Research Policy 41 (2012) 401–413

Contents lists available at SciVerse ScienceDirect

Research Policy

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

Production technologies and financial performance: The effect of uneven diffusion among competitors

Lucio Fuentelsaz[a,1], Jaime Gómez[a,1], Sergio Palomas[b,*]

[a] Research Group Generés, Marketing and Strategy, Universidad de Zaragoza, Gran Vía 2, 50005 Zaragoza, Spain
[b] Research Group Generés, Marketing and Strategy, Universidad de Zaragoza, María de Luna 3 (Edificio Betancourt), 50018 Zaragoza, Spain

ARTICLE INFO

Article history:
Received 9 June 2010
Received in revised form 30 August 2011
Accepted 13 September 2011
Available online 11 October 2011

Keywords:
ATM
Diffusion
Profitability
Relative use
Technology

ABSTRACT

We explore the impact of a production technology on financial performance from the perspectives of technology diffusion and competitive strategy theory. We analyse how diffusion at firm and market levels influences the returns from the technology. We suggest that firm heterogeneity in the level of technology use leads to competitive advantages for relatively intensive adopters. We empirically test our propositions through the analysis of the diffusion of the Automated Teller Machine among Spanish savings banks between 1986 and 2004. Our results show that it is not the absolute but the relative level of use that drives the impact of the technology on profitability. Furthermore, as the technology is more intensively deployed in the market, the profitability of every firm decreases. Interestingly, in our empirical setting, this negative effect eventually leads to an aggregate negative impact on the profitability of the savings banks.

1. Introduction

The management of new technologies is receiving increasing attention in strategic management research (Greve, 2009). The frequent introduction of new technologies, their ever shortening lifecycles and their fast rates of diffusion have redefined the characteristics and boundaries of many industries, posing complex challenges to the firm (Bettis and Hitt, 1995). The ease with which imitation occurs plays a critical role in the determination of the rents that a firm is able to capture from a new technology. One of the consequences of the diffusion of a new technology among the firms operating in an industry is a competitive process which alters the price of goods and services and the remuneration of productive factors (Schumpeter, 1934; Teece, 1986). This process results in the dissipation of the economic rents that might otherwise have accrued to the innovator.

The importance of imitation for the appropriation of the value of an innovation is clear in information technologies (IT). Adopting firms usually have to learn to live with the wide diffusion of these technologies, which should dissipate any potential competitive advantage (Carr, 2003). As a result, these technologies have been described as *strategic necessities*: their impact on performance makes their adoption a necessary condition for any firm to stay in business, but their wide availability reduces their capability to generate above-normal profits (Clemons and Kimbrough, 1986; Clemons and Row, 1991). Given the importance of imitation in this context, this article focuses on an IT application to investigate how competitive imitation conditions the impact of a new production technology on firm profitability.

Researchers on the impact of technological innovations on financial performance have explored several sources of economic rents for adopters apart from the adoption in itself. Among them, we can highlight the control of complementary resources and capabilities (Aral and Weill, 2007; Powell and Dent-Micallef, 1997; Schroeder et al., 2002), the degree of fit between the technology and the strategy of the firm (Chan and Reich, 2007; Chari et al., 2008; Henderson and Venkatraman, 1993; Oh and Pinsonneault, 2007), the importance of innovative capabilities that lead to a continuous flow of innovations (Damanpour et al., 2009; Roberts, 1999; Roberts and Amit, 2003) and the timing of adoption (Dos Santos and Peffers, 1995; Hoppe, 2000). These research streams share the idea that imitability plays a critical role. However, empirical analyses of how the imitation process by itself determines the capability of adopters to profit from their innovations are scarce.

To explore the effect of competitive imitation, we focus on two features of the technology diffusion process. Firstly, it leads to persistent levels of heterogeneity among the firms that populate an industry. Internal deployment differs from adopter to adopter in its intensity and temporal profile (Battisti et al., 2009; Battisti and Stoneman, 2003, 2005; Fuentelsaz et al., 2003; Mansfield, 1963b).

* Corresponding author. Tel.: +34 976 761000; fax: +34 976 761767.
E-mail addresses: lfuente@unizar.es (L. Fuentelsaz), jaime.gomez@unizar.es (J. Gómez), spalomas@unizar.es (S. Palomas).
[1] Tel.: +34 976 761000; fax: +34 976 761767.

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doi:10.1016/j.respol.2011.09.006

Differences in level of use may allow some firms to improve their competitive position in relation to their rivals.[2] Secondly, as a result of the growing intensity with which every firm uses the technology, it becomes more and more intensively deployed in the industry (Battisti and Stoneman, 2003; Karshenas and Stoneman, 1995). The increase in the industry-wide diffusion affects the potential rents that accrue to adopters (Schumpeter, 1934; Teece, 1986). Therefore, the observation of the imitation (diffusion) process of the technology can shed light on the pattern of rent generation and dissipation.

Given that the concept of competitive advantage emphasizes a firm's relative position (Porter, 1985, 1991), in this research, we will focus on the differences in the level of use between firms. Our framework attributes a limited importance to the *absolute* level of use of the technology and changes its focus towards the *relative* level of use of the focal firm compared to its direct competitors. We also analyse how the diffusion process at the market level influences profitability over time through its impact on the attractiveness of the industry.

We study the impact of technology on financial performance in the context of the diffusion of the Automated Teller Machine (ATM) among Spanish savings banks. This classical IT application has frequently been defined as a strategic necessity in the banking sector (Banker and Kauffman, 1988; Clemons, 1991; Clemons and Row, 1991). Previous research suggests that late and non-adopters found themselves at a competitive disadvantage (Banker and Kauffman, 1988; Clemons, 1991; Clemons and Row, 1991; Dos Santos and Peffers, 1995; Hannan and McDowell, 1990). In the Spanish case, this technology was adopted by all the savings banks within a relatively short period of time, questioning its capability to generate competitive advantages. Our sample allows us to analyse the impact of the ATM almost from its inception to its consolidation as a basic IT in retail banking. Interestingly, our data not only allows us to observe the time of first adoption, but also the intensity with which the technology has been internally diffused by each firm.

2. Technology diffusion and competitive advantage

Research on the impact of IT has concluded that these technologies give adopters several benefits, such as increased labour and administrative productivity, higher flexibility and improved cost efficiency (Clemons and Row, 1991; Hitt and Brynjolfsson, 1996; Oh and Pinsonneault, 2007; Rai et al., 1997). However, these benefits do not seem to be easily translated into abnormal economic rents (see, for instance, Hitt and Brynjolfsson, 1996; Rai et al., 1997). The explanation for this apparent contradiction is that the high imitability of IT usually precludes them from generating competitive advantages. In other words, any potential advantages stemming from IT adoption would be competed away as soon as other firms adopt the new technology, leading to a situation of competitive parity. However, any firm that decides not to adopt the technology will find itself at a competitive disadvantage, which threatens its existence. This is what has come to be called the *strategic necessity hypothesis* (Clemons and Kimbrough, 1986; Clemons and Row, 1991). The conclusions of this hypothesis can be summarized in two points: (i) firms failing to adopt the technology will experience a reduction in their competitiveness and have less-than-normal returns; (ii) the only reward that adopters can expect is competitive parity, given that this is a non-scarce (and non-inimitable) resource.

This hypothesis is based on the commodity character of IT and its low acquisition and adjustment costs (Carr, 2003; Mata et al., 1995). However, the hypothesis may result in an unnecessarily restrictive perspective of the diffusion process. Contrary to the assumption of fast and homogeneous adoption that is implicitly maintained in the strategic necessity hypothesis, the diffusion process can be complex. Research on technology diffusion has shown that, even when a technology is valuable and readily available, its adoption by different organizations takes a long time to occur (Battisti and Stoneman, 2003; Greve, 2009; Griliches, 1957; Mansfield, 1961, 1963a; Rogers, 1983) and every adopter also requires long periods to completely incorporate it into its productive process (Battisti and Stoneman, 2005; Fuentelsaz et al., 2003; Mansfield, 1963b). Factors such as the lack of complementary assets or technologies, incompatibility with the strategy or the activities carried out by the firm, the presence of substitute technologies, and differences in financial resources can prevent some firms from exploiting a technology as successfully as others, creating persistent differences in their level of use (Battisti et al., 2009; Battisti and Iona, 2009; Battisti and Stoneman, 2005; Fuentelsaz et al., 2003; Hollenstein and Woerter, 2008; Mansfield, 1963b).

Technological diffusion research shows that diffusion deviates systematically from the ideal scenario of perfect and immediate imitation. Some firms deploy the technology in ways that their rivals seem unable to emulate. Thus, new technologies may be capable of generating firm heterogeneity even when they are widely available in the market. Therefore, to explore whether the diffusion process actually results in the dissipation of superior economic rents or whether, in contrast, differences in intrafirm diffusion are persistent enough to allow for the existence of durable competitive advantages is a valuable task that may complement other perspectives. With these ideas in mind, we argue that the study of the diffusion process of a technology can reveal important information for the explanation of performance differences between firms.

Our framework is borrowed from competitive strategy theory, which states that the success of a firm depends on the *attractiveness* of the industry and on the *relative position* the firm has vis-à-vis its rivals (Porter, 1980, 1991). The concept of *industry attractiveness* includes factors that affect all the firms that compete in the industry. Consequently, it is not useful for explaining intra-industry performance differences. *Relative position* depends on the total cost and the value added by the activities that the firm implements, in comparison to the value added and cost incurred by the other firms operating in the market (Porter, 1991, 1996). The key point of the competitive strategy framework is that the competitive value of any decision made by a firm has to be evaluated in relation to its direct competitors. Therefore, we will focus on the concept of *relative position* and how it can be used to explain competitive advantages stemming from IT-based production technologies. Additionally, to obtain a fuller picture of the result of competitive imitation, we discuss how the diffusion process at the market level affects the profitability of both adopters and non-adopters.

2.1. IT adoption and competitive advantage

In the first years of IT research, there were different positions regarding the potential of IT to provide competitive advantages and superior financial performance. Early case studies characterized IT as groundbreaking technologies which would redefine the basis of modern competition in favour of intensive users (Clemons, 1986; McFarlan, 1984; Parsons, 1983; Porter and Millar, 1985). In this first stage, discussion on the impact of IT on financial performance mostly consisted of conceptual frameworks to assist managers in the introduction of ITs, and empirical evidence was mostly based on selected case studies of successful IT implementation (Powell and

[2] By level of use we mean the intensity with which the technology has been incorporated into the productive process, which has been termed *intrafirm diffusion* in technology diffusion research (Battisti and Stoneman, 2003; Mansfield, 1963b). Therefore, level of use means "amount of technology deployed per activity unit".