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ABSTRACT

Organizations deal with complex information systems innovations such as enterprise resource planning systems to enable and support their operations. While there is considerable research on organizations' adoption, implementation, and use of such complex information systems, prior literature has not dwelt as much on the diffusion or the spread of such complex information systems across a population of organizations. A limited number of studies have shown different information sources such as external, internal, and mixed influences to drive diffusion, and found variations in the diffusion patterns of different complex information systems. These findings, however, belong to different populations and do not account for organizational or technology characteristics that may be influential in diffusion. This study seeks to expand our understanding by examining the diffusion of several complex information systems within the same population of S&P-500 organizations between 1990 and 2008 by modeling different influence mechanisms and employing event-history analysis.

Keywords

Complex information systems, innovations, diffusion, influence models, event-history analyses.

INTRODUCTION

The study of complex information systems innovations has become increasingly important as organizations continue to make huge investments in information technologies such as enterprise resource planning (ERP) systems, supply chain management (SCM) systems, customer relationship management (CRM) systems, business-to-business (B2B) systems, and inter-organizational systems (IOS). While there is considerable knowledge of why organizations adopt complex information systems and ways in which they implement complex information systems, not much is known about how such information systems diffuse or spread across organizations in a population. This study seeks to address this gap in our knowledge by examining the diffusion of multiple complex information systems within the same population of organizations.

COMPLEX INFORMATION SYSTEMS INNOVATIONS

Information systems such ERP systems, SCM systems, CRM systems, B2B systems, and IOS may be considered as complex information systems innovations (e.g. Wang et al. 2008). Unlike information systems such as productivity tools (word processors, worksheets, etc.) or functional silo systems (payroll, front office, etc.) that impact specific users or functions within an organization, complex information systems typically cut across functional boundaries within an organization or even organizational boundaries.

As an example, consider the Microsoft Dynamics –GP ERP suite by Microsoft Corporation. It provides complete and scalable financial and operational functionalities for organizations to streamline their processes and make better decisions (Microsoft Corporation 2007). Microsoft Dynamics –GP is capable of supporting a variety of organizational activities such as financials (e.g. cash flow management, fixed assets management, general ledger, payables management, and receivables management), inventory and order processing (e.g. bill of materials, inventory control, invoicing, purchase order processing, and sales order processing), manufacturing (e.g. planning, production, and management), human resources and payroll, and project management. The suite also allows for audit trails, electronic signatures, and analytics.

Such complex information systems pose high knowledge barriers for adoption and use, require coordination across multiple users, take a long time for implementation, may not be exploited completely by users, and may entail the reengineering of existing business processes (Attewell 1992; Fichman and Kemerer 1999; Gallivan 2001). These complex information systems may be viewed as Type III innovations that integrate information systems products and services with core business technologies (Swanson 1994) or as enterprise information technologies (McAfee 2006).

Extant literature on complex information systems can be categorized into two broad research streams: adoption (discussed here) and diffusion (discussed in the next section). Adoption refers to the acceptance, implementation, and use of complex information systems by organizations. There has been considerable research on the adoption of complex information systems over the last 20 years. Prior studies have examined electronic data interchange (EDI) systems (e.g., Saunders and Clark 1992; Premkumar et al. 1997; Chwelos et al. 2001; Seyal et al. 2007), e-business (e.g., Chatterjee et al. 2001; Zhu et al. 2002), inter-organizational systems (e.g., Grover 1993; Henriksen 2006), ERP systems (e.g., Wang et al. 2008). The phenomena examined by such studies include intention to adopt, adoption, initiation, use, adaptation, assimilation, infusion, integration, and routinization (e.g., Chatterjee et al. 2001; Chwelos et al. 2001; Iacovou et al. 1995; Zhu et al. 2006). This research stream generally employed cross-sectional designs that were not amenable to understanding the diffusion of complex information systems over time.

DIFFUSION OF COMPLEX INFORMATION SYSTEMS INNOVATIONS

Diffusion refers to the spread of complex information systems across a population of organizations. Prior research has not engaged very much on the diffusion of complex information systems. There have been only a few studies that have examined the diffusion of information systems across organizations, of which some (e.g., Tam 1996; Tam and Hui 2001; Shao 1999; Florkowski and Olivas-Lujan 2006) have focused on non-complex information systems such as personal computers or specific applications while some (e.g., Teng et al. 2002; Loh and Venkatraman 1992; Hu et al. 1997; Fichman and Kemerer 1999) have focused on complex information systems such as EDI or outsourcing. The latter set of studies (that dealt with complex information systems and the focus of this study) have shed light on the spread of complex information systems across a population of organizations (e.g., Teng et al. 2002) or the gaps between the spread of the adoption and assimilation of complex information systems across a population (e.g. Fichman and Kemerer 1999). This research stream typically employed longitudinal designs which enabled the differentiation between early and late adopters of complex information systems (e.g. Rogers 1995).

Prior research on diffusion of complex information systems have employed different approaches and highlighted different aspects of the diffusion process over time. Several studies (e.g., Teng et al. 2002; Loh and Venkatraman 1992; Hu et al. 1997) have examined the information sources that impact diffusion: external or internal sources (Rogers 1995). External influence refers to situations in which all communication about complex information systems emanate from outside sources such as mass media (newspapers, magazines, etc.), consulting organizations, or vendor organizations. In other words, the organizations in the population do not communicate with each other regarding complex information systems. Internal influence, on the other hand, refers to situations in which all communication about complex information systems originate from organizations within the population. That is, organizations learn from each other about complex information systems. Studies have also examined mixed influence models, such as the Bass model (Bass 1969), that include both external and influence.

Some studies (e.g., Chang et al. 2008) have focused on the diffusion on a single complex information system where others (e.g., Teng et al. 2002) have focused on the diffusion of multiple complex information systems. Studies that examine a single information system typically shed light on the diffusion patterns and have the potential to also help understand how the characteristics of organizations in the population (e.g., organization size) can influence diffusion. Studies that examine multiple information systems are capable of providing insights on the above aspects but also provide nuanced understanding on how the characteristics of the technology (e.g., scope) may influence diffusion and have the potential to determine if the characteristics of the organizations in the population (e.g., experience) can influence diffusion.

Studies have also employed different ways of identifying the population of organizations and determining the diffusion patterns. Some studies (e.g., Teng et al. 2002) have used surveys of organizations to gather data on the information systems in organizations as well as the dates of adoption. Other studies (e.g., Loh and Venkatraman 1992) have relied on announcements regarding information systems available on the public domain. The organizations responding to the surveys or for which announcements are found are generally treated as the population for the study. Some studies (e.g., Fichman and Kemerer 1999) reviewed the profiles of the responding organizations and short-listed organizations on certain criteria to be members of the population. Some studies (e.g., Teng et al. 2002) employed mathematical models (e.g., Bass, Gompertz) to examine the diffusion of complex information systems whereas others (e.g., Fichman and Kemerer 1999) employed survival analyses.

RESEARCH FRAMEWORK

Despite the foregoing, our knowledge of the diffusion of complex information systems is somewhat limited due to certain research approaches and designs as explained below.

First, prior research has examined diffusion of complex information systems in isolation. That is, individual studies have generally taken one complex information system and examined the diffusion pattern over time. [An exception to this general practice is Teng et al. (2002), which actually examined 19 information systems; however, only a few of the innovations examined (such as EDI and CASE) may be classified as complex information systems. Another exception is Fichman and Kemerer (1999), which examined three innovations, but only one complex information system.] Such studies rarely go beyond the S-shaped trajectory generally associated with diffusion (Bass 1969; Rogers 1995). [An exception to this restriction is Teng et al. (2002), which also examined the diffusion trajectories across innovations and provided some explanations of different clusters of innovations that exhibit similarities within cluster and differences across clusters; however, only a few of the innovations were really complex information systems. Similarly, Fichman and Kemerer (1999) also compared diffusion trajectories, but the major thrust of that study was on the gaps between adoption and deployment.]

Second, the findings of prior research are generally based on different populations of organizations. This is partly due to the isolated approaches above (which necessarily makes the populations different) and partly due to the empirical designs (which result in different populations based on responses to surveys or announcements made in the public domain). This provides some understanding of diffusion, such as, for instance, a comparison of diffusion trajectories for the various complex information systems, but does not provide additional insights, such as, for instance, a characterization of the organizations and their approaches to complex information systems.

This research seeks to expand our understanding on the diffusion of complex information systems innovations within a population of organizations by seeking answers to the following research questions: a) *What are the patterns of diffusion for the various complex information systems innovations?* and b) *What are the characteristics of the organizations in the population that influence the diffusion of complex information systems innovations?*

EMPIRICAL DESIGN

To address the two research questions outlined above, the following research designs and methods are employed in this empirical study. Multiple complex information systems innovations such as ERP, SCM, and B2B are included for analysis. A longitudinal design is used to model diffusion processes that unfold over time and to accommodate early and late adopters. Specifically, this study captures diffusion activity from 1990 through 2008. The population is kept constant by relying on the Standard & Poor's (S&P) 500 listings published every year. That is, the S&P-500 lists published in each year from 1990 through 2008 are used to identify the common population of those organizations that made to the S&P-500 list every year from 1990 through 2008.

The "year of adoption" data of each complex information system are gathered for each organization in the common population from secondary sources such as the company web sites, annual reports, white papers, newspapers, and magazines as well as databases such as *Lexis Nexis*. For each organization and for each innovation, the year of adoption is used to compute the "time taken to adopt the innovation" relative to the "year of inception" of the innovation (i.e., the year in which the innovation was initially available for adoption". The data on organizational characteristics (e.g., size, slack resources, competing sector, etc.) are obtained from the *Compustat* database. Data on prior experience with complex innovations is obtained by comparing the year of adoption data across various innovations for the same organization.

Data analyses will be conducted in several stages. First, the influence models (internal, external, and mixed as in Bass) will be used to map the diffusion trajectories of the diffusion of the various complex information systems across the common population. This analysis provides an understanding of whether or not mass (i.e. external to population) and/or interpersonal (i.e. internal to population) influences enable diffusion of complex innovations across organizations. Second, the common population will be split into different industry sectors (such as manufacturing) and the influence models applied for each industry sector for each complex innovation. This analysis yields an understanding of whether or not there exist differences in diffusion of complex information systems across different industry sectors. Finally, the "time to adoption" data will be used to conduct a survival (i.e., event-history) analysis with various independent variables involving organizational characteristics (e.g., size, slack resources, competing sector, and prior experience with complex information systems). This analysis will provide an understanding of the various enablers of complex innovations across organizations.

POTENTIAL CONTRIBUTIONS

This study has the potential to make several contributions for research and practice. First, this study yields insights into the diffusion of complex information systems across a population of organizations, which remains a somewhat understudied area of research. This study also provides an understanding of whether or not there are differences between different clusters of homogeneous (such as manufacturing and service) organizations. Finally, this study informs on the various antecedents, including characteristics of organizations within the population such as size, slack resources, competing sector, and prior

experience with complex information systems, of the diffusion of complex information systems across organizations. The findings of this study will be useful for organizations as they contemplate the adoption of complex information systems for their operations.

This is a research-in-progress study. The identification of the common population of organizations from the S&P-500 lists from 1990 through 2008 is now complete. The common population comprises 200+ organizations. The data for adoption of the various complex information systems is currently in progress. The preliminary results of the various data analyses will be presented at the conference.

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