Research Policy 37 (2008) 1317–1328

Contents lists available at ScienceDirect

Research Policy

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

The relationship between technology, innovation, and firm performance—Empirical evidence from e-business in Europe

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ARTICLE INFO

Article history:
Received 13 April 2006
Received in revised form 29 April 2008
Accepted 30 April 2008
Available online 10 June 2008

Keywords:
Information technology
Innovation
Firm performance

ABSTRACT

This article analyzes the relationship between the usage of Internet-based technologies, different types of innovation, and performance at the firm level. Data for the empirical investigation originates from a sample of 7302 European enterprises. The empirical results show that Internet-based technologies were an important enabler of innovation in the year 2003. It was found that all studied types of innovation, including Internet-enabled and non-Internet-enabled product or process innovations, are positively associated with turnover and employment growth. Firms that rely on Internet-enabled innovations are at least as likely to grow as firms that rely on non-Internet-enabled innovations. Finally, it was found that innovative activity is not necessarily associated with higher profitability. Possible reasons for this and implications are discussed.

1. Introduction

The importance of new technologies and innovations for competitiveness and growth is a truism among managers, policy makers, and researchers. However, not all new technologies and innovations lead to success. Given the manifold technological opportunities and types of innovations from which firms can potentially choose, it is desirable to know which innovative activities and technologies are most clearly associated with improved competitiveness and growth. Arguably even more important is an understanding of the factors that make the success of new technologies and innovative activities more or less likely in general. The aim of this article is to provide some new insights regarding this topic.

A conceptual framework is developed that assists in analyzing the relationship between technology, innovation, and firm performance. It is argued that the performance implications of new technologies, such as information and communication technologies (IT), are mediated by innovative activities that result from the adoption of these technologies. Furthermore, the performance implications can vary across different types of innovation, depending on firm-internal and market-specific factors. This conceptual framework serves as a guide for the empirical investigation and the interpretation of its results.

The empirical part of the study compares the performance of innovative and non-innovative companies. Performance is measured in terms of turnover development, employment development, and profitability. In particular, four different types of innovative activity are distinguished: product innovations or process innovations that were enabled by Internet-based technologies, and product innovations or process innovations that were not related to the use of Internet-based technologies. The article is organized as follows: succeeding this introduction, the theoretical

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doi:10.1016/j.respol.2008.04.024

background of this study and a short overview of related literature is provided in Section 2; the conceptual framework that links technology, innovation, and firm performance is introduced in Section 3; the econometric estimation model is explained and derived in Section 4; Section 5 describes the data set and reports some descriptive findings; the estimation results are presented in Section 6 and discussed in Section 7; limitations of the empirical analysis are pointed out in Section 8; and finally, Section 9 concludes the paper.

2. Theoretical background

On the conceptual level, the adoption of new technology, such as IT, can be viewed as an enabler of process innovations from the perspective of the adopter if the implementation succeeds, the routines are changed, and the new system is actually utilized. Newly adopted technology can also act as an enabler of product or service innovations from the perspective of the adopter if it is successfully used to offer a new service or to deliver products to customers in a way that is new to the enterprise. For example, a company that adopts and implements new online shop software usually changes the routine of how incoming orders are processed. This is a process innovation. Furthermore, the new online shop software may allow the firm to deliver its products to customers in a new way or to offer additional services, such as tracking orders online or getting immediate information about availability. This would be a service innovation. Both types of innovations (process and product/service) have clear economic implications. In micro-economic terms, a product innovation corresponds to the generation of a new production function (Kamien and Schwartz, 1982), which includes the possibility to differentiate an existing product (Beath et al., 1987; Shaked and Sutton, 1982; Vickers, 1986)[1]. A process innovation, on the other hand, can be viewed as an outward shift of an existing supply function, which corresponds to lower variable costs in the production of an existing product or service, and is therefore a productivity increase (Beath et al., 1995; Dasgupta and Stiglitz, 1980; Reinganum, 1981).

The payoffs of innovative activities in a firm are determined via a market process that involves not only the activities of the innovator, but also the reactions of customers and competitors. Thus, the payoffs of all actors in a market are interrelated. Economic theory suggests that, *ceteris paribus*, both the creation of a new supply function[2] and the outward shift of an existing supply function[3] can lead to higher output levels and thus revenue growth, although via different mechanisms. Thus, both product and process innovations can lead to growth of the innovator, independent of the firm's ability to appropriate private profits from the investment that caused the innovation (Götz, 1999; Hannan and McDowell, 1990; Reinganum, 1981; Sutton, 1991).

The relationship between innovation and profitability is more complex because it critically depends on the reaction of competing firms. The fundamental problem for the innovator is to protect its novel process or product from imitation by rivals. As soon as all competitors use the same (improved) process and produce the same product, no single firm in the market will be able to outperform its rivals, including the firm that first brought the innovation to the market (Teece, 1986, 2006). The quicker an innovation is copied by other firms, the less time each innovating firm has to reap additional payoffs from the investment in the innovation. This is known as the appropriability problem (Geroski, 1995). Thus, the timing of an innovation influences the expected payoff. The game-theoretic literature points out that firms that are able to outpace their direct competitors in technological development will capture market shares and profits from their rivals, possibly up to the degree that they drive their competitors out of business. However, profits from innovation are only sustainable until competitors are able to copy the innovation and all associated complementary assets completely. In addition, potential early mover advantages will be limited or even reversed if the technologies on which the innovations are based exhibit either falling prices or rapid technological improvements over time (Beath et al., 1995; Fudenberg and Tirole, 1985; Götz, 1999; Reinganum, 1981). Summarizing, economic theory predicts that successful innovators are more likely to grow and to survive in their markets. Various empirical studies are consistent with this message (Audretsch, 1995; Cefis and Marsili, 2003; Mansfield, 1968). They might also be able to capture excess profits, but this is contingent on the behavior of rivals and on other exogenous factors that are beyond the control of the innovator (Geroski et al., 1993; Stoneman and Kwon, 1996).

Various empirical studies also show that innovating firms fail to obtain competitive advantages from an innovation, while customers, imitators, and other industry participants benefit (Levin et al., 1987; Teece, 1986). To circumvent this problem, firms typically try to appropriate private returns from innovation using a wide range of mechanisms, including patents, secrecy, lead time advantages, and the use of complementary capabilities (Cohen et al., 2000). Methods of appropriability vary markedly across and within industries, and not all methods work well in all cases (Harabi, 1994; Levin et al., 1987; Teece, 1986).

A different vein of the literature analyzes the firm-level impacts of investments in new technologies, often without linking such investments explicitly to innovation. The consequences of investments into IT have especially been subject to an intense debate among scholars because not all studies have demonstrated clear payoffs from IT (Brynjolfsson and Hitt, 1996, 2000, 2003; Hitt and Brynjolfsson, 1996; Carr, 2003; Chan, 2000; Kohli and Devaraj, 2003).

A particular advantage of seeing the adoption of new technologies as an enabler of innovation is that it allows us to identify the firm- and market-specific mechanisms that can lead to different consequences for firms that invested

[1] The products or services represented by these production functions may be substitutes from the consumer's perspective and/or they may vary in quality. Thus, a new production function does not necessarily reflect a radical innovation.

[2] Assuming the new good or service is not a close substitute to other goods or services offered by the firm.

[3] Assuming the price elasticity of demand is large enough.