ELSEVIER

Energy Policy 36 (2008) 2143–2153

ENERGY POLICY

www.elsevier.com/locate/enpol

Learning for supplying as a motive to be the early adopter of a new energy technology: A study on the adoption of stationary fuel cells

Albert Ying-Je Huang[a,b,*], Ruey-Hua Liu[b]

[a]*Department of Business Administration, Minghsin University of Science and Technology, Hsinchu 30401, Taiwan*
[b]*Department of Economics, National Tsing Hua University, Hsinchu 30013, Taiwan*

Received 25 July 2007; accepted 11 February 2008
Available online 10 April 2008

Abstract

By early adopting a new technology, firms may attempt to improve their production efficiency and become further involved in the supply chain of the technology. These two different advantages derived from learning a new technology are identified as motives for adopting the technology. When learning for supplying (LFS) (becoming involved in the supply chain of the new technology) highlighted in this paper is significant enough, potential adopters may still be willing to adopt the new technology, even though learning for using (LFU) (increasing current production efficiency) is not significant. This paper identifies LFS as a motive for early adopters of the new technology. Firms may adopt a new technology for the purpose of learning how to become the suppliers of the relevant parts, materials, or equipment for the new technology. By investigating the adoption decision of a new energy technology (namely, phosphoric acid fuel cells (PAFC)), our arguments are supported by both observation of early adopters' attributes and a survey of Taiwanese firms' willingness to adopt new technology.

Keywords: Learning for using; Learning for supplying; Learning by doing

1. Introduction

Why is a firm willing to spend much money on adopting a new technology and consume much time in learning the technology? A commonly noted motive is that a firm may adopt and use a new technology for reducing production cost and improving product quality to competitively serve customers' needs. In contrast, we argue that a firm, not the innovator and initial provider of a new technology, may be willing to install and learn a new technology to profit from becoming involved in the future supply chain of the technology. Based on our arguments, potential adopters of a new technology are not restricted to pure users only. Moreover, adopters may include those firms which may not be cost-efficient as pure users, but may profit as future suppliers including researchers/designers, feedstock/fuel suppliers, component/system manufacturers, marketers/distributors, and other mediating institutions between innovators and end-users. This is not only important to a technology-transferring agency which is promoting a new technology, but also should be considered by government policymakers who are developing related industries of the new technology.

The adoption of a new, developing, and non-pervasive technology, inevitably involves learning processes. The resultant learning effects can reflect the profitability gained from adopting the new technology. In order to emphasize different motives of the potential adopter, "learning for" is substituted for "learning by" in this study. A frequently noted learning effect for adopters of a new technology, identified as "learning for using" (LFU) in this paper, is a reduction in unit labor costs of an adopter's production (e.g. Arrow's (1962) "learning by doing") or improved productivity with/without any modification of the new technology (e.g. Rosenberg's (1982) "learning by using" and von Hippel's (1988) "user innovation"). More recently, Karger and Bongartz (2007) indicate that both "cost efficiency" and "secure energy supply" are important

*Corresponding author.
E-mail addresses: yjhuang@must.edu.tw (A.Y.-J. Huang), rhliu@mx.nthu.edu.tw (R.-H. Liu).

0301-4215/$ - see front matter
doi:10.1016/j.enpol.2008.02.003

factors in the adoption decision of fuel cells for industrial users. Some literature has analyzed learning effects shared among participants in network relationships (Douthwaite et al., 2001; Hendry et al., 2004; Jacobsson and Bergek, 2004; Junginger et al., 2006; Kim et al., 2007; Lettl et al., 2006; Meyers and Athaide, 1991; Mody, 1993; Pisano et al., 2007). Hendry et al. (2007) indicated both the importance of ''the role of users'' and the ''transferring experience to industry'' in evaluating learning effects due to the precursory adoption of phosphoric acid fuel cells (henceforth PAFC) technology. The learning effects mentioned above, that can be categorized as LFU, and do not clearly indicate that the adopters may learn to be suppliers of the new adopted technology.

In addition to LFU, an early adopter can learn much about the adopted technology by doing R&D, supplying feedstock, testing prototypes and providing other services. Thus, an early adopter with early-mover advantages will have a chance to gain profit and facilitate commercialization by entering the innovative industry in the form of a designer, manufacturer, marketing distributor, feedstock supplier, and other complementary services supplier. This highlighted learning effect, termed ''learning for supplying'' (LFS), will be employed to explain the motives of those early users in this paper. Recently, while Shah (2000) and Baldwin et al. (2006) showed that some users (''user-innovators'') innovating new products may later become initial manufacturers (''user-manufacturers'') of their innovations, their arguments mainly focused on the process of commercializing users' innovations in the field of consumer products. In contrast, we argue that some established domestic or foreign firms in various industries may have strong motives to learn how to become involved in the future supply chain of a new technology by early adopting and using the technology. This paper argues that becoming involved in the future supply chain of a new technology is a crucial motive to early adopt and learn the technology.

The fuel cell, a developing energy technology with many advantages, has been shown to have great potential to replace traditional combustion-based electricity-generating technologies in the energy market (Shipley and Elliott, 2004). While the fuel cell can be used in mobile and stationary applications, only the latter will be discussed in this paper. More specifically, we will focus on PAFC, which is the first commercially available stationary fuel cell. Fuel cell technology has at least three advantages as follows. First, its overall energy efficiency is high in combined heat and power (CHP) applications. Second, it is very clean which can facilitate the mandatory reduction of greenhouse gas emissions in the Kyoto Protocol. Finally, it is a distributed generation system, which enables users to control energy supply by themselves, and reduce transmission and distribution losses occurring in a central generation grid. Based on advantages above, the potential marketability of the fuel cell is clear. Firms which are not innovators of fuel cells, but have the ability to provide outsourcing services, can probably profit from becoming involved in the future fuel cells' supply chain.

Our arguments are empirically supported in two ways. First, many early adopters of fuel cells are actually involved in activities relevant to supplying fuel cells. According to Worldwide Stationary Fuel Cell Installation database of the Fuel Cells 2000, many PAFC were installed in some firms associated with supplying fuels, components, systems, and researchers (e.g. gas companies, power companies, wastewater treatment plants, fuel cell manufacturers, and R&D institutes). Second, by surveying firms' willingness to adopt PAFC in Taiwan, we find some firms interested in being involved in the future PAFC supply chain are willing to adopt the technology. The remaining parts of this paper will be organized as follows. Literature about learning effects will be briefly reviewed in Section 2. The theoretical analysis of LFS will be done in Section 3. Some observations of the current PAFC industry and our empirical analysis on willingness to adopt PAFC will be shown in Section 4. Finally, some concluding remarks will be given in Section 5.

2. Literature review on learning effects

Understanding learning effects for early adopters of a new technology is crucial in analyzing the adoption of the technology. Rosegger pointed out that the economic impact of innovations depends on ''the speed with which they are diffused'' (Rosegger, 1980, p. 232). Rogers first classified five adopter categories in his 1958 article. As the bridge between ''innovators'' and ''early majority'', ''early adopters'' play an important role in the diffusion process (Rogers, 2003, p. 279–281). Being one of the important ''attributes of innovations'', the ''relative advantage'' (the ratio of the expected benefits and the costs) of an innovation adoption has been found to be positively related to its rate of adoption in much previous research (Rogers, 2003, p. 233). Moreover, in the ''stepwise process'' of assessing the innovation for potential adopters of energy conservation interventions, Völlink et al. (2002) indicate that the ''advantage'' of an innovation is the foremost one among various decision factors. While innovation is an important factor for economic development, its rapid diffusion and wide adoption are no less important than the innovation itself. Without (or with very few and barely accessible) preceding adopters, potential early adopters can hardly observe and imitate the experiences of preceding adopters to reduce uncertainties in adopting new technologies. One effective way to absorb knowledge and accumulate experience is to adopt the new technology directly. Hence, potential profits derived from adopting a new technology are employed to reflect the relevant learning effects in this paper.

Starting from Arrow's (1962) analysis of learning by doing, many discussions on learning effects can be found in the existing literature. They emphasize analysis of how firms can improve production efficiency or reduce average