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Mapping the benefits and costs associated with process innovation: The case of RFID adoption

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ABSTRACT

The successful implementation of any innovation requires an understanding of its benefits and costs. This study examines the changes in the magnitude of costs and benefits associated with technology process innovation adoption as the innovation diffuses across different industries. Using RFID as an exemplar technology, the study shows that the magnitude of benefits and costs associated with technological process innovation adoption within different industries varies as technology diffuses beyond early adopters to the early majority. During the early stages of technology evolution, the development cost, the cost of capital, ethical costs and simple direct implementation costs (in the form of the cost of tags) predominate. As a dominant design emerges the profile of costs changes with the emphasis on initiation costs, more holistic direct implementation costs and indirect implementation costs. A similar change in the emphasis of benefits is observed, with a shift from direct to indirect benefits being noticeable as the technology moves from early adopters to early majority adopters. Our findings help to explain the difficulties in consistently measuring innovation outcomes observed in the innovation implementation literature, and emphasize the need to take into consideration the stage of technology development as a significant factor that influences the realised outcomes from innovation implementation.

1. Introduction

The benefits and costs associated with the organizational adoption of technology innovation in general, and technology process innovation in particular, have been widely covered in the innovation literature. For example a wealth of research has considered the benefits (Chwelos et al., 2001; Cunningham and Tynan, 1993; Iacovou et al., 1995; Subramani, 2004) and, to a more limited extent, the costs (Premkumar et al., 1994; Zhu et al., 2006) associated with the adoption of information technology (IT) innovation in organizations, one of the most researched forms of process innovation (Tidd et al., 2005). Longitudinal studies of technology diffusion have also identified the role of innovation outcomes (in particular benefits and cost) in shaping technology diffusion. For example, Attewell (1992) notes the role that the cost of equipment plays in shaping the adoption of business computing.

The adoption of innovation in organizations can be seen as a stage process involving the *generation* of an innovative idea, the *acceptance* of that innovation represented by an organizational mandate to change and its *implementation* so that the innovation becomes ingrained within the organization (Bunduchi and Smart, 2010; Thompson, 1965). Existing literature has examined the benefits and costs associated with innovation adoption either as antecedents of the decision to accept and/or to implement an innovation (e.g. Chwelos et al., 2001; Premkumar et al., 1994) or, less often, as the outcomes of successful or not so successful acceptance and/or implementation (e.g. Klein and Sorra, 1996; Meyers et al., 1999). One strand of literature – adoption studies – has focused on users' expectations of a particular innovation and the role that these expectations play in driving innovation adoption, concentrating particularly on the acceptance of innovations within an organization. A second strand – implementation studies – has emphasized the realised outcomes of innovation acceptance and implementation, and in particular the relationship between implementation success and innovation outcomes. While adoption studies have identified different types of anticipated benefits and, to lesser extent, anticipated costs (see Bunduchi and Smart, 2010), implementation studies have generally been vague in identifying the nature of innovation outcomes, and have instead highlighted the difficulty of assessing the precise nature of innovation benefits (Linton, 2002). Implementation literature has also recognized that the realization of these benefits is dependent upon the "success" of innovation implementation (Klein and Sorra, 1996). These observations illustrate

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Weick's comment that *"we typically do a fine grained analysis to isolate separate causes but then do a coarse grained analysis when we examine effects"* (1974, p. 366). Meyer and Goes (1988) also observed that the antecedents of innovation adoption, such as expected outcomes, were carefully identified and isolated in the literature, while realised outcomes were generally lumped together and treated as a single effect of implementation.

Drawing from the categories of benefits and costs identified in the adoption literature, our study contributes to the implementation literature by examining (1) the realised benefits and costs associated with the adoption of innovations and (2) whether these innovation outcomes vary depending on the stage of technology development. This dynamic approach to the benefits and costs associated with innovation adoption over time is rare in the literature which, by and large, has examined these variables only at one particular point in time. This snapshot approach to examine innovation outcomes has been helpful in assessing the impact that benefits and costs have on the decision to adopt/accept a particular innovation at a particular point in time (adoption studies), and on what constitutes innovation (implementation) success. However, research to date has not attempted to examine how the magnitude of the different constituents of the benefit and cost variables changes with time. We propose that the changing magnitude of the benefits and costs associated with technology adoption represents one reason why, as Linton (2002) notes, implementation research to date has had difficulty in consistently measuring innovation implementation outcomes. For example, the costs and benefits associated with the implementation of an emergent technology in the early stages of its development may be very different from the cost and benefits incurred by organizations that implement the same technology once it has matured and become established within an industry.

This paper focuses on one particular type of innovation: technological process innovation. Process innovations are new ways of producing and/or delivering goods and services (Edquist et al., 2001; OECD, 2001; Tidd et al., 2005) and can be divided into two broad categories: technological and organizational process innovations. The term "technological process innovation" refers to new products (such as new information systems) that are used in the production process, while "organizational process innovations" (such as new management accounting methods) are new ways of organizing business activities (Edquist et al., 2001). However, in practice the distinction between technology and organizational process innovations if often blurred, as the introduction of many new technologies is accompanied by changes in the organization of business activities (Reichstein and Salter, 2006).

While the vast majority of technology process innovation adoption studies focus on firm level adoption (e.g. the adoption of e-business by European firms (Zhu et al., 2006)) or individual level adoption (e.g. the adoption of e-mail by employees (Davis, 1989)), we consider adoption at the level of the industry. In doing so, we draw upon longitudinal studies of technology development that have shown how radical new technologies often emerge in market niches or industry sectors. These niches/sectors act as incubators of a technology in the early stages of its development (van den Ende and Kemp, 1999); the technology then diffuses gradually to other sectors (Geels, 2002). For example, the Internet was first developed for military use in the 1950s, diffused to academic settings in the 1970s and found broad commercial use only in the 1990s. By considering the industry, rather than the firm, as the principal unit of analysis we also aim to address a shortcoming of existing adoption literature, which overemphasizes individuals and/or organizations as the locus of adoption, ignoring the fact that individual industries can move to adopt particular technologies at different stages in the technology life-cycle. For example, research on IT diffusion has shown that whole industries acted as early adopters, while other industries were laggards due to variations in industry level information processing requirements (Melville and Ramirez, 2008). In a comprehensive review of IT diffusion research, Fichman (1992) argues that although most diffusion research focuses at the individual and organizational level, *"the adoption of IT by other aggregates (small groups, industries) is certainly possible and well-worth of future study"* (p. 8). Consequently, existing literature supports the need for research to also consider the industry rather than simply the organization or individual as the locus of innovation adoption.

We use RFID technology as an exemplar technology and assess the benefits and costs associated with RFID adoption as the innovation is implemented by an early majority of users (exemplified by healthcare industry), and compare these with existing results assessing the benefits (Curtin et al., 2007; Hellstrom, 2009; Jones et al., 2005; Lee and Ozer, 2007; Sharma and Citurs, 2005) and costs (Hellstrom, 2009; Sharma and Citurs, 2005; Smart et al., 2010) associated with RFID adoption by early adopters (exemplified by the retail and automotive industries).

This paper comprises six sections. Section 2 examines previous literature investigating the technology life cycle, and the benefits and costs associated with innovation. The last part of Section 2 examines the evolution of RFID and reviews existing studies considering the costs and benefits associated with RFID adoption by early adopters. The research design is discussed in Section 3. The analysis of the interview data on RFID adoption by the early majority of users is discussed in Section 4. Section 5 compares the findings from RFID adoption by early majority with the findings in existing literature considering the adoption of RFID by early adopters. Section 6 discusses the implications of these findings and concludes the paper.

2. Literature review

The study builds on literature from three main areas: technology innovation life-cycle, the costs and benefits of innovation adoption and RFID adoption. Each of these literatures is considered in turn in this section.

2.1. Technology innovation life-cycle

One of the most pervasive theories of technology innovation is the diffusion of innovation theory, which proposes that technology adoption follows an *S*-curve: diffusion rates start slowly, rise and then fall over time, leading to a period of fast adoption squeezed in between an early period of slow take-up and a later period of saturation, until the technology is replaced (Rogers, 1995). Research has refined the diffusion of innovation model by clearly distinguishing three separate stages during technology development and diffusion (Utterback and Abernathy, 1975). For example, the dominant design model (Anderson and Tushman, 1990) argues that technology innovation passes through an era of ferment, followed by the emergence of a dominant design that stabilizes the innovation, and concluding with a stage of incremental innovation when efforts are focused on refining the dominant design. Different types of users, characterized by different attributes, tend to become involved at different stages of technology evolution. Rogers (1995) distinguished between five categories of users: lead users, early adopters, early majority, late majority and laggards. Lead users and early adopters tend to become involved in innovation during the early stages of evolution, when the take-up is generally slow. The majority of users adopt an innovation only once the dominant design has emerged. Late adopters delay even longer, and consider adoption only after