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IDENTIFYING FACTORS TO IMPROVE EFFECTIVE XML ADOPTION IN ELECTRONIC BUSINESSES

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Abstract

XML (eXtensible Markup Language) is emerging as the industry standard platform for application integration and many organizations are either adopting the technology or seriously evaluating this option. One of the major concerns of the senior management in such an endeavor is the cost associated with the decision. In this paper, a model is proposed to evaluate an organization's position in an XML adoption space by evaluating its current level of IT sophistication. The model identifies critical factors necessary for the successful adoption of XML technology along three dimensions – intranet, extranet and Internet. A simulation experiment is conducted to find the most cost effective strategy for allocating the resources to achieve the desired goal. Two options are evaluated under the constraint that the organization can increment the diffusion level of a factor only by a fixed amount. It has been observed that improving the factor that has the highest significance in the dimension in which the company needs to improve most is a more effective strategy than improving the diffusion level of the factor that has organization-wide highest importance.

Keywords: XML adoption, IT sophistication, IT investment

Introduction

XML (eXtensible Markup Language) has caught much attention in the business environment recently. Using XML, it is possible to represent information in a standard and structured manner that can be processed by any software application. Businesses today are either XML-enabling their current applications or seriously considering adopting the technology. While there is no lack of articles published on XML in popular press journals, there is little academic research effort to address the specific issue of XML adoption from a business information technology (IT) perspective.

Chen et al. (2003) proposed an XML adoption space model to measure the efforts/costs that a company would incur in order to establish XML-enabled IT applications with consideration of the company's current status of IT applications. The result of their model can serve as the basis for further cost/benefit analysis of final XML adoption decision. Their model implies that the higher the "level of sophistication" of a company's current IT applications, the easier it is to transform those applications into XML-enabled ones. In this paper, we attempt to formalize a way to locate the position of a company in the XML adoption space based on a company's "level of sophistication" of its current IT applications by examining relevant factors. Further, our research aims to help businesses in the decision making process of XML adoption by providing guidelines that would help them achieve this goal most effectively by choosing specific factors for further improvement under the constraints of limited resources.

In order to introduce any new technology, one of the major concerns of senior management is the cost associated with the change. The success of the endeavor depends on various factors. One of our objectives in this paper is to identify the factors relevant to the context of XML technology adoption in an organization and to provide an estimate of the potential costs that would be incurred by the process. We argue that the higher the level of IT sophistication of a company is, the lower the cost to adopt XML technology will be. Hence, we first attempt to identify the factors that will collectively determine the level of IT sophistication of a company. The status of IT is determined by (1) using the relative importance of the factors and (2) their level of diffusion within the organization. Given the status of IT, we are interested in identifying the factor(s) that would be the most effective in helping an organization to achieve its goal of adopting XML-enabled applications. Our findings show that when resource allocation is constrained in such a way that the organization can increment the diffusion level of a factor only by a fixed amount, improving the factor that has the highest importance in the dimension in which the company needs to improve most is a more effective strategy than improving the diffusion level of the factor that has organization-wide highest importance.

Foundational Theories and Literature Review

To identify the determinants of IT sophistication, the subject has to be viewed from various perspectives. First, since the process involves the adoption of new technology within the organization, we need to consider the factors that promote user acceptance of IT applications. We review existing literature on technology acceptance and information systems (IS) effectiveness as a foundation to recognize the relevant issues in this area. Second, one of the main reasons a company would undertake an IT endeavor is to gain a competitive advantage (or maintain a competitive parity). XML, being a new technology, would clearly provide a competitive edge to its successful early adopters. Theories on how IT can provide a competitive advantage have provided the necessary groundwork in this dimension. Third, we need to determine what types of technology characteristics are considered as critical in today's business environment. Some practitioner articles and popular press journals helped us identify those features.

One of the earliest and widely accepted theories on the adoption of innovation within organizations is the technology acceptance model (TAM) proposed initially by Davis (1989) and later modified by Davis *et al*. (1989). TAM suggests that two specific beliefs – perceived ease of use and perceived usefulness – determine an individual's intention to use a technology. TAM has been extended and modified by a number of IS researchers who contributed to the growing body of literature. Matheison et al. (2001) incorporated another dimension into TAM – perceived user resources – to capture the extent to which individuals perceive that they possess the necessary personal and organizational resources to adopt an information system. Lim et al. (1998) mentioned perceived benefit as an important motivation factor in their conceptual model to explain the adoption of electronic commerce in organizations. Their concept of complexity is similar to the perceived ease of use in TAM although the work is presented in the specific context of adopting Internet technology for commercial purposes.

To facilitate successful introduction of a new technology into an organization, this new technology has to be compatible with the current business processes, practices, and existing IS applications. The works of both Lim et al. (1998) and Chin et al. (1995) emphasized this requirement. While the former research focused the adoption of Internet, the work of the latter focused on the importance of different user perceptions in a Group Support System (GSS) setting.

As mentioned earlier, the purpose of adopting a new technology is often to gain a competitive advantage. There is a body of knowledge in the IS literature that attempts to explain how IT helps gain a competitive advantage using the Resource-Based-View of the firm (Barney, 1991). According to this view, competing firms vary in the resources they possess, and heterogeneity and immobility of those resources are the sources of competitive advantages. From a review of the extant literature, three resources emerged to be critical in this context – financial, technological, and managerial resources. Iacovou et al. (1995) cited organizational readiness, which they defined as the "availability of technical and financial resources" as one of the important factors for the adoption of EDI in small firms. Kambil et al. (2000) stressed on the significance of financial factors in corporate adoption of Web technology. They looked at market value, sales, ROI, and assets. Their study suggested a strong correlation of the firm's Web presence and its financial strengths. In their proposed model for evaluation and adoption of Enterprise Integration Technology (EAI), Thermistocleous and Irani (2002) cited various technological factors such as maintainability, flexibility, scalability, and portability as the necessary requirements for integration. In an empirical study of the adoption of object-oriented technology in software organizations, Sultan and Chan (2000) suggested individual's experience as one of the many important factors.

Whether a firm possesses the necessary resources or not, the final decision to adopt a new technology is always made by top management. There are a considerable number of literatures that underscore the role of top management support as one of the deciding factors for the success of any IT endeavor (Kambil et al., 2000; Zolla, 1999; Eder and Igbaria, 2001). Leadership and strategic direction of management were cited as the most important factors for corporate adoption of Web technology in Kambil et al.'s work. Zolla (1999) conducted two case studies to compare the adoption of intranet using a modified version of Cooper and Zmud's (1990) model of IT implementation. In that study, top management support emerged as a critical factor in the diffusion phase as well as in the fit stage (Zolla described fit as the stage in which the innovation is tailored to meet the organization's requirements).

Firm size is often considered as a proxy of financial and technological resources and is hence believed to be positively associated with IT adoption. In his research on IS innovation in organizations, Swanson (1994) found that the early adoption of IS innovation is more likely to happen when both the organization and its IT department are large. Eder and Igbaria (2001) found that firm size is positively correlated with intranet diffusion. Damanpour (1992) explored the relationship between size and innovation under different moderating factors. Although this study found that the correlation between size and innovation is stronger in manufacturing industries than that in service industries, a significant finding suggested that a better fit between organizational size and innovation is more likely to occur if innovation is organization-wide rather than centered within a small part of the organization.

Apart from the organizational factors discussed above, the evaluation of IT infrastructure is necessary to estimate the IT sophistication of an organization. Thermistocleous and Irani (2002) considered both IT infrastructure and IT sophistication as important components for application integration adoption. Straub et al. (1989) conducted a survey to identify the key information technologies that would have the greatest organizational impact. Three groups of technologies emerged as critical from their survey – (1) human interface technologies, (2) communication technologies, and (3) systems support technologies. The various hardware and software components that are considered to be critical for businesses include office automation systems, various storage and compression devices, networking devices, and decision support systems (Straub *et al*., 1989; Paré and Sicotte, 2001; Anonymous, 1993). Since businesses need to transfer huge amounts of data within and across organizations, bandwidth is another important determinant (Carr and Snyder, 1997; Fitzgerald and Dennis, 2001). Moreover, the security of information to be transferred and stored is of utmost importance (Rist, 1999). The use of technologies like firewall, SSL (Secure Socket Layer), encryption, and digital signature can be considered as an indicator of the measures the organization undertakes to protect its data. With the advent of the Internet, cyberspace has become a parallel business outlet for most businesses. In this context, the presence of B2B (business-to-business) and B2C (business-to-consumer) electronic commerce platforms seemed to be two key indicators of technology sophistication. Zhu and Kreamer (2002) developed a metric to measure the e-commerce capability of organizations that conduct at least part of their businesses over the Internet. They measured such capability along four dimensions – information, transaction, customization, and supplier connection. The information and transaction dimensions point towards content management capabilities. While a secure Internet site serves as the interface for B2C transactions, Virtual Private Networks (VPN) is essential for interorgnizational transactions via an extranet. Moreover, B2B applications often require interoperability of disparate information systems, and the presence of web services offer a unique solution to this problem by providing an infrastructure for communication of public processes while maintaining the confidentiality of private processes.

Proposed Model

In order to make an informed decision to adopt any new technology, senior management must first evaluate the level of IT sophistication in their organization. An assessment of the status of IT within an organization would provide a guideline for determining the efforts required for the adoption and the potential costs associated with it.

Since the introduction of Internet technology for commercial purposes in the early 1990s, it has quickly become the standard platform of communication worldwide. The wide acceptance of the Internet as a medium of information transfer has enabled businesses to reach within and outside their respective organizations in a much less expensive manner to communicate with their employees, partners, and customers. Consequently, companies have used Internet technology to manage their business activities in three domains – enterprise intranet, value chain extranet, and global Internet. In order to locate the position of a company in the XML adoption space proposed by Chen et al. (2003), it is necessary to identify the specific factors that contribute to each of these three domains. Some factors would be common to all three domains, while the others would be specific to a particular domain. Our literature review suggests that there are certain degrees of overlap among the various factors captured by different authors. We have grouped the factors into three broad categories – *organizational*, *structural*, and *technological*. These factors contribute equally to all the three dimensions of Chen *et al*'s model. These are also considered to be the deciding elements in the intranet axis since the intranet is the most basic form of technology among the three. It can be argued that sophistication in either of the other two dimensions requires some additional competence over the intranet capabilities. By the same token, it is reasonable to state that the presence of intranet and extranet applications indicates the organization's capability of extending its reach into the extranet and Internet dimensions, respectively. The other factors specific to Internet and extranet follow from our discussion in the last paragraph of the previous section. Table 1 presents a concise list of the various aspects used to measure the "level of sophistication" of a company's IT application.

Table 1. Factors for Measuring the "Level of Sophistication" of a Company's IT Applications

Common factors for intranet, extranet, and Internet			Special factors for extranet	Special factors for Internet
Organizational Factors	**Structural Factors**	**Technological Factors**		
Financial and technology resources	IT utilization *	Connectivity devices, bandwidth	Intranet applications	Extranet applications
Top management support	Level of integration **	Web/Internet technology	Virtual private network	Applications such as B2C, B2G, C2B, etc.
IT department size/IT budget	XML/web services infrastructure and platform/ services	Security	B2B connection	Server capacity
Perceived ease of use/relative advantage	IT compatibility	XML/web services tools	Content management	Content management

* IT utilization refers to the adequacy of the existing hardware/software and the extent to which they are used.
** IT integration refers to the extent to which different IT applications are integrated with each other and the overall business process.

It is worthy mentioning here that some authors (e.g., Iacovou et al. 1995, Thermistocleous and Irani 2002) cite external pressure from competitors as a motivating factor for adopting a certain technology. However, our focus is to find and evaluate an organization's capabilities that are determinants of successful adoption as opposed to the models that seek to explain the driving factors behind an adoption decision. We include factors that are reflective from those components described in one level of the model proposed by Thermistocleous and Irani (2002) but exclude factors such as pressures and motivations from the other two levels. However, even we do not incorporate any external factors into our current model, it certainly is an area worth pursuing for future research.

For a company, the distance from its current position P (x_o, y_o, z_o), to its desired XML-enabled position Q (x_d, y_d, z_d), in the adoption space represents the magnitude of the associated costs to reach the desired position. That is, once the co-ordinates of an organization in the adoption space are found and the destination is decided, the distance, d, between point P and destination Q represents the effort that the company needs to dedicate in order to achieve the desired amount of XML adoption (see Figure 1). So the projected costs of moving from P to Q for a company are estimated by calculating the distance d $= \sqrt{(x_d - x_o)^2 + (y_d - y_o)^2 + (z_d - z_o)^2}$.

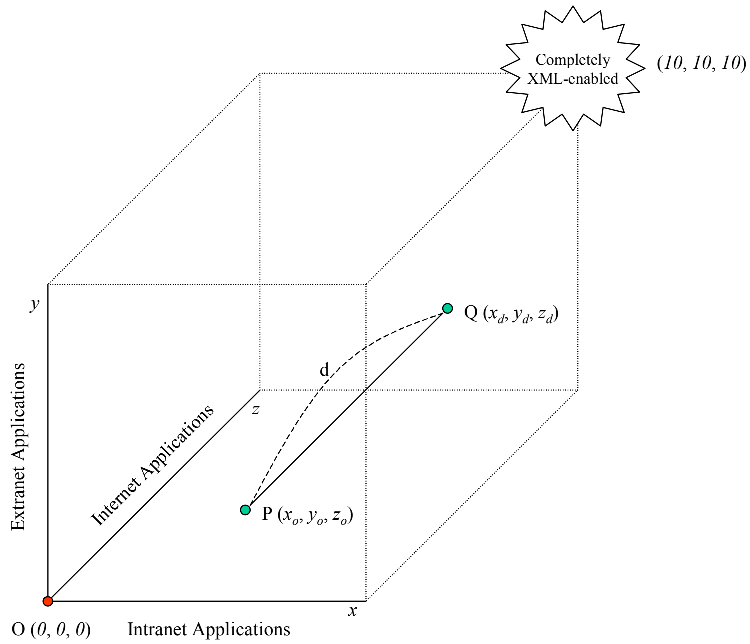

Figure 1. XML Adoption Space Model

If it is perceived that different costs will be incurred for the adoption along the three dimensions, then the distance would be measured by taking into account the different weights along the three dimensions. For example, if the weights are w_x, w_y, and w_z along the x, y, and z axes, the distance would be given by $\sqrt{w_x(x_d-x_o)^2+w_y(y_d-y_o)^2+w_z(z_d-z_o)^2}$ where w_x, w_y, and w_z represent the proportion of the total costs required to make one unit change in the x, y and z axis respectively (we would use x, y, and z to represent the intranet, extranet and the Internet domain respectively). For a computational purpose, we use a scale of 0 to 10 to represent the length of each axis. Hence, if a company is at (10,10,10), it is perceived to be completely XML-enabled given the organization's own evaluation of the importance of the various factors. However, if the relative importance of these factors changes in the future, the company has to re-estimate its status with respect to XML adoption.

To determine the position along an axis, we need to find out the relative importance of each of the factors that constitute the domain, and the extent to which they are presently diffused. For example, if "top management support" is considered to be one of contributing factors along the intranet dimension, we need to determine how important it is for XML adoption in the intranet domain. We also need to find out how much of the needed support actually exists now in the organization. Formally, the co-ordinate D_j of a company along any dimension j (= x, y, and z) will be given by:

$$D_j = \frac{\sum_{i=1}^{I_j} \alpha_i T_i}{\sum_{i=1}^{I_j} \alpha_i} \times S \qquad j = \text{x, y, and z}$$

where I_j = total number of factors to be evaluated in dimension j
α_i = the weight or the importance of factor i in the dimension
T_i = degree of adoption/diffusion of factor i in the dimension
S = scale to which the distance is compared (10 in our example).

Research Methodology

As defined by Bratley et al. (1987), simulation means driving a model of a system with suitable inputs and observing the corresponding outputs. Simulation approach is often used in social science when people have complex problems that cannot be solved by other means such as optimization modeling, survey, and case study. Simulation allows the social scientist to experiment with "artificial society" and explore the implications of theories in ways not otherwise possible. In our study, we mainly utilize simulation approach for the discovery and formalization purpose (Gilbert and Troitzsch, 1999). We try to set up random variations that may exist in many factors affecting technology adoption in real life. That is, we try to use simulation to discover important relationships and principles from model (Axelrod, 1997). More specifically, with many possible variations of status of IT, we are interested in identifying the factor(s) that would be the most effective in helping an organization to achieve its goal of adopting XML-enabled applications.

A simulation program was developed using Visual Basic. The program provides an interactive interface that enables the users to input the values for the weights (importance) and/or diffusions of the different factors along each of the three dimensions. Once the values are provided, the program would locate the company's current position in the adoption space and calculate its distance from (10, 10, 10) or any specific destination. We also have a separate module that can feed the weights and diffusions automatically with random numbers generated from different probability distributions. In the first phase of investigation, we tried to focus on how the different combinations of weights and diffusions influence the company's strategy for further enhancement/adoption of XML technology. The questions that we tried to answer are as follows:

- What is the best strategy for a company to move from its current position to the desired position given that a company can adjust its strategy to manipulate different weights and levels of diffusion for the factors along the three dimensions?
- How do the relative high/low values of the weights and/or the level of diffusion affect the adoption strategy?

Since the intranet dimension has twelve individual factors and extranet and Internet dimensions each has sixteen factors, it would be cumbersome to investigate adjusting effects if we exhaustively varied each of the different factors across all the three dimensions. To facilitate better result interpretation, at current stage we assigned equal values to the variables in each one of the five categories presented in Table 1. For example, in one iteration of the simulation, all the variables in the category "organizational factors" of the "intranet domain" might have a value of 0.8 for the weights and a value of 0.5 for the diffusion level. In the same iteration, the "organizational factors" for the other two domains may have the same or different values. This design also makes sense from a practical perspective. Since our application captures the various organizational factors from the senior management's point of view, the variables have been grouped logically into wider categories such that each of these categories represents standard areas that are of importance to senior management. Often management would concentrate, from a high level, on one particular area rather than each individual factor. Therefore, it would not be unusual for all the variables in a particular category along a dimension to assume the same values. However, it is worth mentioning that our application has the flexibility to capture the different values of all the relevant variables if decision makers desire so.

For our investigation purpose, we assumed the final destination to be (10,10,10). This was done only for computational demonstration since our aim is to investigate the effect of the weights and diffusions of the various factors on the adoption costs, which are proportional to the distance between the current position and the destination. This would not alter our findings if we used a different destination. On the other hand, our simulation program was designed to have the flexibility to use any destination point other than (10, 10, 10). Actually it would be interesting and realistic to have different destinations reflecting different goals of companies. For example, a company wants to concentrate on adopting XML technology on intranet applications but not so much on extranet or Internet applications, this company can set its destination as (10, 5, 5) instead of (10, 10, 10).

In a complete iteration of our experiment, the weights of the different groups of variables were kept constant, and we varied the levels of diffusion to find the best strategy. The argument to keep weights fixed is that in the short run the relative importance of the various factors tends to remain the same, but management can take measures to enhance the penetration levels of the most important factors to improve its position. However, with the consideration that in the long run the relative importance of the various factors might change, our future simulation will adjust the weights as well as the levels of diffusion.

Results and Discussion

We first attempt to identify the factor(s) that would be the most effective in improving the current position of an organization towards its desired position in the adoption space. The question asked was – whether it is advisable to improve the factor that has the greatest importance (and hence the highest overall weight) among all factors in the three dimensions or is it better to improve the factor that has the highest weight among all factors in the specific dimension where the company needs to move the farthest to reach its destination? For example, let us assume that the "organizational factors" in the "intranet domain" carry the highest overall weight (0.9), while in the "extranet domain" the "technological factors" are of the highest importance, having a weight of 0.5. If the company's current position is (7, 3, 6) and the destination is (10, 10, 10), should the organization spend the money on the organizational factors in the intranet domain or should they concentrate more on the technological factors in the extranet domain? Our simulation results show that *when resource allocation is constrained in such a way that the organization can increment the diffusion level of a factor only by a fixed amount, improving the factor that has the highest importance in the dimension in which the company needs to improve most is a more effective strategy to move closer to the destination than improving the diffusion level of the factor that has organization-wide highest importance*.

In the above example, since the company has to move farthest distance along the extranet dimension (the company has to move 10 – 3 = 7 units along this dimension, whereas the required movements in the intranet and Internet domain are 10 – 7 = 3 and 10 – 6 = 4 units respectively), improving the "technological factors" in the extranet dimension (which have the highest weight in that specific dimension) would be the most effective move.

The above finding has an important implication in helping firms decide the best strategy for XML adoption. When an organization decides to invest in improving its current status with respect to adopting the XML technology, it should allocate the resources in such a way that the farthest distance to be traveled among the three dimensions has to be reduced first, not in a way that focuses on the most important factor organization wide. Once that distance become less than the required moving distance in some other direction, the company should invest in the latter dimension. In our example, as soon as the extranet position of the company becomes greater than 6 (i.e., the required movement along that direction becomes less than 4), Internet dimension becomes the candidate for improvement because now the longest distance to be moved is along the Internet dimension. Hence we need to pick the highest-weight factor in the Internet domain and invest on improving the diffusion level of that factor. The implication of the above analysis is that a step-by-step approach is the best approach to arrive at a desired destination in the presence of resource constraints.

Two assumptions are made here: (1) the company cannot make improvements in two dimensions simultaneously; and (2) the level of diffusion has been changed by the same amount in both the directions. The first assumption is based on the fact that resource constraints often play a major role in this type of projects and management has to choose the one area that they perceive to be of utmost significance. However, the finding can be extended to more than one dimension if the availability of resources is not a major concern. If the organization can invest in more than one dimension simultaneously, then we can rank the required movements in each dimension, and improve the factor with the highest weight in each of the dimensions. The second assumption was made for making comparisons easier. Although we relaxed this assumption later to see how it affects the decision if the organization is allowed to make more improvements in the area that has the global highest weight. The simulations suggest that as long as the difference between the highest and the next highest distance is not small, our previous finding still holds. However, when the difference between them is very small, improving the diffusion level of the globally highest factor by more amount than the one in the highest-distance dimension takes the organization closer to the destination. For example, in our above example, if the company had the resources to make more improvements in the intranet domain than in the extranet domain, it is better to improve the diffusion level of the "organizational factors" (being the factors that have the globally highest weight) in the intranet domain by a higher amount if the difference in the required shift along the intranet and extranet dimensions were small.

Conclusion and Future Research Direction

In this paper, we attempt to position a company in the XML adoption space by examining specific factors to measure a company's "level of sophistication" of its current IT applications. Further, our research aims to help businesses in the decision making process of XML adoption by providing guidelines that would help them achieve this goal most effectively by choosing specific factors to improve under the constraint of limited resources. Our results show that when the resource allocation is constrained in such a way that the organization can increment the diffusion level of a factor only by a fixed amount, improving the factor having the highest importance in the dimension in which the company needs to improve most is a more effective strategy than improving the factor having organization-wide highest importance.

Our ongoing research will extend our simulation program to find out how adjusting each individual factor will affect a company's effort to achieve its goal of adopting XML-enabled technologies. We can further relax the assumption that a company cannot make improvements in two dimensions simultaneously. We can investigate the optimal allocation of resources to improve factors on more than one dimension simultaneously; therefore, top management of a company will have more flexibility to set technology priority. Further, the assumption that levels of diffusion are changed by the same amount in any dimension can be relaxed as well. It would be interesting to find out how to allocate resources in pieces on different factors of each dimension in order to achieve the specific goal for a company. Since we argue that the distance traveled by an organization is proportional to the cost associated with the adoption decision, our research can be extended to estimate the potential expenses. A complementary research is to find the benefits of XML adoption so that it would enable businesses to have a cost-benefit analysis of the adoption decision.

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