovation management strategies so that they may guide managers at both large firms and new ventures who are attempting to create value from the confluence of technologies. We argue that three innovation management strategies are central to the development of radical innovation from the confluence of technologies: importing ideas from broad networks, creating environments which allow for deep collaboration, and technology-market matching. Importing ideas from broad networks involves a broad search and synthesis of concepts from disparate technology streams. Deep collaboration refers to interactive input and feedback between R&D groups, where "each group makes an essential contribution to different stages of the research process" (Rafols and Meyer, 2007). Technology-market matching involves recognition and prioritization of the most promising technology solutions for a market application or the most appropriate markets for a technology. Through analysis of three case studies, we demonstrate the commonality of these three innovation management strategies in enabling radical innovation at the confluence of technologies.

The context in which we explore strategies which connect the confluence of technologies to radical innovations is the emerging nanobiotechnology industry. After an analysis of the well documented development of the transistor, we provide detailed and novel case studies of two of the earliest and most significant nanobiotechnology innovations – Doxil® and Zevalin® – both in the new drug class of therapeutic nanoparticles (Burgess et al., 2010). We provide nuanced detail on the role of both the confluence of technologies and the role of specific innovation management strategies in enabling these radical innovations of liposomal drug delivery and radiolabeled antibody therapy. This context is especially appropriate to our research question as all three case studies document radical innovation enabled by the confluence of technologies. Advances in the technological streams of physics, advanced materials, electronics and instrumentation enabled the transistor, from which the modern consumer electronics industry emerged. Similarly, advances across several previously distinct technological fields enabled radical innovations in therapeutic nanoparticles, and a nanobiotechnology industry is currently emerging.

This paper contributes to three distinct knowledge domains: innovation management, opportunity creation from the confluence of technologies, and innovation management strategies for the emerging nanobiotechnology industry. The innovation management strategies that emerge from our paper are relevant across industry contexts, demonstrating how radical innovation emerged from the confluence of technologies. Further, we make a contribution by integrating streams of management literature to suggest that opportunity creation may be more likely at the confluence of technologies. Finally, we provide innovation management strategies for the emerging nanobiotechnology industry, a context in which very few studies of innovation have been conducted. Management researchers have recently begun examining opportunities created by the confluence of biotechnology and nanotechnology: however, studies to date have been dominated by patent and bibliometric analysis, which focus on invention rather than innovation (No and Park, 2010; Takeda et al., 2009; Grodal and Thoma, 2009; Pei and Porter, 2011; Barirani et al., 2013). The few valuable case study contributions in the context of nanobiotechnology innovation focus either at the lab level (Rafols, 2007; Rafols and Meyer, 2007) or extrapolate implications from the ICT industry to the nanobiotechnology industry