Horizontal and Vertical Factors Influencing the Adoption of Web Services

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Abstract

Organizations across many industries are implementing or exploring Web services technology. According to recent industry surveys, however, many organizations are still hesitating to adopt Web services on a larger scale. This article explores the challenges organizations are facing and identifies factors that can lead to differences in the adoption of Web services between industries. While Web services at their core are a horizontal or cross-industry technology, the findings of this exploratory study suggest that there are important vertical or industry specific factors that can either promote or inhibit the adoption of Web services in a particular industry.

1. Introduction

Web services technology is expected to play a pivotal role in information systems (IS) development and integration [3, 19], but it has arguably not been as widely adopted for major applications on a larger scale as some of its proponents have suggested [32]. A recent industry survey [1] reports that 68% of respondents stated that their deployment of Web services are on hold until the various standards bodies reach some agreement on how Web services will actually work. Barely 5% of the respondents classified their firms as large-scale Web services-based SOA deployment sites, having more than 20 Web services in production and these services are shared between two or more business units across the enterprise. Most firms are still in the early stages of adoption and have only a few (<5), if any, Web services in production.

This article explores the challenges of Web services adoption based on the experiences of eight firms in four different industries. This study is an extension of a previous study [7] that identified several barriers to the adoption of Web services as experienced by firms in the financial industry. The main objectives of this research are to identify and explain horizontal factors that pose a challenge across industries and vertical factors that can explain varying adoption progress in different industries.

2. Literature review

2.1 Innovation adoption research

The adoption of new information technology (IT) has been widely researched in the past and several models have been established to explain adoption decisions and processes. For instance, Moore and Benbasat [26] developed the Perceived Characteristics of Innovating (PCI) belief constructs to measure the perceptions of adopting an IT innovation. PCI builds on Roger's [29] work of the diffusion of innovations, which incorporates five characteristics as antecedents to any adoption decision: relative advantage, compatibility, complexity, trialability, and observability. PCI incorporates three of these constructs: relative advantage, compatibility, and trialability. It further replaces complexity with ease-of-use and adds visibility, image, result demonstrability, and voluntariness. Other IT adoption models that address an individual's technology adoption decision are the technology acceptance model (TAM) [9] and, more recently, the unified theory of acceptance and use of technology (UTAUT) [37].

Studies of innovation adoption have primarily focused on two different contexts: individual level and organizational level [13]. The latter is relevant in the context of infrastructure technologies, including Web services. In the context of EDI, Kwon and Zmud [21] and Premkumar et al. [28] utilize five broad categories of variables that influence the adoption of an innovation: innovation, environmental, organizational, task, and individual characteristics. These studies focused on the organizational level adoption of EDI and found only three categories to be relevant: innovation, environmental, and organizational. DePietro et al. [10] also used those same three categories as the elements of a firm's context that influence the process by which it adopts and implements technological innovations. This technology-organization-environment (TOE) framework has also been applied in other research on IT adoption [18, 39].

The results of some studies suggested that environmental factors are the predominant forces that motivate firms to adopt [28, 35], while others [6] found that organizational factors emerged as the most salient for the adoption of interorganizational IT. We will use the TOE framework to organize our findings and employ the

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antecedents of adoption of PCI [25] to discuss the challenges of Web services adoption. The unit of analysis for this study is the organization. While the antecedents of adoption of PCI have originally been developed for individual adoption of technology, they also provide a useful framework for analyzing the adoption of technology at the organizational level.

2.2 Web services

Analogous to the World Wide Web Consortium (W3C) [14], we define Web services as a software system designed to support interoperable machine-to-machine interaction over a network with an interface described in a machine-processable format (specifically WSDL). Other systems interact with Web services in a manner prescribed by its description using SOAP messages, typically conveyed using HTTP with an XML serialization in conjunction with other Web-related standards. A service registry based on the UDDI standard can be employed to publish and discover Web services. It is important to note that we clearly distinguish Web services from other forms of XML-based messaging that do not employ WSDL descriptions and the SOAP messaging protocol.

Web services technology has received a significant amount of attention in trade publications and more recently in the academic literature, as well as through academic conferences. Several articles and surveys indicate that Web services have gained substantial traction, are being implemented [3, 19], and are among the significant investments in IT that organizations are making today [30]. Key benefits that are frequently associated with Web services are ease and cheapness of connectivity [15], leveraging to create a more flexible IT infrastructure, and possibly the generation of new revenue streams [16]. Web services, therefore, may impact software development, the nature of IT jobs [8], and how IT and businesses operate. To date, however, a high level of adoption of Web services is not commonplace [32]. For many organizations, the immaturity of certain Web services related standards, particularly in the areas of process management, reliability, and security, is a key concern. In some cases, such as reliable messaging, the issue is not the absence of technical solutions and proposed standards, but the availability of one commonly accepted standard [20]. According to a Gartner analyst, about 95% of Web services being done today are internal between single-vendor systems, while external Web services are single-partner in nature as a means to address security [32].

Performance and the complexity of applications based on Web services are also cited as important issues [12, 22, 26]. Other articles indicate that the return on investment is unclear and that it is difficult to obtain management buy-in [4, 38]. The adoption of Web services can entail organizational changes that may be difficult to manage and necessary IT skills may not be readily available [8, 16]. While Web services are supported by most IT vendors, it appears that the support for standard Web services APIs and the availability of effective tools is still lacking in some key areas of application development (i.e., testing of Web services) [27, 31]. Finally, although a substantial number of organizations are experimenting with Web services, many organizations appear to hold back on large scale deployments due to a lack of convincing result demonstrability in a major "use case" of Web services [2, 24] in their industry.

2.3 Industry factors

The results of our previous study suggest that environmental factors play a major role in the adoption of Web services. Presumably, the environment in which a firm operates is likely to vary between industries. Some of these differences may be pertinent to the adoption of Web services. In the context of EDI, for instance, the power relationships between firms in a specific industry have played an important role in the adoption of EDI. The power that a relatively large and influential firm has over another firm, which has been examined in past EDI research (e.g., [17, 33, 35]), is likely to vary the adoption of Web services in different industries. In the past, firm size has also been identified as a factor influencing the adoption of new technologies. Large firms are more likely to adopt new technology than small firms [36]. Another difference relevant to the adoption of Web services is the maturity of vertical standards for business-to-business exchanges [5, 23]. "Mindlessly" adopting new technologies without consideration of industry-specific characteristics can result in undesirable levels of risk-taking [34]. Consequently, we expect that the industry context in which Web services are adopted is important and that the adoption of Web services is likely to vary between industries.

3. Conceptual model

This study attempts to identify key factors that are challenges for the adoption of Web services by examining eight cases in four different industries. In our previous study [7], which solely focused on the financial industry, we applied the TOE framework [10] to organize and discuss the factors that emerge from the case evidence. The model provides three categories: technology (innovation), organizational, and environmental. Since the focus of this study is to elicit and examine factors across industries, we extended the model by further distinguishing factors in the environment category into horizontal and vertical factors (see Figure 1).

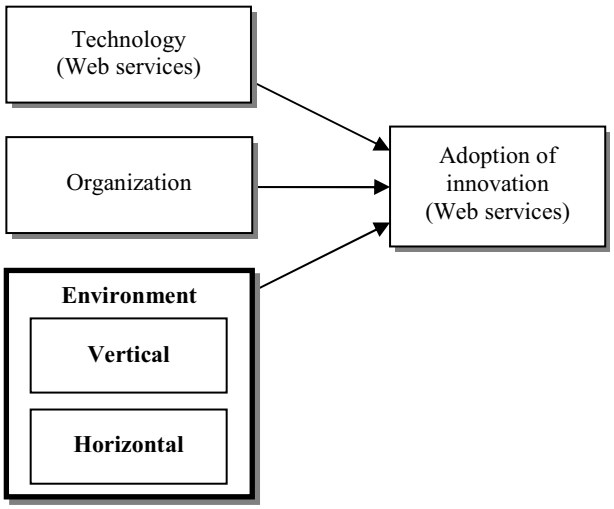

Figure 1. Categories of factors

Factors in the horizontal environment category are expected to have similar implications across industries, while vertical factors are expected to differ between industries, with respect to their relevance and assessment. Consequently, these factors can help explain and perhaps predict the variation in the adoption of Web services in different industries. An awareness and further examination of these factors are important for IT decision makers trying to determine the value of Web services for their particular business and its particular environment. We will view our case evidence through the lens of the key antecedents of the adoption of PCI [25].

4. Methodology

This study employs a multiple case research strategy to explore the adoption of Web services technology. This strategy was chosen because the adoption of Web services is a contemporary event that can be observed in a real-life context, for which little prior academic research has been published. This research addresses which factors influence the adoption of Web services as well as how and why these factors play a role.

4.1 Research design

In this study it was important to gain an understanding of how organizations approach the adoption of Web services. A goal was to elicit a variety of approaches and challenges. Therefore, we decided to use a multiple-case design rather than focusing on a single case. Multiple case designs further allow for cross-case analyses, which force the investigator to look beyond initial impressions and see evidence through multiple perspectives [11].

4.2 Case and participant selection

We choose four new cases from non-financial industries to complement our four previous cases. All of the organizations are major national organizations in their respective industries in the United States. While availability limited the selection of participating organizations, we obtained eight cases with varying levels of Web services adoption and industry characteristics that provided us contrasting results. For each case a minimum of two participants were selected based on the recommendations of our contact person. At least one individual had technical expertise with respect to designing and implementing Web services technology (e.g., an IS analyst) and at least one had managerial responsibility for the Web services projects and a broader business perspective (e.g., a vice-president of information systems). In total, we interviewed 17 individuals in eight participating organizations during the spring of 2004 and spring of 2005.

4.3 Data collection and analysis

The interviews lasted on average 45 minutes. All but three interviews were conducted face-to-face. The three interviews with organization F3 were conducted by phone. The interview process was guided by a semi-structured interview guide. This guide contained eight open-ended questions and was used by interviewers to ensure that all relevant areas of interest were consistently addressed in the interviews. The questions elicited the firm's organizational and IT background, the perspective and involvement of the interviewee, current Web services initiatives, expected benefits, the key challenges, long-term solutions and temporary workarounds, as well as key lessons learned in dealing with Web services technology.

Each interview was recorded and transcribed. The researchers then created summaries of the transcripts and provided the participants with an opportunity to make corrections, such as adding important details or removing sensitive information. In addition, a description for each case was produced, which is summarized in the case evidence (section 5). Each summary was interpreted by each of the three researchers independently. Several potential factors and categorizations (e.g., security concerns, immature standards, etc.) were identified prior to the analysis based on the literature review. While some theoretical constructs were known a-priori, the nature of their relationship with adoption was not known and the possibility for additional factors of influence was left open. The findings from the individual cases are consolidated and presented in the cross-case analysis below (section 6).

5. Case evidence

Interviews were conducted with eight organizations from the financial, manufacturing, retail, and health care industries. Their Web services exposure ranged from several years of development and use to those considering use in the near future. The following is a brief summary of each organization interviewed and their specific views related to the challenges of adopting Web services.

5.1 Organization F1

The first organization has Web services applications that have been operational for over a year. It is primarily a provider as opposed to a consumer of these Web services. The organization has a large number of mainframe computers and historically provided user interfaces to applications on these systems. Its second generation of systems involved the development of a series of more than a dozen separate web applications. These web applications were supported by servers that interfaced with the legacy mainframe systems and allowed the end users to have a graphical user interface. Each of these systems was developed independently in Java (pre-dating EJB's) and did not follow a standard architecture. The third generation of these systems is currently under construction. The plan is to convert all of these existing applications to Web services. The organization is using IBM WebSphere as the server. These systems all pass XML messages, which use industry standards (IFX and OFX) when possible. Web services are not published in a public registry and initially Web-services were only available internally within the firewall or through a virtual private network (VPN). More recently the WS-Security standard was leveraged to secure some Web services. Its primary motivation to move towards Web services was to provide a standard platform for development, provide a method for integration of the various systems, and support its desire to reuse code.

5.2 Organization F2

The second organization has many applications in production that employ "pre-Web services" XML-based messaging, but has a limited adoption of actual Web services. The organization is primarily a J2EE shop. Most applications use thin client technologies, but there are also some rich client applications that have been developed in Visual Basic and C++, more recently leveraging the Microsoft .NET platform. Prior to the introduction of Web services, the organization developed its own standard for formatting XML messages similar to SOAP within its own firewall and used IBM MQ Series for messaging. It considered this home grown architecture to be service-oriented. As the number of .NET applications grows, the likelihood of seeing more Web services applications will increase, since it would be more difficult to move the application to the MQ Series approach.

5.3 Organization F3

The third organization operates as an application service provider and licenses the financial software it develops. Its software is written with the J2EE standard using the Eclipse development tool as well as Oracle development tools and runs on WebSphere application servers with Sun Solaris and IBM AIX as operating systems. All the messaging between these EJBs and the servlets that support the graphical user interface is using a proprietary format based upon XML. While some industry standards exist (e.g., OFX and IFX) they do not provide all the data required in some of their existing applications. While the architectural structure could be converted to a Web services model, the cost of conversion currently outweighs its benefits. The real drive for change will occur when the organization's key customers or partners start demanding functionality delivered through standard Web services.

5.4 Organization F4

The fourth organization's primary role is to serve as the facilitator of business-to-business communications between consumers and financial services vendors. These vendors represent significant players in the financial industry and they exert great influence over the protocols by which communication takes place. The development platform is J2EE and the development environment is Eclipse. The applications run on UNIX servers using the BEA Web Logic application servers and the Apache Web server. The transport protocol used is primarily MQ Series with some using HTTP or FTP. The organization does not currently have any Web services applications. While it sees a number of benefits related to Web services, it is only delivering what its business partners demand. If its business partners were to require Web services, it would meet those requirements.

5.5 Organization M1

The fifth organization is a manufacturing organization. The company is currently putting integration structure in place to facilitate moving to a service-oriented architecture. The organization has a variety of platforms ranging from HP Unix systems running J2EE based applications to Microsoft Windows servers running ASP and VB applications. One application is currently Web services-enabled and plans exist to interface the HR package (PeopleSoft) with existing systems and the portal project using Web

services. XML over HTTP was previously used to feed information to the existing portal, but the portal vendor has discontinued this feature. The call center application package is Web services-enabled, which may provide an opportunity to employ Web services.

5.6 Organization M2

The sixth organization is a manufacturing organization that currently does a lot of EDI between both its suppliers and its customers. The environment includes IBM mainframes, Sun Solar Unix servers, and Microsoft Windows servers. Its currently in the middle of a large project of implementing an ERP system worldwide. Some of this EDI is leveraging the traditional proprietary approach and some is using Web-based EDI carried over value-added networks (VAN). The organization has been involved in a small project using Web Services. It sees Web Services as providing an opportunity to reduce latency (providing real time data and inventories with all its partners), therefore allowing for cutting costs. It is concerned that Web services may currently offer more hype and real functionality and is waiting until it can demonstrate a good cost benefit for using the technology.

5.7 Organization R1

The seventh organization is a large retailer. It has two major IT divisions: corporate IT and retail locations. Its corporate efforts include a lot of legacy COBOL applications running on their IBM mainframes, with all new work being developed using J2EE running on AIX servers. One Web service application has been developed to interface with a third party system. A second application interfaces to an interactive voice response (IVR) system. IT's second effort is support of the organization's many retail locations. The approximately 1,000 retail locations use a single IT model, which is based on the Microsoft Windows platform. A major Web service project in this area is in the "proof-of-concept" stage that will be used to communicate inventory demands among the retail locations and the corporate location.

5.8 Organization H1

The eighth organization is an intermediary in the health care industry. It connects customers with suppliers for long-term health care products. Historically it has interacted with business partners using EDI, first through VANs and now primarily through HTTPS. It also has some experience transferring XML over HTTP. Essentially all IT is based on the Microsoft Windows platform and most applications are custom developed in-house using either VB, C++, and more recently C#. It currently is developing its first Web services with a supplier to transmit data in real time. It sees Web services as a solution to move from a batch mode, which is typical of EDI, to real-time interactions. As a technology leader in the long-term health care industry, it faces the challenge of convincing business partners of the value of moving to Web services in a highly fragmented industry that is traditionally slow to adopt any new technology.

6. Cross case analysis

The data analysis of the cases led to a number of key themes that emerged from the evidence. The following analysis presents these key themes, or challenge factors, across all eight cases. We distinguish vertical factors that have the potential to explain variation of Web services adoption between industries and horizontal factors that play a role independent of industry. The four new cases reinforced the findings from the previous study that a key challenge for adoption is the lack of external demand for Web services, regardless of the industries represented in this study. The demand for Web services is influenced by factors that are industry specific, as well as factors that apply to any organization considering the adoption of Web services. The key vertical factors that emerged in the case evidence are industry leadership and vertical payload standards. Industries can also vary in their response to new technologies in general, whether it is fax or Web services. Our case evidence suggests that industry fragmentation can play a key role in this respect.

Table 1. Case-factor overview

			F1	F2	F3	F4	M1	M2	R1	H1
Environment	Vertical	Industry leadership		+		+	+		o	
		Industry fragmentation								+
		Vertical standards		+	+	+	+	+		o
	Horizontal	Partner demand	o	+	+	+	+	+	+	+
		Alternative technologies	o	+	o	o	+	o	+	+
		Vendor support								
		- Tools					-	-	-	-
		- API		+			-	o	-	
		Security	o	+	+	+	+	o	+	+
Org.		Justification and ROI		+	+	+	+	+	+	
		Management support			+		+		+	
		Web services expertise								
		- Technical	-		-	-	-	-	-	+
		- Conceptual			o	-	+	+	+	-
Tech.		Performance					o		+	

In addition, there are also a number of challenges that organizations across industries are facing, including Web services expertise, justification, management support, alternative technologies, performance concerns, vendor support, and business partner demand. An overview of the factors and their manifestation for each case is

provided in Table 1 above. A "+" indicates that statements made by the participants suggest that the factor is a challenge to the adoption of Web services. A "–" indicates that statements explicitly suggest that this factor is not a challenge. A blank indicates that factor was not addressed in the case, and a "o" indicates that the factor was addressed but the statements made by the participants are inconclusive.

6.1 Vertical factors

6.1.1. Vertical standards maturity. Participants from several cases mentioned the immaturity of vertical "payload" standards as an important challenge to the adoption of Web services. Although from a technical perspective Web services are independent from XML-based payloads, the availability of industry standards appears to be an important factor in the larger picture of Web services use. A participant from organization M1, for example, mentioned that the lack of industry payload standards is inhibiting it from exposing functionality as a Web service because it is not clear which format would be appropriate for its potential business partners. A participant from organization M2 pointed out that payload definitions are a key challenge as current industry standards are immature and too basic to be useful. He further added that the organization itself is not in a position to provide the payload definitions. This has to be accomplished through an industry consortium to gain the necessary acceptance. Particularly in industries that are not dominated by a few "big players" that can just push their definitions, the lack of vertical standards inhibit organizations to be leaders in providing Web services. Different industries are at different stages in the process of forming consortia and developing vertical payload standards. As a result, the progress of Web services adoption can be expected to vary between industries based on the maturity of vertical payload standards.

6.1.2. Industry leadership. While B2B interactions are only one aspect of Web services, it has relevance regarding the adoption of Web services technology. There are several industries, such as the automotive and financial industry, in which a majority of participating businesses has to interact with a few big players. In this scenario, the adoption of a new technology largely depends on the leadership that the dominant organizations provide. A participant in the M2 case, for instance, pointed out that one large retailer that is a major customer of the manufacturer is currently focusing on AS2 rather than Web services. The organizations in the financial industry also provided evidence that major players have not yet moved from proprietary protocols to standard Web services. As the power structures and technology leadership can be expected to vary between industries, so can the adoption of Web services technology, at least to the extent they are used for B2B interactions.

6.1.3. Industry fragmentation & inertia. The adoption of any new technology is generally more difficult in a highly fragmented industry with many relatively small sized businesses [36]. This is illustrated in the case of organization H1. Many customers as well as some suppliers are very small organizations with limited IT resources and a lack of IT expertise. The adoption of new technologies, whether it was fax or the Web, has historically been slow. Although there are substantial benefits for H1 to provide a standard interface, such as drastically reducing the number of different interfaces that need to be maintained, it will be difficult to persuade relatively small sized firms to adopt Web services.

6.2 Horizontal factors

6.2.1. Business partner demand. The lack of business partner demand for Web services is still an important inhibitor to its adoption. This appears to be true not only for the financial industry, but in all our cases. These findings are consistent with other industry surveys [1] that show a majority of organizations still holding back on large scale Web services deployments.

6.2.2. Availability of web services expertise. The participants differentiated among the types of expertise that is necessary to develop Web services-based applications, including technical skills, conceptual skills, and tool skills. Technical skills, such as knowing an appropriate implementation language (e.g., Java or C#) or knowledge of the relevant standards (mainly WSDL and SOAP), were viewed as "just another technology to learn" and not considered a major challenge by most participants. As multiple participants pointed out, the bigger issues are the conceptual changes and "change in mindset" involved in moving towards a distributed and service-oriented application architecture.

Beyond the individual skills, the IT function of organizations faces the challenge of developing the ability to effectively agree on standards and foster the reuse of components. Some participants further suggested that the IT function may also face changes as there will be a need for new roles (e.g., service librarian), new ownership and control structures, as well as new software development processes.

6.2.3. Justification and ROI of web services. The issue of justifying and demonstrating a sufficient ROI for Web services was mentioned as a challenge by all organizations. Common problems were the difficulty to find an appropriate case to demonstrate the benefits of Web services and the obscurity or indirectness of some of the potential benefits. As one participant from

organization H1 pointed out, customers may not see the immediate advantages of Web services working behind the scenes and view the introduction of a Web services-based solution as just another technology they need to adopt. The difficulty of linking Web services to immediate business benefits was also corroborated by statements made from participants in organization R1. A participant from organization M2 mentioned that the current ROI is not sufficient for rapid adoption, as Web services do not offer anything that matters to their business that cannot be achieved with some alternative technology, albeit less flexible and more costly in the long run.

6.2.4. Management awareness and support. Several participants pointed out that Web services use on a larger scale would require a strategic mandate from upper management. Several participants noted that current software development priorities do not permit sufficient time and resources to seriously explore and assess Web services and SOA.

6.2.5. Alternative technologies. Other technologies that are employed instead of Web services are still an important challenge to the adoption of Web services. AS2, CORBA, JMS, and XML over HTTP (or HTTPS) were mentioned as possible alternatives to using SOAP messages in conjunction with WSDL service descriptions. While these alternatives lack the level of standardization and/or some features offered by Web services, they may already be used by the organization and are sufficient to accomplish a particular task or they may be imposed by dominant organizations (e.g., AS2).

6.2.6. Performance of web services-based applications. Performance was mentioned as a potential challenge in two cases. In the case of organization R1 some Web services would have to process information from several million rows of data from a database. Converting and sending this data as XML documents could further slow down applications. In another case, the sentiment was that the use of Web services may only add additional and arguably unnecessary layers that require expensive transformations between applications that could otherwise communicate in a native protocol. The performance issue, however, has not been confirmed in actual use or testing of Web services by any of the participating organizations.

6.2.7. Vendor support for web services. The support for Web services by IT vendors can be a determining factor of whether Web services or some alternative technology are used. As one participant stated, "The way the […] tool is designed you're kind of forced […] to use a certain architecture, and that's how the Web services end up in there." The increasing support for Web services in development tools and making them the preferred API for integration in packaged applications provide strong incentives for organizations to adopt Web services to the extent that developers may sometimes be "forced" to use them.

The participants with experience in developing applications using Web services noted that the tools support is good. In fact, the existing tool support is viewed as a contributor for software development efficiencies, a key benefit associated with the use of Web services. It is important to pick the right tool, however, as the H1 case illustrates. The initial open source tool selected in this case was replaced with a commercial tool after it became clear that the open source tool was not able to correctly create valid WSDL documents from given C++ classes.

6.2.8. Security. Security, including confidentiality, integrity, and availability of information exchanged via Web services, is an issue that concerned all participating organizations. Security standards around Web services have been established only recently (e.g., WS-Security became an OASIS standard in March 2004); however, custom security arrangements between business partners using Web services have been used for some time, as with XML over HTTPS. A member of one of the participating organizations in the financial industry recently stated that his organization views Web services as an opportunity to streamline and consequently improve security by using Web services in conjunction with the recent security standards. Security, however, was viewed by some participants as more of a business and standards problem rather than a technical problem. Clearly, the perceived maturity of Web service security standards is a crucial element for the broader adoption of Web services. Without a reasonable "peace of mind" when exposing Web services or when consuming external services, the availability of Web services will likely remain limited and not reach the critical mass necessary to realize key benefits associated with Web services, such as reuse and flexibility.

7. Discussion

The following summarizes a number of noteworthy findings from the analysis organized by the three broad categories of innovation: technology, organizational, and environmental. In this discussion, we relate the factors to the antecedents of PCI [25] (see Table 2) and provide an assessment of the importance of the challenges emanating from each group of factors.

Table 2. Antecedents of PCI assessment

Antecedent	Assessment
Relative advantage	Relative advantage not clear in most cases, few benefits have been realized in small scale Web services applications. Focus on software development efficiencies.
Compatibility	Few compatibility issues regarding the existing technical skills. Conceptually, however, Web services can require a new mindset. Overall compatibility is not a major issue.
Trialability	Trialability does not seem to be an issue. All organizations experimented with Web services technology in some way.
Ease-of-use	The perception of ease-of-use appears to be fairly high (e.g., good tool support)
Visibility	Visibility of Web services is high
Image	Web services are one of the newer technologies for all organizations. No strong opinions were voiced for or against Web services. The image appears to be neutral.
Result demonstrability	Difficult to find real examples within industry, thus low result demonstrability.
Voluntariness	Not an issue in this context. The adoption of Web services is usually not an individual decision.

7.1 Technology

As an innovation, Web services technology does not appear to pose a major challenge. It is widely visible in the trade press and other publication outlets, and there is no indication that it is perceived as particularly complex. The participants underscored the ease-of-use and potential for development efficiencies associated with Web services, partly due to the good tool support. Participants indicated that their organizations would be ready to move to Web services as soon as they were demanded. Only one participant described Web services as an immature technology. There clearly are concerns regarding security in the context of Web services. However, the concerns were directed at the immaturity of security standards and a lack of knowledge rather than the general ability to secure Web services, albeit in a non-standard way. Concerns about performance were mentioned by one participant, but not substantiated in actual tests or use of Web services. Overall challenges associated with the technology aspect of Web services as an innovation appear to play a marginal role.

7.2 Organizational

Some important challenges emerged at the organizational level. A key problem appears to be the ability to justify the adoption of Web services, as it is often difficult to establish a clear link between Web services and business benefits. Web services are an infrastructure investment, and its benefits, such as flexibility and development efficiencies, are largely obscure to customers, may not be realized immediately and may only become substantial if Web services are adopted on a larger scale. While most organizations are confident that their developers and IT organizations will be able to easily learn the technical aspects of Web services, several participants stated that using Web services in the context of a service-oriented architecture requires a different mind set. Some training will be required to provide individuals as well as the IT organization as a whole with the capability to effectively leverage Web services. Efficiencies in software development were identified by participants from all organizations as a key benefit of Web services in a SOA. The case evidence suggests that the relative advantage, a key antecedent for adoption, is currently not evident for many organizations. Compatibility of the innovation with the organizational resources (e.g., developer skills) and requirements, on the other hand, does not seem to pose a major challenge. While the participating organizations only have a few or no Web services in production, the trialability of Web services has not been noted as a problem. In fact, most organizations we interviewed had experimented with Web services technology. Overall, organizational factors are considered a moderate challenge for Web services adoption.

7.3 Environmental

As IT decision makers have to take into consideration the specific context (i.e., industry or industry segment) in which the organization operates, we distinguish horizontal environment factors from vertical factors that can be expected to vary between industries. Three important vertical factors emerged from the cases: vertical standards development, industry leadership, and industry fragmentation (see Figure 2). The availability of vertical payload standards is important for the compatibility of Web services offerings, not only at the messaging level, but also at the business document level. The case evidence suggests that a lack of payload standards will inhibit organizations from offering Web services to business partners. The lack of industry leadership and examples of best practices within an industry affects, for instance, result demonstrability, another important antecedent for adoption. The fragmentation of an industry and the small size of participating organizations [36] generally slow down the adoption of a new technology.

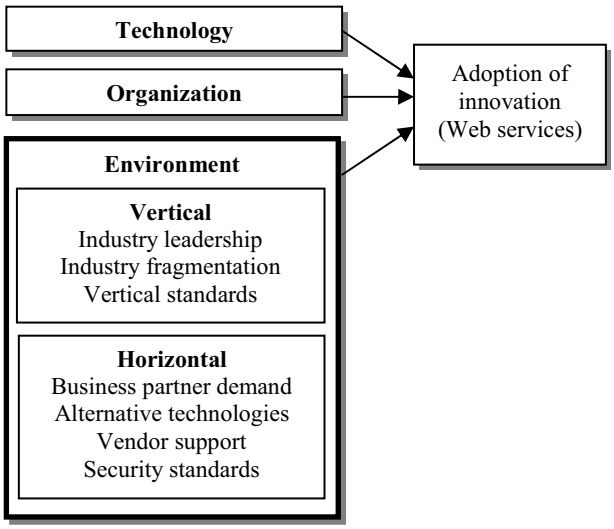

Figure 2: Environmental adoption challenges

One of the key challenges in using Web services for B2B interactions is the lack of demand by business partners in combination with the availability and existence of alternative technologies. Due to a lack of demand and uncertainty regarding vertical industry standards, a "chicken-and-egg" problem exists both from a Web services consumer and Web services provider perspective. This situation makes it difficult to justify the immediate adoption of Web services.

8. Conclusion

Our case studies corroborate a recent survey that the adoption of Web services is still slow. We examined several factors that pose a challenge. Some factors are universal for all organizations, while a number of vertical factors can be expected to differ between industries. Therefore, the pace of adoption can be expected to vary between industries as well. For IT decision makers, it is important to be aware of and carefully assess these factors to make "mindful" adoption decisions [34].

It is important to note that the findings of this study only reflect the current experiences of these eight organizations. The importance of factors may vary over time, and factors that were not mentioned in these cases may surface. As in most case studies, the ability to generalize the findings is limited. Further research will be necessary to substantiate the findings. One approach is to develop a quantitative survey based on the findings from this study. A longitudinal approach in which we revisit the organizations at a later time could be helpful to compare current attitudes towards adoption with actual adoption (or non-adoption) decisions in the future.

9. References

[1] C. Adam, "From Web Services to SOA and Everything in Between: The Journey Begins", http://www.webservices.org/index.php/ws/content/view/full/63404 (accessed 2005, June), 2005.

[2] L. Bielski, "Web Services Goes Live: One Deployment at a Time", *American Bankers Association (ABA) Banking Journal,* 2003.

[3] M. Brown, "The Integration Report", *EAI Journal,* 5, 2, 2003, 29-30, http://www.bijonline.com/Article.asp?ArticleID=660.

[4] M. Chen, "Factors Affecting the Adoption and Diffusion of XML and Web Services Standards for E-Business Systems", *International Journal of Human Computer Studies,* 58, 3, 2003, pp. 259-279.

[5] E. Christiaanse, "Performance Benefits Through Integration Hubs", *Communications of the ACM,* 48, 4, 2005, pp. 95-100.

[6] P. Chwelos, I. Benbasat and A. S. Dexter, "Research Report: Empirical Test of an EDI Adoption Model", *Information Systems Research,* 12, 3, 2001, pp. 304-321.

[7] A. P. Ciganek, M. N. Haines and W. D. Haseman, "Challenges of Adopting Web Services: Experiences from the Financial Industry", *38th Hawaii International Conference on System Sciences,* Big Island, HI, 2005, pp. 1-10.

[8] E. C. Cuneo, "Tech-Driven: How Web Services Could Change IT Jobs", *InformationWeek,* 936, 2003, 30-31,

[9] F. D. Davis, "Perceived Usefulness, Perceived Ease of Use, and User Acceptance of Information Technology", *MIS Quarterly,* 13, 3, 1989, pp. 319-340.

[10] R. DePietro, E. Wiarda and M. Fleischer, "The Context for Change: Organization, Technology, and Environment," in *The Process of Technological Innovation*, L. G. Tornatzky and M. Fleischer, Eds. Lexington: Lexington Books, 1990, pp. 151-175.

[11] K. M. Eisenhardt, "Building Theories From Case Study Research", *Academy of Management Review,* 14, 4, 1989, pp. 532-551.

[12] N. D. Evans, *Business Innovation and Disruptive Technology*, Prentice Hall, Upper Saddle River, NJ, 2003.

[13] R. G. Fichman, "Information Technology Diffusion: A Review of Empirical Research." *Thirteenth International Conference on Information Systems,* Dallas, 1992, pp. 195-206.

[14] H. Haas and A. Brown, "Web Services Glossary", http://www.w3.org/TR/2004/NOTE-ws-gloss-20040211/ (accessed 2004, June 10), 2004.

[15] J. Hagel, "Edging into Web Services", *McKinsey Quarterly,* 2002, 29-37.

[16] J. Hagel and J. S. Brown, "Your Next IT Strategy", *Harvard Business Review,* 79, 9, 2001, pp. 105-113.

[17] P. J. Hart and C. S. Saunders, "Emerging Electronic Partnerships: Antecedents and Dimensions of EDI Use from the Supplier's Perspective", *Journal of Management Information Systems,* 14, 4, 1998, pp. 87-111.

[18] C. L. Iacovou, I. Benbasat and A. S. Dexter, "Electronic Data Interchange and Small Organizations: Adoption and Impact of Technology", *MIS Quarterly,* 19, 4, 1995, pp. 465-485.

[19] InfoWorld, "InfoWorld Research Brief on Web Services Applications", *InfoWorld,* 2002,

[20] C. Koch, "The Battle for Web Services", *CIO Magazine,* 2003, http://www.cio.com/archive/100103/standards.html.
[21] T. H. Kwon and R. W. Zmud, "Unifying the Fragmented Models of Information Systems Implementation," in *Critical Issues in Information Systems Research*, R. J. Boland and R. A. Hirschheim, Eds. New York: John-Wiley, 1987, pp. 252-257.
[22] M. LaMonica, "Trying to Make Web Services Make Sense", http://news.zdnet.com/2100-3513-5242747.html (accessed 2004, September 27), 2004.
[23] A. McAfee, "Will Web Services Really Transform Collaboration?" *MIT Sloan Management Review,* 46, 2, 2005, pp. 78-84.
[24] M. S. Mimoso, "Web Services Can be a Means of Generating Revenue", http://searchwebservices.techtarget.com/originalContent/0,289142,sid26_gci968487,00.html (accessed 2004, June 3), 2004.
[25] G. C. Moore and I. Benbasat, "Development of an Instrument to Measure the Perceptions of Adopting an Information Technology Innovation", *Information Systems Research,* 2, 3, 1991, pp. 192-222.
[26] OASIS, "OASIS Announces Framework for Web Services Implementation (FWSI) TC", http://xml.coverpages.org/ni2003-09-29-a.html (accessed 2004, September 27), 2003.
[27] S. Olsen, "New Web Services Tools Look to Security", http://news.zdnet.com/2100-3513_22-964636.html (accessed 2004, September 28), 2002.
[28] G. Premkumar, K. Ramamurthy and M. R. Crum, "Determinants of EDI Adoption in the Transportation Industry", *European Journal of Information Systems,* 6, 2, 1997, pp. 107-121.
[29] E. M. Rogers, *Diffusion of Innovations*, The Free Press, New York, 1995.
[30] V. Sambamurthy, A. Bharadwaj and V. Grover, "Shaping Agility Through Digital Options: Reconceptualizing the Role of Information Technology in Contemporary Firms", *MIS Quarterly,* 27, 2, 2003, pp. 237-263.
[31] R. Seeley, "Search is On for Web Services Testing Tools", http://www.adtmag.com/article.asp?id=6678 (accessed 2004, September 28), 2002.
[32] C. Sliwa, "Users Proceed Cautiously On Web Services Track", *Computerworld,* 37, 48, 2003, pp. 10.
[33] M. Subramani, "How Do Suppliers Benefit from Information Technology Use in Supply Chain Relationships?" *MIS Quarterly,* 28, 1, 2004, pp. 45-73.
[34] E. B. Swanson and N. C. Ramiller, "Innovating Mindfully with Information Technology", *MIS Quarterly,* 28, 4, 2004, pp. 553-583.
[35] H. H. Teo, K. K. Wei and I. Benbasat, "Predicting Intention to Adopt Interorganizational Linkages: An Institutional Perspective", *MIS Quarterly,* 27, 1, 2003, pp. 19-49.
[36] C. G. Thirtle and V. W. Ruttan, *The Role of Demand and Supply in the Generation and Diffusion of Technical Change*, Harwood Academic Publishers, Chur, 1987.
[37] V. Venkatesh, M. G. Morris, G. B. Davis and F. D. Davis, "User Acceptance of Information Technology: Toward a Unified View", *MIS Quarterly,* 27, 3, 2003, pp. 425-478.
[38] C. Weaver, "Beyond Web Services: The Next Critical Step", *Web Services Journal,* 2, 7, 2002, 66, http://www.sys-con.com/webservices/article.cfm?id=291.
[39] K. Zhu, K. L. Kraemer, S. Xu and J. Dedrick, "Information Technology Payoff in E-Business Environments: An International Perspective on Value Creation of E-Business in the Financial Services Industry", *Journal of Management Information Systems,* 21, 1, 2004, pp. 17-54.