Available online at www.sciencedirect.com

SCIENCE DIRECT®

Research Policy 35 (2006) 375–393

research policy

www.elsevier.com/locate/respol

Commercializing generic technology: The case of advanced materials ventures

Elicia Maine [a,*], Elizabeth Garnsey [b]

[a] Segal Graduate School of Business, Simon Fraser University, 515 West Hastings Street, Vancouver, BC, Canada V6B 5K3

[b] Centre for Technology Management, University of Cambridge, Mill Lane, Cambridge CB2 1RX, UK

Received 10 December 2004; received in revised form 14 December 2005; accepted 21 December 2005

Available online 30 March 2006

Abstract

Generic, radical technology is of interest because of its potential for value creation across a broad range of industries and applications. Advanced materials ventures are attracted by this opportunity yet face distinctive challenges in commercializing such technology. We explore an anomaly in common assumptions about the commercialization of generic technology. We build on Freeman's concept of technological innovation as a technological and market matching process, on existing literature and on prior experience to build, inductively, a model of the variables influencing value creation by advanced materials ventures. We then test the model on the basis of detailed observation and analysis of two case studies, which have successfully created value through commercialization of advanced materials technology. Extending this theory, we offer managerial and policy recommendations to support value creation by advanced materials ventures.

Keywords: Generic technology; Radical innovation; Value chain; Opportunity exploitation; Advanced materials; Technology innovation; Technology entrepreneurship

1. Introduction

Generic, radical technology is of interest because of its potential for value creation across a broad range of industries and applications. By 'generic technology' we refer to "a technology the exploitation of which will yield benefits for a wide range of sectors of the economy and/or society" (Keenan, 2003). We define "radical technology" as having "the potential for delivering dramatically better product performance or lower production costs, or both" (Utterback, 1994, p. 158). Thus defined, the commercialization of generic, radical technology is highly desirable both to national governments and to firms seeking profit. Nevertheless, generic, radical technology may face very high barriers to commercialization despite its potential for value creation.

Information technology is a well studied example of a generic technology that has created new value for a broad range of industries throughout the economy. Radical developments in advanced materials technology are now viewed as an enabler for further innovations with the potential for major economic impact across a broad range of industries and applications (Massachusetts Technology Collaborative, 2004; Oliver, 1999; OECD, 1998). Advanced materials are attracting both government interest and new entrants. Existing literature investigates the benefits of generic technologies, and predicts that new ventures will enjoy substantial advantages when they commercialize generic technologies (Shane,

* Corresponding author. Tel.: +1 604 291 5260; fax: +1 604 291 5153.

E-mail address: emaine@sfu.ca (E. Maine).

0048-7333/$ – see front matter © 2006 Elsevier B.V. All rights reserved.

doi:10.1016/j.respol.2005.12.006

2004). However, the upstream position in the value chain accessible to most entrants, along with the costs, time and uncertainty associated with commercializing radical advanced materials technology have implications that have not been widely recognized in policy discussions. This paper sets out to explain the challenges to commercialization faced by advanced materials ventures and the ways in which these challenges can be addressed.

We build on Freeman's (1982) concept of technological innovation as a technology and market matching process, existing literature, and prior experience to inductively develop a model of the variables influencing value creation by advanced materials ventures. We show how the generic and radical nature of the technologies of advanced materials ventures, combined with their upstream position in one or several industry value chains and the need for industry specific and application specific complementary innovations, lead to high sustained levels of technology and market uncertainty impacting their ability to create value.

Radical advanced materials technologies are here defined as product and process improvements that significantly enhance the cost-performance frontier of functional materials. This type of technology has the potential to lead to radical innovations downstream in several industry value chains (Klevorick et al., 1995). Examples of radical advanced materials innovations include the use of nanomaterials to alter the mechanical, electrical, and/or thermal properties of components of products in a broad range of industries, organic light emitting polymers used to create diodes for flat panel displays and other consumer electronic applications, and Kevlar fibre used as a light-weight reinforcement in aerospace, sports equipment, automotive, military, and marine applications.

The structure of this paper is as follows. We first review the technology innovation literature. We interpret this literature in the light of other research relevant to advanced materials innovation, with the prior experience of one of the authors, and with discussions with the senior managers of advanced materials ventures,[1] to develop a model of the variables influencing value creation by advanced materials ventures. We provide preliminary testing of the model through observation and analysis of two in-depth case studies. After building and testing this exploratory theory, we outline future research and provide managerial and policy recommendations to assist advanced materials ventures in creating and capturing value.

1.1. Literature review

There is an extensive management literature on technological innovation, but no known studies that explicitly address the issue with which we are concerned: the commercialization of generic technology that is radical in nature and initiated from an upstream position in several industry value chains. In this section, we review relevant management literature on technological innovation, distinguishing between generic technology, radical technology, revolutionary innovation, disruptive innovation, product versus process innovation, and upstream versus downstream innovation, as shown in Table 1.

A generic technology[2] has a wide breadth of applications across industry sectors (Keenan, 2003; Martin, 1993; Hagedoorn and Schakenraad, 1991). Examples of generic technologies include steam power, telecommunications and Information Technology (Rosenberg and Trajtenberg, 2004; Bresnahan and Trajtenberg, 1995). Shane (2004) proposes five benefits to new ventures who exploit such technologies: first, they allow the flexibility to pursue alternative market applications should the first attempt prove unviable; second, they allow ventures to diversify risks and amortize R&D costs across separate applications; third, the markets with potential are at various stages of maturity, and thus provide short-term, medium-term and long-term revenue opportunities; fourth, target market applications in different sectors can be compared; fifth, the breadth and scope of opportunity attracts investment. Shane argues further that new ventures benefit from the very features of generic technologies, which hinder commercialization efforts by established firms (Shane, 2004, pp. 123–124). In Section 2, we show how, for advanced materials ventures, these benefits are counterbalanced by difficulties created by the generic, radical and upstream nature of advanced materials technology.

Where the term generic technology signifies breadth, radical technology signifies depth. That is to say, a radical technology has significant value potential in an individual application. Foster (1986) depicted a radical innovation as achieving a higher performance level than the incumbent technology along S-curves of performance attributes over time. Thus, equivalent efforts

[1] The authors interviewed the founders and/or senior managers of all identifiable advanced materials ventures in the Boston, USA, and Cambridge, UK regions from 2000 to 2003.

[2] A closely related term, general purpose technology, also refers to technology that impacts a broad range of industries.