Factors Affecting the Adoption of Open Systems: An Exploratory Study

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Abstract

Advocates of open systems believe that problems related to compatibility, interoperability, scalability, and efficient use of IT resources can be resolved by setting software and hardware standards and strictly adhering to these standards in systems development and management. Representing a major departure from the traditional way of running an IS operation, the adoption of open systems has major ramifications on the IT infrastructure with long-lasting effects. Unfortunately, little research has been done to study this ubiquitous phenomenon despite its impacts on organizational computing worldwide. To fill this research gap, a model that incorporates seven factors perceived to affect the adoption is developed and tested. In-depth interviews with senior executives responsible for managing corporate IS functions from 89 organizations were conducted to collect data for empirical analysis. The findings suggest that organizations tend to (1) focus more on their “ability to adopt” than on the “benefits from adoption,” and (2) take a “reactive” rather than “proactive” attitude in adopting open systems technology. Managerial implications are also discussed.

Keywords: Information systems infrastructure, technology diffusion, open systems, IT adoption

ISRL Categories: AI0106, DD05, EG, EL05

Introduction

The adoption of open systems in organizational computing represents a major paradigm shift in information systems development and management. The locus of this pervasive development is the increasing attention focused on standard compliance. By establishing and strictly adhering to hardware and software standards, IS resources can be allocated more effectively. Adopting an open system, however, has significant ramifications on the IS infrastructure. For example, mainframe-oriented central processing will be replaced by a network of servers and workstations running in a distributed mode. Such a change not only affects the technical aspect of an IT infrastructure but also requires a redesign of the its administrative procedures and operation mechanism.

Considerations involved in the decision to adopt open systems have been widely publicized. However, it is still unclear whether common perceptions and publicized facts about open systems have any impact on their actual...
Adoption of Open Systems

adoption. Given the importance of the topic, it is surprising that little research has been done in this area. Porra (1993) concludes that "interest of the academic community in open systems is nonexistent" after finding that no articles on the subject have been published in major IS journals from 1989 to 1992. In sharp contrast, more than a thousand articles have appeared in trade magazines and periodicals during the same period. There is a gap between development in IS research and the observed changes in the fundamentals of corporate computing brought about by open systems in recent years. This study attempts to fill this gap. In particular, the study focuses on identifying factors that affect actual adoption of open systems. In terms of its contribution to IS research, the current work supplements previous innovation studies by providing new insights on organizational adoption of complex technological innovations that affect all facets of a corporate IS infrastructure. Findings of this study are also relevant to practitioners in discriminating vendors' "sales pitches" from the actual benefits of open systems and in complementing widely publicized success stories with concerns and problems that confront IS managers.

The organization of the paper is as follows. The following section discusses open systems from an innovation perspective. Next, the theoretical framework proposed by Tornatzky and Fleischer (1990) on studying the adoption of technological innovation is described. A research model derived from this general framework is then presented, followed by the research method, data analysis and results. The paper concludes with discussions of research findings and contributions of the study from both the research and managerial perspectives.

Adoption of Open Systems: An Innovation Perspective

According to X/Open, a standard-setting body for open systems, open systems can be defined as "computers and communications environments based on de facto and formal interface standards." De facto standards originate from popular hardware/software products which have established a considerable market share. These standards are proprietary in nature in the sense that they are developed, introduced and maintained by vendors. Well known examples include Microsoft's Window for PC operating systems and Excel for spreadsheet products.

Formal standards are published by standards setting groups including (1) traditional standard setting bodies such as the International Standard Organization (ISO) and the Institute of Electrical and Electronics Engineers (IEEE), (2) vendor consortia such as the Open Software Foundation (OSF) and UNIX International Incorporated (UI), and (3) user groups such as Open User Recommended Solutions (OURS). The National Microcomputer Manager Association (NMMA). A major source of formal standards is the body of existing de facto standards. Without any formal definition, the continuous development of de facto standard products and other hardware/software that need to interface with them may be hindered. For example, the diffusion of UNIX from scientific and engineering environments into mainstream corporate computing has fueled the establishment of many bodies such as the POSIX 1003.1 Group to establish standards for the operating system and its interface.

The definition suggests that open systems represent a novel approach to implement a suite of interface standards between system software/hardware, applications, and communications systems whose purpose is to enhance compatibility, interoperability, scalability, and flexibility of the IT infrastructure. Unlike other technological artifacts studied in previous IS research which have a specific application, the scope of an open system is wide, affecting every component of an IS infrastructure. Yet, the innovation is primarily of a technical nature and is transparent to the users. This type of innovation is viewed as IS technological process innovation (Type Ib) (Swanson 1994). Type Ib innovations are those that are (1) process innovations restricted to the functional
IS core and (2) centered on the technical IS task itself. Thus, the migration from a proprietary system to an open environment is transparent to the business processes being supported. Although the adoption of open systems may lead to changes in the routines used by the IS or other business units to deal with tasks of internal and external alignments, the effects are of a "weak-order." "They may support but they do not compel innovation elsewhere" (Swanson 1994, p.1077).

As pointed out by Swanson, current innovation theories explain little about IT innovation. Many of the IT innovation studies so far are either application-specific (e.g., MRP (Cooper and Zmud 1990), ATM (Hannan and McDowell 1984), scanner (Sinkula 1991), EDI (O'Callaghan, et al. 1992)) or related to end-user computing (e.g., spreadsheet (Brancheau and Wetherbe 1990), personal computer (Breitschneider and Wittmer 1993; Lind et al. 1989), laptop (Gatignon and Robertson 1989)). Little has been done to study the adoption of IT innovations that affect the entire organizational computing structure. One possible exception is the study on the role of organizational context in CASE innovation (Rai and Howard 1993). Also classifiable as a Type Ia innovation, CASE technology can be recognized as a potential means to enhance productivity and performance by redefining the software development process. In that study, four important dimensions of organizational context for an information system department (ISD) are proposed, namely organizational structure, management process, management support, and the nature of corporate systems. Based on these dimensions, a model of factors affecting CASE penetration in an ISD was developed and then tested using data collected from interviews with 13 IS managers. Although empirical evidence was found for the support of the model, the small sample size and the lack of reliability and construct validity tests restrict the validity of the model and the factors included therein.

From a theoretical perspective, innovation studies based on classical diffusion theory (e.g., Rogers 1983; Rogers and Shoemaker 1971) have received a lot of criticism when applied to organizational innovations. As Rogers’ framework focuses on the diffusion of mass-produced items through a process of communications among individual members in the population, many researchers have questioned the validity of its application to complex technological innovations at the organization level (Attrawell 1992; Bigonese and Perreault 1981; Brown 1981; Downs 1976; Eveland and Tornatzky 1990). When generalizing findings of individual adoption to the organization level, much of the inconsistency in report results could be explained by the failure to recognize the differences in unit of analysis, environment, and technology characteristics.

It has recently been suggested that the study of innovation and adoption of IT requires both organizational and task considerations (Breitschneider 1990; Cooper and Zmud 1990). Cooper and Zmud propose a model in which IT adoption is a function of task compatibility and technology characteristics. As Brancheau and Wetherbe (1990) note, "It was clear that innovation diffusion theory did not provide a complete explanation for technology diffusion in organizations." Zmud (1982) contends "Much of the inconclusiveness of prior research can be attributed to a failure to recognize that innovation attributes can be perceived very differently according to the specific organizational context involved." In a review of IT innovation studies, Fichman (1992) argues that classical diffusion variables by themselves are unlikely to be strong predictors of adoption and diffusion for complex organizational technology, suggesting that additional factors, either as independent or control variables, should be added.

As many researchers have suggested, to be useful, any borrowed theory needs to be refined and tailored to match the context of application. Many of the conflicting results on organizational innovation reported in the literature could be attributed to the contextual differences of these studies. Thus, innovation adoption decisions must be studied within appropriate contexts and with variables tailored to the specificity of the innovation.
A Theoretical Framework for Open Systems Adoption

The ubiquitous nature of the "open movement" suggests that more attention should be devoted to the construction of a theoretical model of IT infrastructure development. The lack of research on both open systems and IT infrastructure preclude building on existing theories directly. A model for open systems adoption needs to take into account factors that affect the propensity to adopt and the specific technological and environmental circumstances of an organization. Reviewing the adoption literature suggests that the framework developed by Tornatzky and Fleischer (1990) may provide a useful starting point to look into open systems adoption as it highlights the specific context in which the adoption process takes place.

In the Tornatzky and Fleischer framework, there are three elements that influence the process by which innovations are adopted. They are (1) the external environmental context, (2) the technological context, and (3) the organizational context.

The external environmental context is the arena in which an organization conducts its business. This includes the industry, competitors, regulations, and relationships with the government. These are factors external to an organization that present constraints and opportunities for technological innovations. Among these, market conditions, in terms of competitive market forces and market uncertainty, are a major factor in the innovation process. Two well-known early studies on market conditions and their impact on the adoption of new technologies are Mansfield (1968) and Mansfield, et al. (1977). In these studies, empirical evidence was found to support the theory that intense competition stimulates the rapid spread of an innovation and that firms, when confronted with a high degree of market uncertainty, are more likely to pursue an aggressive technology policy.

The technological context relates to the technologies available to an organization. Its main focus is on how technology characteristics themselves can influence the adoption process (Tornatzky and Fleischer 1990). Innovations are classified into three categories (Hage 1980): (1) incremental changes that provide added features or enhancements to an existing product or process; (2) synthetic changes that involve the combination of existing ideas or technologies in ways that create significantly new products or processes; and (3) discontinuous changes that involve the development of significant new products or processes. Different organizations may face very different innovation opportunities. Whether these innovation opportunities can be exploited depends on the degree of match between the innovation's characteristics and the practices and equipment currently adopted by the organization. Also, not all innovations are relevant to an organization. The degree of relevance depends on the potential benefits received and the ability to adopt. For example, innovations that induce discontinuous changes may impose large knowledge barriers which outstrip their potential benefits. The emphasis on context implies that the operationalization of benefits and adoption capability must be defined in light of the innovation characteristics.

The organizational context describes the characteristics of an organization. Common organization characteristics include firm size, degree of centralization, formalization, complexity of its managerial structure, the quality of its human resources, and the amount of slack resources available internally. It looks at the structure and processes of an organization that constrain or facilitate the adoption and implementation of innovations. Early studies have reported evidence about the links between these characteristics and innovations (Tornatzky and Fleischer 1990).

The theoretical framework suggested by Tornatzky and Fleischer provides a useful starting point to look into innovation adoptions. It allows us to evaluate the importance of different factors which affect the propensity to adopt open systems. However, as suggested, IS innovations can be of different types—some may affect the technical IS core only, but some may have influence on the whole organization.
(Swanson 1994). Care must be taken when applying this framework to study the links between contexts and adoption decision discussed in the framework.

Research Model

Based on the framework described above, an adoption model tailored for open systems is developed and depicted in Figure 1. It ties together seven factors representing three major contexts of open systems adoption: (1) external environment, (2) characteristics of the open systems technology innovation, and (3) organizational technology.

The environmental context follows closely the definition of the Tornatzky and Fleischer framework. The technological context is relabeled as “characteristics of the open systems technology” to better reflect the unique attributes of open systems. It highlights the perceived benefits and the ability to adopt. Since open systems have a direct impact on the functional IS core, the organizational context suggested by Tornatzky and Fleischer actually refers to the organization’s IT infrastructure in this model. It is labeled as “organizational technology” to better reflect its focus. Other organization characteristics which may have a second or lower order effect on open systems adoption are not included. The organizational technology context looks into issues being confronted in efforts to introduce open systems technology. The following subsections describe each of them in detail.

External environmental context

There is evidence that intense market competition appears to stimulate the rapid diffusion of an innovation (Mansfield et al. 1977). When an organization faces a complex and rapidly changing environment, IT is both necessary and justified (Pfeffer and Leblebici 1977). Recently, in a study of the adoption of telecommunications technologies among U.S. organizations, Grover and Goslar (1993) found significant relationships between environmental uncertainty and the usage of these technologies.

One criticism of classical diffusion theory is that it has neglected market characteristics as an important factor in the adoption decision (Kwon and Zmud 1987; Robertson and Gatignon 1986; Tornatzky and Fleischer 1990). Yet few studies in IS research have explicitly incorporated market characteristics in modeling the organizational adoption of IT.
companies are facing keen competition, it is the misalignment between the IT infrastructure and the way business is conducted that fuels the migration to open systems.

For example, many strategic alliances between trading partners created recently are facilitated by interorganizational systems (IOS). One primary objective to establish such strategic links is to maintain a competitive edge in an increasingly volatile market environment. These IOSs require a tight coupling between systems of the connected companies. Standard compliance becomes a key issue and the ability to interface successfully with different components on both sides are crucial in their successful implementation.

Another source of market uncertainty is the globalization of business. On one hand, companies benefit from a rapid expansion of their businesses to other parts of the world. On the other hand, they now have to deal with demand uncertainty, logistics, and economic fluctuations at a global level. The traditional IS architecture may no longer cope. Supporting global business calls for a more flexible infrastructure to interconnect regional information systems that are developed and managed with a high level of autonomy while allowing senior management to exercise control and monitoring at the headquarters. To function as a whole while maintaining a high level of flexibility in each region calls for the development of a suite of hardware, software, and communication standards and their proper enforcement by units worldwide.

Market and environmental factors, such as the degree of competition in the market, the stability of demand for the products, and the degree of loyalty of the customers, cannot be controlled by the management of an organization but can affect the way its business is conducted. From an IT viewpoint, management will demand more responsiveness and flexibility in IT support. Thus, it is hypothesized that companies facing a higher level of market uncertainty are more likely to adopt open systems.

H1: Higher levels of market uncertainty will positively affect the likelihood of open systems adoption.

Characteristics of the "open systems technology" innovation

The influence of characteristics of innovations on the innovation process has been studied quite extensively (Kwon and Zmud 1987). An important group of factors affecting the degree of influence are those related to the cost-benefit trade-off of adopting a particular innovation. Open systems technology is a novel approach in infrastructure development. Therefore, quantification of the costs and benefits related to it may lead to perceptions of the possible gains and barriers. These perceptions, in the context of open systems adoption, can be operationalized as three "perceived" factors as described below.

The first factor represents perceived benefits of adopting open systems in relation to an organization's specific setting. It is advocated that open systems provide a more flexible environment that is no longer constrained by proprietary systems, offer more choices for hardware and software, better utilize IT resources, promote flexibility and integration, and allow transparent data access. These benefits are consistently perceived worldwide. In fact, a global survey by X/Open has found no significant geographical bias among practitioners in terms of their understanding and perceptions of open systems (Xtra'93 Global Directions). Note that perceived benefits are not the same as awareness. Awareness is mainly concerned with the reception of information about open systems, while perceived benefits capture the extent of agreement with claimed benefits (i.e., do open systems deliver as advertised?) relative to the adopter's local conditions. While awareness is a precondition of forming a belief (i.e., perception on benefits), it is the latter that drives an adoption decision. The hypothesis is therefore formulated as follows:

H2: Higher levels of perceived benefits of adopting an open system will positively affect the likelihood of open systems adoption.

The second factor is the obstacles or barriers to open systems adoption. Open systems require a substantial degree of technical com-
petence to ensure smooth adoption. Attewell (1992) offers a very useful perspective on innovation adoption by emphasizing the role of know-how and organizational learning. His perspective goes beyond the monetary cost of the innovation to higher dimensions of organizational knowledge and the role of mediating parties in facilitating the adoption process. In the case of open systems, major barriers include the cost of migration, the technical expertise of existing IT staff members and the degree of entrenchment with a proprietary technology. Attewell argues that "firms delay in-house adoption of complex technology until they obtain sufficient technical know-how to implement and operate it successfully." This line of reasoning concurs with the notion of learning by doing: it takes time and expertise to incorporate complex technologies in an organization (Arrow 1962). Adoption of complex technology is not a single event but can be described as a process of knowledge accumulation. This perspective is most applicable to innovations that (1) have an abstract and demanding scientific base, (2) are fragile in the sense that they do not always operate as expected, (3) are difficult to try in a meaningful way, and (4) are "unpackaged" in the sense that adopters cannot treat the technology as a black box but must acquire broad tacit knowledge and procedural know-how to use it effectively (Attewell 1992). Open systems seem to possess these properties. First, every open system represents a unique way to interconnect a large number of hardware and software components. The level of complexity grows exponentially not only with the number of components but also with the different versions of the same component. Not all behavior of the integrated system can be accurately determined given such a high level of complexity. It is likely that the system may not function as expected occasionally. Second, an open system is not an artifact that can be mass produced with identical characteristics. It is unique and difficult to experience in its totality before the end system is implemented. Third, development and management of an open system requires not only knowledge of individual hardware and software components but also their interconnection arrangement as well as an updated knowledge of a large number of stan-

ards that are undergoing rapid changes themselves. The breath and depth of knowledge required are likely to set barriers to potential adopters of open systems. Based on these above viewpoints, the following hypothesis is proposed:

H3: Higher levels of perceived barriers to adopting an open system will negatively affect the likelihood of open systems adoption.

Adoption of open systems entails the selection and implementation of a suite of interface standards between system software/hardware, applications, and communications systems. The objective is to enhance the compatibility and flexibility of the IT infrastructure. Whether or not open system technology is perceived as better than the technology currently used in an organization is closely related to the degree of perceived importance on standard compliance, interoperability, and interconnectivity. Organizations satisfied with proprietary systems may not necessarily share the view of those seriously considering open systems. Since each organization is facing a different set of constraints and opportunities, the degree of perceived importance on standard compliance, interoperability and interconnectivity will not be identical. Those who don't see much gain from having an IT infrastructure with these properties will not be enthusiastic in adopting open systems. These arguments lead to the following hypothesis:

H4: Higher levels of perceived importance of standard compliance, interoperability and interconnectivity to an organization will positively affect the likelihood of open systems adoption.

Organizational technology context

Depending on the existing practices and hardware/software currently adopted, some organizations may require more efforts to introduce an IT innovation than others. The question can be viewed as the degree of match between the characteristics of the innovation and the cur-
rent technological setting of an organization. In the context of open systems adoption, three factors are proposed: (1) complexity of the existing IT infrastructure, (2) satisfaction level with existing systems, and (3) degree of formalization of systems development and management. Reasons for their inclusion are discussed below.

Open systems are advocated to better accommodate a complex IT infrastructure consisting of multiple platforms with different connectivity arrangements. This complexity dimension takes into account the existence of a variety of machines, operating systems and applications. A complex IT infrastructure will enhance the adoption of open systems for the following reasons. First, a complex IT infrastructure will increase the complexity of tasks as a wide array of hardware and software have to be managed. Research in organizational behavior has suggested that task complexity will promote the ability of an organization to innovate. The rationale is that task complexity leads to the creation of specialized positions or units. These units help to enhance successful implementation of innovations. For example, Zmud (1982; 1983) finds internal liaison groups to be a key element in facilitating the adoption of innovations. An earlier paper reports that the diversity of expertise promotes innovativeness by conceiving and proposing more innovative ideas (Zaltman et al. 1973). Highly specialized positions which did not exist a decade ago, such as information architect and telecommunication specialist, are not uncommon in today's organizations. The pool of diverse expertise possessed by these specialists plays a significant role in reducing knowledge barriers during the migration process. This in turn will reduce the adoption risk.

Second, vendors have become more and more specialized in their offerings, meaning that no one single vendor can offer competitive products in all segments of the market. However, for organizations that have a simple infrastructure, it is possible that they may be satisfied with solutions offered by a single or a small number of vendors even though they are proprietary in nature. There is a low incentive to adopt open systems in this situation. However, unlike simple infrastructure, a complex system typically consists of components supplied by a larger number of vendors. The level of component heterogeneity is high. The need to integrate a large number of platforms calls for a more effective way to manage the IT infrastructure. One way to tackle component heterogeneity is to enforce standard compliance in system development and management. Thus, a complex infrastructure provides management with the impetus to explore novel means, including open systems, to resolve this problem.

Third, a complex IT infrastructure also provides more opportunities and motivations for adoption since small-scale studies can be conducted to learn more about the technology. These viewpoints suggest the following hypothesis:

**H5:** Higher degrees of complexity of IT infrastructure will positively affect the likelihood of open systems adoption.

The satisfaction level with existing systems also plays a significant role as far as motivation to change is concerned. Organizational innovation proceeds in phases in which problems are first identified and then solutions are compared and evaluated (Rogers 1983; Tornatzky and Fleischer 1990). A low satisfaction level with existing systems, generally referred to as performance gap, will provide the impetus to find new ways to improve performance (Rogers 1983). Based on this argument, the following hypothesis is suggested:

**H6:** Higher levels of satisfaction with existing systems will negatively affect the likelihood of open systems adoption.

Open systems imply changes in the way applications are developed and managed. Standard compliance as a core requirement of an open system extends the process of standardization from technical items to related administrative procedures such as procurement and system development. Here, formalization applies to the IS function rather than to the entire organization. Companies that currently have a formal
policy on system-related matters are better prepared to adopt open systems for at least two reasons. First, to enforce standard compliance requires setting up procurement and testing procedures. Organizations that already have a formal system policy in place such as those reported in Zmud (1982) incur a much lower overhead to establish new policy and procedures developed for open systems. For example, if a formal procurement procedure is already in place, it is much easier to incorporate new standard requirements, say TCP/IP support for all client/servers, into the procurement and tendering procedure than to start from scratch. Second, the requirements of interoperability and interconnectivity apply to all levels of the information technology hardware, system software and applications. A high level of formalization within the IS function implies a wider and more detail control at each system level. Thus, it is easier to incorporate the specific rules and interface requirements (e.g., IP addressing scheme) related to a standard (e.g., TCP/IP) into the existing control mechanism than otherwise. The following hypothesis is proposed:

**H7:** Higher degrees of formalization on systems development and management will positively affect the likelihood of open systems adoption.

**Method**

**Operationalization of factors**

To operationalize these factors, direct use of instruments in previous studies of technology innovation is not possible because, as discussed above, the adoption of open systems is very different from the adoption of other technological artifacts. Therefore, the majority of these items were specifically developed for this study.

Market uncertainty was operationalized by asking respondents to describe (1) the market for their company's products; (2) the competition for their company's products; (3) the demand of their major customers; (4) the degree of loyalty of their major customers; and (5) the frequency of price-cutting in their industry. A seven-point Likert-type scale was used, with anchors ranging from "extremely stable" to "extremely unstable." The five items that respondents were asked to describe were adapted from Robertson and Gatignon (1986).

Perceived benefits were measured by five items adapted from various IT magazines for practitioners and pamphlets published by vendors of open systems products. Respondents were asked to give their level of agreement or disagreement with the following five potential benefits of adopting an open system: (1) no longer constrained by proprietary systems; (2) greater flexibility in the use of hardware and software; (3) better utilization of IT resources; (4) promote flexibility and integration; and (5) allow transparent data access. A seven-point Likert-type scale was employed.

Perceived barriers were operationalized with three items. Respondents were asked to indicate the extent to which they agreed with statements relating to the potential barriers to open systems migration in their organizations relative to their local conditions: (1) high cost for migration, (2) existing IS personnel are only familiar with proprietary systems, and (3) infeasible to dispose of existing proprietary systems. These items were also adapted from various open systems surveys published in trade journals. A seven-point Likert-type scale was used.

Perceived importance of compliance to standards, interoperability, and interconnectivity was operationalized with three items. Respondents were asked to rate the importance of each of these three items, on a scale from 1 (not at all important) to 7 (extremely important), relative to their local conditions. These items were based on the report by Critchley and Batty (1993).

Complexity of IT infrastructure was operationalized with six items which measured the degree of heterogeneity of the IT environment in terms of both hardware and software. The six items used for the measures were (1) number of mainframes, (2) number of distinct operating systems, (3) number of PCs, (4) number of
applications, (5) number of additional applications needed over the next 12 months, and (6) number of applications currently used in the organization. To ensure that the measure reflects the complexity of the IT infrastructure, rather than a combination of size and IT intensity, each of the six items was normalized to ensure an equal weighting of each in the factor.

The satisfaction with existing systems factor included two items: (1) does your existing computing system serve the needs of the company? and (2) are you satisfied with the price/performance of your system? Respondents were asked to opine on these questions using a seven-point Likert-type scale with anchors from “to a great extent” to “only a little” and from “very satisfied” to “very dissatisfied” respectively.

Formalization on systems development and management was operationalized by counting the number of formal policies or standards (relating to tasks performed in systems development and management) being used in the organization and then normalizing the result. Tasks included project control, feasibility study, budget estimation, schedule estimation, requirements analysis, systems design, program design, coding, testing, documentation, and conversion. These items were adapted from Zmud (1982).

The dependent variable, open systems adoption was determined by a binary measure: adopters or non-adopters. Organizations were classified as adopters if they met each of three specific criteria: (1) an open system migration plan had been developed, (2) the plan had already been endorsed by top management, and (3) a financial budget and a migration schedule had been approved.

A preliminary questionnaire was developed and pilot-tested with five IS managers to assess consistency, ease of understanding, and appropriateness of the question sequence. Face-to-face interviews were conducted to ensure that all the questions and terms used in the questionnaire could be clearly understood by the respondents. There were some modifications to the original questionnaire to clarify the meaning of particular questions. None of the responses in the pilot test were used in the analysis reported from this study.

**Informants**

The hypotheses described in the previous section were defined at the organizational level of analysis. Informants for this study, therefore, were required to be senior informed respondents within the organizational unit. An interview list of 300 senior executives responsible for managing the corporate IT functions was compiled from two sources: a major IT vendor and the Hong Kong section of the *Asian Computer Directory 1992*. A letter stating the purpose of the study was sent and a follow-up telephone call was made to each of these IT executives.

Eighty-nine respondents (30 percent) agreed to participate. They included 11 directors/vice-presidents of IS, 64 managers/section-heads of IS, and 14 holding non-IS titles such as financial controller or engineering manager. The firms they represented were involved in a wide spectrum of industries including manufacturing, utilities, transportation, trading, finance, construction, and retail. Therefore, though organizations in the sample were not randomly selected, they represented major IT users in various industries. Again, face-to-face in-depth interviews, each ranging from one hour to four hours, were conducted with these 89 respondents to ensure that all of the questions and terms used in the questionnaire were clearly understood. Based on our definition of adopters—those who already had an open system migration plan with budget and schedule approved by top management—27 (30%) of the 89 organizations were adopters, and 62 (70%) were not.

To test whether there was a statistical difference between IS and non-IS respondents, their responses to each factor were compared. The results are summarized in Table 1. As indicated, there is no apparent difference between the two groups. Since the sample size is limited, care should be exercised in interpreting the results.
Table 1. IS versus Non-IS Respondents

<table>
<thead>
<tr>
<th>Factor</th>
<th>IS Respondents (n = 75)</th>
<th>Non-IS Respondents (n = 14)</th>
<th>P-value*</th>
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</thead>
<tbody>
<tr>
<td></td>
<td>Mean</td>
<td>S. D.</td>
<td>Mean</td>
</tr>
<tr>
<td>Market Uncertainty</td>
<td>3.548</td>
<td>1.074</td>
<td>3.308</td>
</tr>
<tr>
<td>Perceived Benefits</td>
<td>5.563</td>
<td>0.807</td>
<td>5.171</td>
</tr>
<tr>
<td>Perceived Barriers</td>
<td>4.800</td>
<td>1.297</td>
<td>5.000</td>
</tr>
<tr>
<td>Perceived Importance of Compliance</td>
<td>6.130</td>
<td>0.699</td>
<td>6.143</td>
</tr>
<tr>
<td>to Standards, Interoperability, and Interconnectivity</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Complexity of IT Infrastructure</td>
<td>0.118</td>
<td>0.063</td>
<td>0.243</td>
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<tr>
<td>Satisfaction with Existing Systems</td>
<td>4.957</td>
<td>1.053</td>
<td>4.893</td>
</tr>
<tr>
<td>Formalization on Systems Development and Management</td>
<td>0.652</td>
<td>0.329</td>
<td>0.784</td>
</tr>
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</table>

* P-value of 2-tail t test.

Test of factors

The factors proposed in the model were evaluated for reliability, convergent validity and discriminant validity.

The reliability or internal consistency was assessed by computing Cronbach’s alpha (Table 2). The alpha values range from 0.6294 to 0.8744. The lower reliability for “satisfaction with existing systems” can be partly attributed to the small number of items in the factor as the calculation of alpha is affected by the length of the construct (Thompson, et al. 1991). Nunnally (1967) suggests that a reliability of at least 0.6 suffices for early stages of basic research. Given the exploratory nature of the study, the factors are deemed acceptable.

Convergent validity is demonstrated if items that measure the same factor correlate highly with one another. To assess this validity, statistical significance was computed using the one-tailed t-statistic test. Appendix A provides the correlation one-tailed significance matrix. All of the potential correlations are statistically different from zero at the 0.05 level of significance. Therefore, convergent validity is demonstrated.

Discriminant validity is achieved if an item correlates more highly with items intended to measure the same factor than with items used to measure a different factor. Validity is determined by counting the number of times an item has a higher correlation with an item from another factor than with items in its own factor. Campbell and Fiske (1959) suggest that a count of less than one-half is acceptable as valid. An examination of the correlation matrix of items (Appendix B) reveals that only 14 (3.7%) of the 300 comparisons of within-factor correlations associate higher on an item outside the factor. Based on this assessment, discriminant validity is established.

Factor analysis was also used to examine the convergent and discriminant validity of the constructs. A Principal Components Analysis with VARIMAX rotation and specifying a six-factor solution was performed. Degree of formalization was not included in the analysis as it was a
Table 2. Reliability of Factors

<table>
<thead>
<tr>
<th>Factor</th>
<th>Cronbach's alpha</th>
</tr>
</thead>
<tbody>
<tr>
<td>Market Uncertainty (5 items)</td>
<td>0.7022</td>
</tr>
<tr>
<td>Perceived Benefits (5 items)</td>
<td>0.7294</td>
</tr>
<tr>
<td>Perceived Barriers (3 items)</td>
<td>0.7126</td>
</tr>
<tr>
<td>Perceived Importance of Compliance to Standards, Interoperability,</td>
<td></td>
</tr>
<tr>
<td>and Interconnectivity (3 items)</td>
<td>0.6990</td>
</tr>
<tr>
<td>Complexity of IT Infrastructure (6 items)</td>
<td>0.8744</td>
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<tr>
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<td>0.6294</td>
</tr>
<tr>
<td>Formalization on Systems Development and Management (single item)</td>
<td></td>
</tr>
<tr>
<td>Open Systems Adoption (single item)</td>
<td></td>
</tr>
</tbody>
</table>

single-item factor. Convergent validity is demonstrated if items load highly on their associated factors. Appendix C shows the results of the factor analysis. Without exception, all items load highly (loading > 0.50) on their associated factors, confirming the convergent validity of the factors. As for discriminant validity, the primary criterion is that each item must load higher on its associated factor than on any other construct. From Appendix C, the condition for discriminant validity is also satisfied.

Data Analysis and Results

The logistic regression technique was applied to test the research hypotheses. This multivariate statistical technique was chosen over multiple regression analysis because the dependent variable (open systems adoption) was dichotomous. Using a dichotomous variable in multiple regression analysis would necessarily violate the assumptions necessary for hypothesis testing. Also, logistic regression analysis requires fewer assumptions than discriminant analysis; even when the assumptions required in discriminant analysis are satisfied, logistic regression still performs well (SPSS 1990).

The significance of the regression coefficients of the hypothesized independent variables was examined to determine support for the hypotheses. The Wald statistic was used in the significance test as all except one coefficient were smaller than one (Hauck and Donner 1977). Table 3 shows the results. The goodness-of-fit statistic (chi-square = 86.72; significance = 0.3116) indicates that the logistic regression model is not significantly different from a perfect model which correctly classifies all respondents into their respective groups: adopters and non-adopters. As for individual factors, the coefficients of both “perceived barriers” and “satisfaction with existing systems” are significantly different from zero (p < 0.05). The coefficient of “perceived importance of compliance to standards, interoperability, and interconnectivity” approached significance at the 5% level (p = 0.0558). The coefficients of the other four variables were not significant. Support was found for Hypothesis 3, which postulates that the extent of perceived barriers to adopting an open system negatively influences open systems adoption, and for Hypothesis 6, which states that the greater the satisfaction with the existing computing systems, the less the likelihood of adopting open systems. Moderate support was also found for Hypothesis 4, which postulates that the higher the importance level of compliance to standards, interoperability, and interconnectivity perceived by the organizations, the higher the likelihood of open systems adoption.

Statistical power analysis was conducted to evaluate if the insignificant results were due to the relatively small sample size. Following the
Table 3. Results of the Logistic Regression

<table>
<thead>
<tr>
<th>Factor</th>
<th>Coefficient</th>
<th>Wald Statistic</th>
<th>Significance</th>
</tr>
</thead>
<tbody>
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<td>Market Uncertainty</td>
<td>0.0680</td>
<td>0.0757</td>
<td>0.7832</td>
</tr>
<tr>
<td>Perceived Benefits</td>
<td>-0.0999</td>
<td>0.0856</td>
<td>0.7698</td>
</tr>
<tr>
<td>Perceived Barriers</td>
<td>-0.4548</td>
<td>4.7416</td>
<td>0.0294</td>
</tr>
<tr>
<td>Perceived Importance of Compliance to Standards, Interoperability, and Interconnectivity</td>
<td>0.7930</td>
<td>3.6566</td>
<td>0.0558</td>
</tr>
<tr>
<td>Complexity of IT Infrastructure</td>
<td>1.9779</td>
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<td>-0.5374</td>
<td>4.4490</td>
<td>0.0349</td>
</tr>
<tr>
<td>Formalization on Systems Development and Management</td>
<td>0.3130</td>
<td>0.1416</td>
<td>0.7067</td>
</tr>
</tbody>
</table>

-2 Log Likelihood: Chi-square = 95.134 (d.f. = 81); Significance = 0.1349.
Goodness of Fit: Chi-square = 86.718 (d.f. = 81); Significance = 0.3116.

procedures suggested by Menard (1995), the R-squared of the logistic regression was first computed (R² = 0.1490). The effect size was then calculated based on the method suggested by Cohen (1988); it turned out to be of 0.1751, suggesting a medium effect size. Choosing the significance criterion at 5% (a Type I error), the power for the logistic regression model was found to be 0.7973, which just met the generally recommended value of 0.80 (Baroudi and Orlikowski 1989).

The model was also assessed for its discriminating power. As there were 62 non-adopters and 27 adopters, guessing the adoption by random choice would have a 57.73% accuracy ((62/89)^2 + (1-62/89)^2 = 0.5773). The logistic regression model achieved a classification accuracy of 73.03%, which is better than by random choice.

Discussion

Definition of an open system

As many will agree, the definition of an open system is quite open itself. It is important to interpret the findings of the current study with reference to the respondents' perception of open systems. To better understand the scope and boundaries of open systems, respondents were asked how they defined open systems and, in particular, what keywords/phrases they would use to describe open systems. A summary of the responses is presented in Table 4. It turns out that the five most popular terms are interoperability, UNIX, non-proprietary, interconnectivity, and compatibility, in descending order. Table 4 shows that, although the non-IS people had a higher tendency to conceive open systems as systems that achieve interoperability, the two groups of respondents do not differ very much in terms of the popularity, which they ascribed to each term, i.e., the order in which they listed them.

All five terms except UNIX refer to the desired properties of open systems. This, to a certain extent, reflects that respondents' perceptions of open systems are implementation independent. It is also interesting to note that the scope of the definition is quite wide and is not restricted to narrowly defined standards. In fact, respondents did not favor vendor-based standards. Only four respondents mentioned proprietary systems or product names. This is consistent with the popularity of the term "non-proprietary" in the keyword analysis. During the interviews, many respondents expressed their concerns about relying on only a few vendors. Some had bitter experiences with vendors that went out of business, seriously disrupting their operations.
Table 4. Keyword Analysis for IS and Non-IS Respondents

<table>
<thead>
<tr>
<th>Keyword</th>
<th>IS (75)</th>
<th>Non-IS (14)</th>
<th>Total (89)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Interoperability</td>
<td>51%</td>
<td>86%</td>
<td>56%</td>
</tr>
<tr>
<td>UNIX</td>
<td>44%</td>
<td>29%</td>
<td>42%</td>
</tr>
<tr>
<td>Interconnectivity</td>
<td>37%</td>
<td>29%</td>
<td>36%</td>
</tr>
<tr>
<td>Non-Proprietary</td>
<td>35%</td>
<td>29%</td>
<td>34%</td>
</tr>
<tr>
<td>Compatibility</td>
<td>25%</td>
<td>21%</td>
<td>25%</td>
</tr>
</tbody>
</table>

Note: Entries represent the percentage of respondents in each category who mentioned the term.

External environmental context

A number of innovation diffusion studies have reported that variations in the external market environment have an effect on IT adoption decisions (Hannan and McDowell 1984; Kamien and Schwartz 1982; Romeo 1975). The main argument is that when a company is facing keen market competition, there are strong incentives for it to search for new innovations to help maintain or enhance its competitive edge. This study shows that this is not the case in open systems adoption. The relationship between market uncertainty and open systems adoption was found to be insignificant. One possible explanation rests in the risk involved in making discontinuous changes to the IT infrastructure of a firm when it is facing keen competition and demand uncertainty. Given the high risk involved, many non-adopting companies might simply be taking a wait-and-see attitude.

Another explanation is based on IS innovation (Swanson 1994). As discussed earlier in the paper, open systems can be viewed as a Type Ib innovation (IS technological process innovation), which tends to be more IS professionally oriented, rather than business oriented. As such, it is generally far removed from the core value-added processes of most businesses. Thus, environmental factors are likely to be of lesser importance.

This concurs with the typology developed by Prescott and Conger (1995), which classifies innovations by their locus of impact. In this typology, IS innovations can be classified as having impacts on IS units only, on the whole organization, and across organizations. Based on a review of IS innovations studies, the conclusion is that external environmental variables are less important to the adoption and diffusion of innovations that solely affect the IS core such as open systems.

Characteristics of the open systems technology innovation

As for factors related to the characteristics of the open systems technology innovation, perceived benefits of adopting an open system were found to be insignificant. Even though benefits such as providing a more flexible environment for systems development and integration, offering more choices for hardware and software selection, and providing better utilization of IT resources have been constantly advocated by IT vendors and the trade press, this study fails to find any significant relationship between these benefits and adoption. Adopters and non-adopters of open systems are not significantly different in their beliefs about the benefits of open systems.

On the other hand, perceived barriers to adopting an open system were found to be significant. This finding supports the view that adoption of complex technology is a process of reducing knowledge barriers (Attewell 1992). Others report that new technologies generally require changes in the skill sets that firms demand of employees. (Flynn 1988; Hirschorn 1984). Successful implementation of open systems requires a satisfactory level of competence in technologies such as UNIX and
TCP/IP, which are not yet dominant in corporate computing environments. Expertise in these areas is scarce and undersupplied.

To the extent that an organization can lower these knowledge barriers, it may facilitate the path to open systems. Among these, two obstacles are identified to be most critical. First, the lack of a skilled labor force (Tornatzky and Fleischer 1990) in the market slows the diffusion process. Given the knowledge-intensive nature of the migration process, the risks involved become excessive when the required expertise is not available, outweighing the potential benefits. Second, open systems may not be compatible with the vested interests of existing employees (Aiken, et al. 1980; Daft 1978; Moch and Morse 1977), especially those belonging to the technical core. As Zmud (1982) argues, these vested interests must be accounted for when adopting an innovation. Swanson (1994) also argues that "competence with older technologies may offer 'traps' which make it difficult to shift to new and potentially better technologies. The older the systems, the more pernicious may be these traps" (p. 1082). Evidence of this mismatch is found in observations of the systems architectures of surveyed companies. A significant portion of their applications are running on proprietary platforms (e.g., DEC VMS and IBM AS400), and the majority of their staff are experienced in a mainframe environment only. With little doubt, the request to move away from these proprietary platforms would make their skills less relevant if not obsolete. Resistance to change would increase if concerns and worries among existing IT staff were not properly addressed.

The study also found moderate support for the positive relationship between the perceived importance of compliance to standards, interoperability and interconnectivity and open systems adoption. This finding, together with the two above, has at least two important implications. First, it implies that what matters in the adoption of open systems is not whether potential adopters agree on the potential benefits, but rather whether those benefits are salient in relation to the organization's circumstances. Systems vendors should put more emphasis on educating managers as to when adoption is most appropriate and to provide support to facilitate the migration process. Second, the results point to the fact that knowledge barriers are a major obstacle for most organizations. Building up the necessary skill sets is a key issue for many adopting organizations, and they may address it in the following ways: (1) outsourcing the migration plan, (2) making the move with new staff who have the required skills, (3) hiring outside parties to implement the migration plan and transferring the know-how to in-house staff, and (4) retraining existing staff to equip them with the required skills.

Organizational technology context

The study found a negative relationship between satisfaction level with current systems and open systems adoption. This is consistent with a long line of research which shows that organizations innovate only in response to some perceived performance gap. The primary aim of the open systems movement is a quest for improvement in the efficiency and cost-effectiveness of the existing IT infrastructure. Such a motivation to improve always relates to a lower level of satisfaction with existing computing systems. The greater the satisfaction, the lower the incentive to change.

The study, however, did not find a significant relationship between complexity of IT infrastructure and the likelihood to adopt open systems. Some plausible explanations are provided below. While earlier work has reported that innovativeness is positively related to the diversity of the expertise in an organization (Zaltman, et al. 1973), there is also evidence that the wide variety of opinions may not converge to one that is acceptable to all (Tornatzky and Fleischer 1990). In this study, IS personnel from a complex IT infrastructure had very different opinions on which standard to select. Following the theory of vested interests mentioned earlier, staff will favor standards that are in line with their experience and interests. Very often, consensus cannot be
reached. In such a situation, conflicting interests may outweigh the benefits that the diversity of expertise can provide.

Another possible explanation for the non-significant complexity effect is that greater heterogeneity actually complicates the task of migrating to open systems, because there are many different kinds of systems and technologies to change over instead of only one, and this may offset any positive effects.

Although it is generally agreed that small-scale tests of open systems are easier to conduct in an organization with a complex IT environment, the organizations participating here did not show this propensity. A closer look at these environments reveals that many of them are simply groups of stand-alone proprietary systems with little or no integration. To their managers, adopting an open system is not to integrate various proprietary systems but to overhaul the existing one and to build an integrated system that conforms to standards and supports interoperability and interconnectivity. In such a case, complexity may not necessarily provide more opportunities for pilot studies nor induce a higher propensity to adopt open systems.

The results also do not show any significant influence of the degree of formalization of systems development and management on open systems adoption. Organizations that had a higher degree of formalization were not found to be predisposed to open systems adoption. One plausible explanation is that the set of rules and procedures involved may be associated with proprietary systems. For example, development methodologies may be strictly coupled with the underlying operating systems. If this is the case, this negative effect may offset any positive effects.

Limitations

As an exploratory study, this work has several limitations. First, open systems is a relatively new concept to users in the business world. Different IS executives might have slightly different interpretations. This potential difference was kept to a minimum by employing face-to-face interviews to ensure that the interpretation of terms and concepts was consistent among all interviewees in this study. Even having done this, bear in mind that different interpretations of some of the terms used might still exist.

Second, as discussed earlier in this paper, open systems are quite different from other IT innovations studied before. Operationalization of the factors proposed in the model had not been carried out extensively in previous studies although reliability, convergent validity, and discriminant validity were demonstrated.

Third, the key informant method (Phillips 1981) was adopted in this study for data collection. Two criteria for the use of this data collection method were identified (Campbell 1955): (1) the respondents should occupy roles that make them knowledgeable about the issues being researched, and (2) they should be able and willing to communicate with the researchers (Boynton, et al. 1994). The decision to use a senior executive responsible for managing the corporate IS function as a single, key informant was based on two considerations: (1) with the help of a major IT vendor, access to such individuals was gained and (2) given the size of the data sample, this method was deemed to be acceptable. As most of the interviewees were at senior level and were involved in organizational decision making in new IT adoption, their views were believed to be representative. Although the possibility of self-justifying reports still remains, the problem is not a serious one as respondents in general were very cooperative in providing detail data for each question. Very often, an interview was followed up by telephone and fax to collect further information.

Fourth, this study does not include variables such as management style, organizational structure and culture in the research model. Because of the study's exploratory nature, the focus is on factors that are relatively easy to measure and are widely publicized. It was originally understood that including cultural and political factors might have enriched the con-
tent of the model, but it might also have con-
founded the data analysis and the interpreta-
tion of the results since operationalization of
those factors remains a challenge facing
researchers studying IT adoption. Fur-
thermore, to assess the impacts of these
factors requires detailed analysis of the struc-
ture of an organization and in-depth on-site
studies. A cross-sectional survey methodology
as used here may not be the most appropriate
means to address these issues.

Conclusions

While open systems are in the headlines of the
IT trade press and have been the focus of
many sales pitches in recent years, little
research has been conducted to study this
ubiquitous phenomenon. It remains unclear
whether common perceptions and publicized
facts about open systems have any effect on
their adoption. A model was proposed to
describe factors affecting the adoption of open
systems. The model was empirically examined
via data collection from in-depth interviews
with 89 senior executives responsible for man-
aging corporate IT functions in Hong Kong.
The findings provide a number of implications
for research and practice.

Implications for research

In spite of the limitations noted above, this
study demonstrates the value of using the
Tornatzky and Fleischer framework to under-
stand the adoption of a complex IS innovation.
As correctly pointed out by Swanson, traditional
views of organizational innovation have not
provided a useful structure for understanding
the adoption of complex technologies. This
study suggests an alternative framework to
study IS innovations and was found to be of
value. One future line of research is to extend
the proposed framework to other innovation
domains, and to other IS innovations of Type I
or even Types II and III.

The results of this study provide empirical evi-
dence that supports the need for a more con-
text-based model of innovation adoption. In
particular, the results suggest the inclusion of
technical knowledge as a barrier to adoption,
one that has not been included in the tradition-
al adoption models. While Attewell (1992)
highlights the role of the innovation supplier as
a facilitator in the knowledge transfer process,
the results of the present study also recognize
the importance of knowledge barriers on the
adopter side. Future research should move
beyond the focus of the innovativeness of indi-
viduals to study factors related to the innova-
tion supplier and other intermediate parties
involved in the innovation adoption process.

Tornatzky and Fleischer suggest that firms are
most likely to invest in new technology when
they are in the intermediate stage of the busi-
ness cycle. The rationale is that in this stage,
firms are operating in a more stable environ-
ment and at the same time have sufficient
slack capacity to experiment with new ideas.
When integrated into the results of this study,
such a perspective provides strong evidence
of the importance of contextual market factors
in the study of organizational innovations. A
fruitful line of research might emerge by focus-
ing on the relationship between innovation
adoption and the business cycle with particular
attention given to control variables such as
industry and size.

Our study also brings an international perspec-
tive to IT innovation research in the literature.
Rosenzweig (1994) challenges the presump-
tion of conceptual equivalence across lan-
guage and cultural barriers in management
research. To be useful, innovation research
must be valid in a larger context. Thus,
researchers must pay attention to the legal,
cultural, and economic factors that may affect
an innovation study, and care must be exer-
cised when comparing research results. Al-
though the innovation process of organiza-
tions is a universal phenomenon, most of the
IS innovation studies conducted to date have
been carried out in developed countries, and
of those the majority were in the U.S. It is
important to investigate whether or not existing
innovation theories can be generalized and
Empirical findings of these studies are applicable in different cultural and economic contexts. To achieve this, a large body of cross-country/cultural studies needs to be accumulated. In the Asia Pacific region, a number of innovation-related studies have been conducted (Ang et al. 1995; Neo et al. 1994). Our study represents another research effort toward this goal.

Future research is necessary to address the limitations of this study. First, more effort should be put into improving the theoretical base for the operationalization of factors. Second, this research used the key informant method for data collection. Acknowledging its limitation, future research on this topic should attempt to obtain multiple sources within the organizations. Third, longitudinal evidence is required to better understand the causality among variables. Fourth, additional variables need to be added, including but not limited to size of both the organization and the IS team and top management support. Last but not the least, while statistical tests have shown the analysis was of adequate power, more non-significant results than significant results in this study suggests that inclusion of factors in the theoretical model should be taken with great care and should be supported by substantive theories and/or strong empirical evidence.

Implications for practice

From a managerial standpoint, the findings of this study suggest that organizations tend to focus more on their "ability to adopt" than on the "benefits from adoption." As long as organizations think that they do not have sufficient technical capabilities to adopt new technology, they would rather maintain their current systems. Open systems vendors, therefore, should put more efforts into helping organizations prepare and equip themselves for open systems adoption than into promoting the potential benefits through mass communication channels.

Organizations also tend to take a "reactive," rather than "proactive," attitude in adopting new, complex technologies. The finding that satisfaction with the current situation leads to lower incentive to adopt illustrates this point. Successful adoption of open systems is believed to provide an organization with competitive advantages and flexibility to cope with the dynamic business environment. Acting passively, organizations seem to focus more on "managing the present" than "preparing for the future." This may indicate the intensive pressure experienced by the organizations and/or the myopia of their IT strategies. Of course, the reactive attitude may also be due to unsuccessful cases of adoption of new technologies that they have experienced or heard of. A better knowledge of the evolution of IS innovations should be helpful to practicing managers in understanding the circumstances under which open systems are most appropriate to their organizations.

Acknowledgements

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References


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### Market Uncertainty (5 items)

<table>
<thead>
<tr>
<th>Item</th>
<th>Score</th>
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<tbody>
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### Perceived Benefits (5 items)

<table>
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<tr>
<th>Item</th>
<th>Score</th>
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<tbody>
<tr>
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### Perceived Barriers (3 items)

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### Complexity of IT Infrastructure (6 items)

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### Satisfaction with Existing Systems (2 items)

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<th>Score</th>
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### Formalization (single item)

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### Perceived Importance of Compliance to Standards, Intercompatibility, Interconnectivity (3 items)

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<th>Item</th>
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### Appendix B

**Correlation Matrix**

<table>
<thead>
<tr>
<th>Market uncertainty (5 items)</th>
<th>Perceived benefits (5 items)</th>
<th>Perceived barriers (3 items)</th>
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<th>Formalization (single item)</th>
<th>Perceived importance of compliance standards, intercompatibility, interconnectivity (3 items)</th>
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Numbers in brackets: incidence of violation of discriminant validity, an item correlates more highly with another item used to measure a different construct than with at least one of other items intended to measure the same construct.

Numbers in brackets and in italics: incidence of two violations of discriminant validity.
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<th>Factor Item</th>
<th>Complexity of IT Infrastructure</th>
<th>Perceived Benefits</th>
<th>Market Uncertainty</th>
<th>Perceived Importance of Compliance to Standards, Interoperability, and Interconnectivity</th>
<th>Perceived Barriers</th>
<th>Satisfaction with Existing Systems</th>
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