



Interdependences in the intrafirm diffusion of technological innovations: Confronting the rational and social accounts of diffusion



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ABSTRACT

This article investigates the intrafirm diffusion of technological innovations, and the interdependences that exist among rival firms in this process. Previous research has offered two potential explanations for these interdependences: social accounts, in which they result from institutional pressures, and rational accounts, in which firms are interdependent as a result of how adoption by rivals affects expectations about the profitability of the technology. The article offers two contributions. First, we propose a competitive interaction mechanism that is consistent with the fundamentals of rational accounts of diffusion. Second, the empirical analysis shows the dominance of the proposed rational mechanism over social accounts of innovation diffusion in the generation of interdependences in the process of intrafirm diffusion.

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1. Introduction

The adoption of some innovations implies their deployment across an entire organisation as a unitary block. For instance, large scale production technologies, such as the integrated mill in the steel industry or serial production facilities in the automotive industry, are normally incorporated entirely at the same time. However, when innovations are divisible, the adopting organisation becomes immersed in long transition periods in which the innovation is progressively incorporated into the activities of the firm. This process is referred to as ‘intrafirm diffusion’ (Battisti and Stoneman, 2003; Mansfield, 1963). The existence of an intrafirm diffusion process has been documented in contexts as diverse as the diffusion of diesel locomotives (Mansfield, 1963), optical scanners (Levin et al., 1992), electronic mail systems (Astebro, 1995), automated teller machines (Fuentelsaz et al., 2003), flexible production systems (Battisti and Stoneman, 2005) and e-business activities (Battisti et al., 2009). The objective of this paper is to analyse the process by which innovations are progressively incorporated into the productive activities of the adopting organisation.

To analyse intrafirm diffusion, we borrow from the two main perspectives on innovation diffusion: *rational accounts* and *social accounts* (Ansari et al., 2010; Strang and Macy, 2001). Rational accounts portray firms as profit-maximising rational actors that decide on the adoption (or not) of innovations according to their expected value. Social accounts, in contrast, state that firms adopt innovations in an attempt to gain legitimacy through conformity to social expectations. Both perspectives consider that, among many other factors, interdependences among firms are at the core of the diffusion process because the incentive to adopt an innovation is influenced by its adoption by other firms that operate in the industry.¹ However, these accounts differ with respect to the mechanisms by which these interdependences arise. In this article, we explore interdependences in the intrafirm diffusion process from both perspectives.

One of the main difficulties of this endeavour is that the conditions under which intrafirm diffusion develops makes the applicability of certain rational accounts of diffusion doubtful. Early rational accounts of diffusion relied on the spread of information about innovations (Mansfield, 1961). As a firm observes adoption

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¹ It is not our intention to state that interdependence fully explains the diffusion of innovations. Instead, there are a number of additional factors whose influence has been found to be critical, such as compliance with norms and regulations, co-innovation with suppliers and customers, and the development of other technologies.

by other firms, it updates its expectations about the value of the innovation, which influences its propensity to adopt (Ansari et al., 2010). However, in the post-adoption intrafirm diffusion process, the firm has the opportunity to learn about the value of the technology and its operation through its continued use (Attewell, 1992; Fichman and Kemerer, 1999). As a result, external sources of information become less relevant (Simon and Lieberman, 2010). This peculiarity casts doubts on the applicability of information-based rational accounts of diffusion.

To solve this problem, we analyse how interdependences may still be justified through a rational account based on the maximisation of expected profits. However, we argue that interdependences in the maximisation of profits are due to the competitive interdependences that exist among the firms that operate in the industry. The expectations of a firm about the potential returns from a technological innovation are influenced by the adoption behaviour of its rivals. On the one hand, when rivals innovate, increasing their performance in any productive dimension, the firm feels competitive pressure to innovate as well to avoid losses (Leibenstein, 1976; Mookherjee and Ray, 1991). This is what we will refer to as the *competitive pressure effect*. On the other hand, the diffusion of a technology increases the availability of its products and services to customers. This increases competition to capture the economic rents associated with the technology, reducing the expected profitability and the incentive to adopt (Karshenas and Stoneman, 1993; Schumpeter, 1934; Teece, 1986). We refer to this second effect as the *saturation effect*.

Apart from identifying and testing these two rational account mechanisms, we also test alternative explanations based on social accounts of the diffusion process. We propose two sets of hypotheses about how the diffusion of a technology generates interdependences in the intrafirm diffusion process of the firms that operate in an industry. One set is consistent with our proposed rational account mechanism and the other is consistent with social accounts of diffusion. As the two accounts offer conflicting predictions under certain conditions, we can empirically test which of the accounts better explains the intrafirm diffusion process of technological innovations.

The empirical setting for our analyses is the diffusion of the Automated Teller Machine (ATM) in the Spanish savings banks sector. This is a divisible, externally sourced technology available to any savings bank. This fact, together with the critical impact of the ATM on retail banking, resulted in a fast interfirm diffusion process in which every savings bank adopted its first ATM terminal within a relatively short period of time. The intrafirm diffusion process, in contrast, continued for decades and led to varying and heterogeneous degrees of technology adoption. Our sample describes 19 years of this process, allowing the observation of a long history of competitive interdependence and technology deployment.

The article is structured as follows. Section 2 begins with a brief summary of previous accounts of diffusion, followed by an explanation of how information-based rational accounts may have critical limitations in the context of intrafirm diffusion and the outline of a rational account based on competitive interaction. Section 3 describes hypotheses from this alternative rational viewpoint and from a conventional social perspective. Section 4 describes the empirical analyses. Section 5 discusses the results. Section 6 concludes the article with a discussion of the main findings.

2. Theoretical background

2.1. Rational and social accounts of diffusion

Current research into the diffusion of innovations is dominated by two different conceptions of the process: *rational accounts* and

social accounts (Ansari et al., 2010; Kennedy and Fiss, 2009; Strang and Macy, 2001). In *rational accounts*, firms are depicted as profit-maximising rational actors in search of efficient innovations. Firms decide on the adoption of an innovation depending on its expected returns. *Social accounts* focus on the social embeddedness of firms. Models consistent with this perspective consider that adoption is primarily driven by the desire to conform to social expectations. Consequently, the key difference between the rational and social accounts is that the former emphasises efficiency and the substantive value of the innovation while the latter focuses on its symbolic value.

From both perspectives, the adoption decision is interdependent for the firms that operate in an industry. In rational accounts, interdependence arises through two different mechanisms. In the first of them, in the presence of uncertainty about a new technology or practice, firms infer its potential value after the observation of other organisations that have adopted the innovation (Abrahamson, 1991; Greve, 2009). As the number of adopters increases, firms update their expectations (upwards or downwards) about the value of an innovation (Ansari et al., 2010; Terlaak and King, 2007). Accordingly, the incentive to adopt is influenced by the number of previous adopters as this determines the exposure of prospective adopters to information and the intensity and credibility of the signal received about the value of the innovation (Abrahamson and Rosenkopf, 1993; Bikhchandani et al., 1998). Therefore, in information-based rational accounts, firms are interdependent in their adoption decisions because of the effects of information-revealing bandwagons (Abrahamson and Rosenkopf, 1993; Terlaak and King, 2007).

The second mechanism by which interdependences arise in rational accounts of diffusion is through the effect of the adoption by rivals, which changes the actual value that the prospective adopter can obtain from the technology. Two opposite theories have been proposed to explain interdependences in an interfirm diffusion setting². On the one hand, stock models argue that, as rivals adopt a technology, the potential rents than can be obtained decrease. Thus, as a technology becomes widely diffused, the incentive to adopt it decreases because of the lower expected profitability from the technology. On the other hand, order models argue that adoption by rivals reduces the profits obtainable in the absence of the new technology because rivals may offer a better service or offer it at a lower cost, attracting customers away from the firms that do not adopt. As a result, adoption by rivals may also increase the incentives to adopt the technology (see Geroski, 2000 and Karshenas and Stoneman, 1993 for a detailed discussion of these models). The two models acknowledge that the adoption behaviour of firms is interdependent, although there are divergences about the expected effect that rival precedence has on the propensity of the focal firm to adopt.

In social accounts, interdependences stem from the effect that the diffusion of a technology has on its legitimacy. When an innovation is widely diffused, it becomes taken for granted by constituents, stakeholders and other influential organisations,

² There is a third widely acknowledged type of diffusion model based on profit maximization, referred to as rank or probit models (for a summary see Geroski, 2000, and Karshenas and Stoneman, 1993). In these models certain characteristics of firms determine adoption timing of a technology. These characteristics are distributed across the population of potential adopters following a normal distribution. The minimum value required in this characteristic to adopt the technology decreases over time. As a result, firms progressively adopt the technology, resulting in the conventional s-shaped diffusion pattern. We do not discuss these models explicitly in this article because they do not consider interdependences among firms in their adoption behaviour, and consequently are not related to the research question of this article. Note, however, that in our modelling we control for several relevant firm level effects, which are consistent with rank models.

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