Enablers and benefits of implementing Service-Oriented Architecture : an empirical investigation

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2010

https://hdl.handle.net/10356/100024

https://doi.org/10.1504/IJITM.2010.029432

Enablers and Benefits of Implementing Service-Oriented Architecture:

An Empirical Investigation

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10 July 2006

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Abstract

This paper examines the key managerial factors affecting service-oriented architecture (SOA) implementation in organisations, and whether the implementation of SOA provides benefits to organisations. Based on a cross-sectional survey with 108 organisations, we found that top management support was a significant enabler for SOA implementation. We also found that organisations implementing SOA gained the benefits of improved application integration and the ability to establish external linkages with business partners more quickly.

Author Biographies

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<center>**Enablers and Benefits of Implementing Service-Oriented Architecture:**
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1. INTRODUCTION

Integrating IT systems across the enterprise is a highly complex undertaking, and is thus also time-consuming and resource-intensive (Sandoe et al. 2001). A lack of integration across disparate IT systems developed independently by business units has been a prevalent problem in the industry (Hagel III and Brown 2001; Ross 2003). This creates considerable challenges to organisations in generating a consistent view of their customers, suppliers, and other entities, and in their process improvement initiatives (Bhatt 2000). The lack of systems integration becomes particularly problematic as organisations shift from largely independent business functions to interdependent functions, and from product-based to relationship-based services (Keen 1993). It also poses significant problems in mergers and acquisitions (Hagel III 2002).

Service-oriented architecture (SOA) has often been touted as the 'silver bullet' to solve the systems integration problem (Hannon 2005). SOA refers to an architecture comprising a collection of IT services supporting the enterprise, often (but by no means exclusively) leveraging Web service technologies. Each service is an interface encapsulating a well-defined unit of functionality. Services can be grouped to create aggregate services (Zhang et al. 2005). This grouping is often accomplished by orchestration, which defines the sequencing of calls to services, and may hold information about the state of the business process (OASIS 2006; Peltz 2003). A key idea in SOA is to remove composition and workflow logic from the business function and put it into a separate layer, thereby making it easier to re-use business functions in other contexts and to alter workflows as needed for changing business requirements.

Claimed benefits of SOA include greater business flexibility, better IT utilisation, integration of historically separated systems, faster implementation of new systems, and

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better leverage of existing assets (Bieberstein et al. 2005; Cherbakov et al. 2005; Crawford et al. 2005). These claims, however, remain empirically untested and unverified. Research has not examined managerial issues related to SOA, or provided empirical evidence of the impacts of implementing SOA (Chen et al. 2006). In this paper, we study two key research questions: (1) What are the key managerial factors affecting the implementation of SOA? (2) To what extent does the implementation of SOA benefit organisations?

There are two key contributions of this study. First, ours is the first study to provide empirical evidence across a large number of organisations about the benefits of implementing SOA. Many companies implementing SOA feel that it falls short of expectations due to higher than expected costs, and that organisations are not reaping the benefits expected from implementing SOA (Babcock 2005). Lim & Wen (2003) showed that the business value of employing Web services represents the top concern of organisations. Our study proposes three key potential benefits of SOA: (1) internal application integration, (2) increased capability in establishing external communication links and (3) productivity benefits from shortened systems development cycle time. These benefits result directly from SOA implementation. It is through the leveraging of capabilities created by these first-order benefits that organisations can gain second-order benefits such as increased flexibility and cost savings. Our results provide guidance to organisations in determining the business value of SOA and provide realistic goals regarding what they can and cannot hope to achieve using SOA.

Second, our study identifies factors critical to successful SOA implementation. Prior research on SOA or Web services has focused on the technical aspects of SOA implementation. Several articles highlight that implementing SOA requires organisational changes, which go beyond simple technological implementations (Crawford et al. 2005; Hagel III and Brown 2001). However, little work has examined this topic in-depth, and that work focuses mainly on prescribing tasks that organisations need to complete in order to implement

SOA (e.g., Bieberstein et al. 2005; Cherbakov et al. 2005). We examine the importance of two factors that are potentially critical in ensuring the success of SOA implementation: (1) top management support and (2) the centralisation of IT decision-making. The results of our empirical analysis provide significant guidance to managers in determining the key barriers and enablers that affect efforts to implement SOA in their organisations.

This paper continues as follows. In the next section, we discuss the research model. We present hypotheses about (1) key managerial factors affecting the implementation of SOA, and (2) the effects of implementing SOA. The next section describes the research methodology and design of the firm-level cross-section survey conducted to test the research model. Finally, we present the analysis results and discuss the main research findings and implications.

2. THEORY AND RESEARCH MODEL

SOA is touted as an answer to the problem of inconsistent architecture that prevents applications from being rapidly developed, integrated, and reused (Crawford et al. 2005). Traditionally, new interfaces must be written to connect one system to another. Each connection is created for a specific purpose, and modifications of the connected systems often require recoding of the interfaces. The expense and effort to establish connections across IT systems thus increases exponentially with the number of systems connected. Furthermore, rules for business processes are often hard-coded into IT systems. As a result, it is difficult to change them. Organisations thus incur tremendous costs in redesigning existing code and in creating new connections between systems to keep up with changing business conditions.

SOA takes a different approach; it relies on defining a common set of services that can be reused in different contexts (Brown and Hagel 2004). SOA calls for separating individual business functions from how these functions are coordinated to achieve a particular goal. The implementation of SOA represents a component-based approach, where an IT-enabled

business process is decomposed into a set of well-defined IT services orchestrated by a flexible workflow process. SOA thereby facilitates component re-use and flexible re-composition of individual services (Huang et al. 2005).

The basic technologies underlying SOA are not new: the ability to encapsulate the function of an application behind a public interface, and a standard way for clients to connect and access the application via this interface. The origin of SOA can be traced to remote procedure calls (Birrell and Nelson 1984). The advent of object-oriented computing popularised this idea with Object Management Group's Common Object Request Broker Architecture standard (www.**corba**.org/). This ultimately led to distributed system standards such as J2EE (Enterprise Edition) for Java, and vendor-specific implementations such as .NET by Microsoft. But these technologies can be difficult to integrate with existing technologies. Hence the advent of Web services standards (Turner et al. 2003), which are built on open Internet standards and are easier to use across different types of systems. Although these technologies are useful enablers for SOA, their adoption does not provide a *de facto* SOA; rather, SOA requires careful application of architectural principles and an understanding of which IT functions to encapsulate and the proper interfaces in which to display them within a larger IT context.

Organisations can implement SOA to different extents. Some organisations may only define the interfaces and components of their SOA; others may implement SOA for a subset of their projects. Finally, some companies may invest significant resources in defining and implementing enterprise-wide SOA. Hence, in this paper, we examine empirically the antecedents influencing the extent of SOA implementation in organisations, and the benefits they gain from implementing SOA to different extents. In the rest of this section, we present the hypotheses and research model, which are summarised in Figure 1.

Figure 1 About Here

2.1 Factors Affecting the Implementation of Service-Oriented Architecture

Prior research on SOA focuses on the technology and technical standards underlying SOA. To our knowledge, only Cherbakov et al. (2005) and Bieberstein et al. (2005) have examined managerial issues and business strategies for implementing SOA. Both papers prescribe methodologies for moving towards SOA implementation, but provide limited evidence to support their arguments. Cherbakov et al. (2005) described an on-demand organisation or a 'service-oriented enterprise', which componentises not only its IT systems, but also its business. In this way, enterprises provide business services using business components seamlessly linked internally and across firms. Cherbakov et al. (2005) describe the changes necessary to create the service-oriented enterprise, and explained benefits potentially arising from such organisations. Bieberstein et al. (2005) discuss the managerial and organisational aspects of SOA implementation. They provide a prescription of key tasks required to institute organisational changes for SOA implementation, including establishing IT directives, a funding structure that encourages the development of SOA, a steering committee, various project controls, and different types of standards and methodologies to guide the SOA implementation.

While both works provide significant insights into what organisations should do for SOA implementation, they focus on prescribing specific methodologies. Other methodologies, however, may also enable successful SOA implementation. Hence, instead of examining the tasks involved in SOA implementation, this study focuses on factors that can affect SOA implementation. Prior research stresses the importance for broad organisational and managerial changes to develop SOA management capabilities (Bieberstein et al. 2005; Cherbakov et al. 2005; Crawford et al. 2005; Hagel III and Brown 2001). This study focuses on two relevant organisational factors–top management support and centralisation of IT decision-making (Grover et al. 1996). Both factors have been found important for the success

of enterprise IT initiatives (Ahadi 2004; Wells 1998). Although these two factors are not exhaustive, they are representative of key governance and structural factors likely to impact SOA implementation.

2.1.1   Top Management Support

Top management support is recognised as important for IS projects and IS management (Aladwani 2002). It relates primarily to having commitment from top management for IS initiatives. A top management team that promotes, supports, and guides the IS function enhances the impact of IS resources on performance (Wade and Hulland 2004) and thus plays an important role in the success of any IT endeavour (e.g., Ahadi 2004; Aladwani 2002; Kambil et al. 2000).

The implementation of SOA is not only a matter of adopting new technology. It requires broad organisational and managerial changes and the development of new kinds of capabilities (Bieberstein et al. 2005; Chen et al. 2003b). To effect such pervasive changes, top management support is important to facilitate the mobilisation of resources and to positively influence the attitudes of IT personnel toward SOA implementation. Since implementing SOA requires changes in IT practices, and also requires strong linkages between the business and IT, management support is especially critical for successful implementation (Hagel III and Brown 2001). Hence, we hypothesise:

H1: The level of top management support for an architectural approach to enterprise integration will be positively associated with the extent of service-oriented architecture implementation.

2.1.2   Centralisation of IT Decision Making

Prior research has extensively examined the impact of centralisation of IT decision-making on the management of IT resources (Peterson 2004; Sambamurthy and Zmud 1999, 2000). A centralised IT decision-making structure is present when decision authority resides

primarily with a central corporate IT unit. Conversely, a decentralised IT decision-making structure is present when decision authority resides primarily with business units (Brown and Magill 1998). Centralisation affords greater efficiencies or economies of scale and standardised controls and organisational integration, while decentralisation provides local control and ownership of resources and better responsiveness to business unit needs (Brown and Magill 1994). The centralisation of IT decision-making is expected to affect the implementation of SOA in several ways. First, to implement SOA, organisations have to define shared services to re-use across applications, and the service interactions. Centralising IT decision-making greatly facilitates the process of having all IT personnel work together in identifying and implementing the shared services. Centralisation also facilitates the adoption of standards critical to the implementation of SOA (Boh et al. 2003), and enables organisations to put in place consistent rules and processes that facilitate re-use of shared services. Finally, having a centralised IT decision-making structure enables sharing and leveraging of IT personnel's experiences, skills, and knowledge in managing and developing SOA. Hence, we hypothesise:

H2: The extent of centralisation of IT decision-making will be positively associated with the extent of service-oriented architecture implementation.

2.2 Impacts of Implementing Service-Oriented Architecture

In addition to examining factors influencing the implementation of SOA, we also examine the impacts of SOA implementation. Various studies highlight the potential benefits of SOA for internal integration and for establishing external communication links with business partners (Brown and Hagel 2004; Chen et al. 2003b; Erlanger 2005; Hagel III 2002; Hagel III and Brown 2001). The potential productivity benefits from the ability to re-use components defined by the SOA have also been underscored (Brown and Hagel 2004; Chen et al. 2003b; Erlanger 2005; Kobielus 2005; O'Donnell 2005). The literature suggests that

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internal application integration, ease of setting up communication links with external partners, and productivity improvements from re-use are key goals and benefits of implementing SOA (Lim and Wen 2003). We thus focus on these benefits.

Other benefits such as increased flexibility (Chen et al. 2003b; Hagel III 2002) and cost savings (Brown and Hagel 2004; Lim and Wen 2003) are second-order benefits that depend on the organisation's ability to leverage the increased internal and external integration, and from shortened development cycles enabled by SOA. We did not examine these second-order benefits, for several reasons. First, we believe it is important to examine whether organisations can reap the direct benefits from SOA implementation. Second, as SOA is still in the early stages of development, and most organisations have only recently implemented SOA, the technology may not be sufficiently mature for us to examine second-order benefits such as reduction in costs or improvement in flexibility.

2.2.1   Impact of SOA on Application Integration

Without effective coordination across business units, individual applications are developed in a decentralised manner, which optimises the local unit's business needs without consideration for the need to integrate across applications. Over time, applications become independent silos residing on multiple technology platforms with their own defined sets of data (Ross 2003). Prior approaches to integration have focused on the creation of point-to-point application interfaces to enable applications to communicate with one another. Hardwiring connections between applications creates maintenance problems, as the effort for integration increases exponentially when the number of components to be connected increases. By employing a loose-coupling strategy of defining and reusing the shared services across multiple applications, SOA is expected to improve enterprise application integration (Chen et al. 2003b; Erlanger 2005). Hence, we hypothesise:

H3: The extent of service-oriented architecture implementation will be positively associated with the extent of application integration in the enterprise.

2.2.2   Impact of SOA on External Communication

SOA has the potential to improve systems integration, not only within the organisation, but also with trading partners outside the organisation (Chen and Meixell 2003; Chen et al. 2005; Cherbakov et al. 2005). As different organisations tend to adopt incompatible technology platforms and communication standards, it is often difficult to establish inter-organisational electronic links (Chen 2003). Traditionally, inter-organisational linkages are established with proprietary and therefore expensive electronic data interchange (EDI) standards. Complexity also increases exponentially as the number of point-to-point EDI linkages increases. This approach therefore restricts the flexibility of organisations in responding to new business opportunities (Hagel III 2002).

The implementation of Web services helps to automate connections between business partners (Brown and Hagel 2004; Hagel III 2002). Adopters of Web services can potentially gain the most by implementing Web services at the edges of their enterprises–where limitations of existing IT architectures are most apparent and onerous (Hagel III 2002). They make use of industry XML standards to connect proprietary and heterogeneous applications and systems that tie their companies to business partners (Chen and Meixell 2003; Hagel III and Brown 2001). XML is a key technology element in SOA, whereas legacy systems make it difficult to exploit XML. SOA provides middleware to help legacy systems exploit emerging XML industry standards (Chen et al. 2003a; Manes 2003). Hence those companies that implement SOA are also more able to use industry XML standards for setting up communication links with business partners. We hypothesise:

H4a: The extent of service-oriented architecture implementation will be positively associated with extent to which organisations use industry XML standards for communicating with their business partners.

Industry XML standards help business partners to share document formats and information for processing of business transactions (e.g., inventory information, product status, billing information). There is no need to negotiate individually with each business partner to agree on a set document formats or data structures for transaction processing. All communication between partners makes use of a similar set of industry standards, which greatly reduces the response time needed to set up an external communication link. Hence, we hypothesise:

H4b: The extent to which organisations use industry standards for communicating with their business partners will be associated with shorter response time in setting up external communication links.

2.2.3   Impact of SOA on Systems Development Time

SOA is also expected to improve organisational flexibility and agility in responding to a changing business environment (Cherbakov et al. 2005; Erlanger 2005). By decomposing business logic into a set of services, and isolating the workflow logic into its own layer, organisations can more easily re-use services and create new business flows using different orchestration rules (Peltz 2003). The ability to re-use common services across different applications, and the ability to easily assemble different services into new business offerings is expected to greatly reduce new applications development time (O'Donnell 2005; Zhang et al. 2005). SOA has been 'promoted as a model of efficiency for software development, a way of bringing plug-and-play ease to software services' (Babcock 2005, p. 40), and has been claimed to reduce systems development cost by 30% compared to traditional development approaches (Kobielus 2005). Hence, we hypothesise:

H5: The extent of service–oriented architecture implementation will be associated with shorter systems development cycle time.

3   RESEARCH DESIGN AND METHOD

3.1 Methodology

We conducted a cross-sectional firm-level survey to empirically test our research model and hypotheses. The survey was part of a larger study. It was developed based on exploratory interviews conducted with five organisations and eight system architect consultants. Survey questions were reviewed with four other system architect consultants. Each spent two hours reviewing the questionnaire, explaining how they interpreted each question and answer option, and estimating the extent to which organisations would be able to answer each question. We also reviewed the survey with a usability expert and a statistical expert. We then conducted a pilot study with 30 organisations, after which we checked the reliabilities of the scales and examined which questions respondents had the most difficulties answering. The survey was shortened based on this analysis. The responses of the 30 respondents were included in the final analysis.

The data collection for the survey took place between November 2003 and July 2004. The survey invitation letter stated that the survey was targeted at the chief IT architect or the person in the respondent organisation who had broad IT architecture responsibilities. The survey was implemented on the Web. Survey respondents came from three main sources. First, we sent invitations to IBM clients through consulting architects, who were members of an enterprise architecture virtual community in IBM. The community had a mailing list to keep architects informed about the latest updates in this subject area. Through this mailing list, we requested system architect consultants to forward the invitation for the survey to the appropriate person in their client organisation and encourage their participation. Consultants were also requested to inform us about invitations they forwarded to their clients. Based on

the responses we received from the consultants, we estimated that invitations were sent to 166 client organisations. 135 survey invitations were sent to participants in an IBM insurance industry application architecture conference. We also approached an association–The Open Group–to help us to gain access to their members. The Open Group is an international consortium that focuses on helping organisations integrate technology and IT systems across the enterprise. The association helped us disseminate information about the survey to their members, and posted the link to our survey on their Web site. Through this association, we estimate that invitations were accessible to 170 organisations (the total number of firms participating in the Open Group). In total, invitations were sent or made available to 471 organisations.

We targeted these three sources for several reasons. First, IBM clients were targeted because IBM Global Services has a significant emphasis on helping organisations achieve better integration of IT resources, and many clients are implementing SOA to achieve these objectives. Second, participants in the IBM insurance application architecture conference were generally very interested in using an architectural approach to solve systems integration problems. Moreover, the insurance industry has to deal with many challenges due to its legacy systems, and the potential benefits of SOA are especially important to this segment. Finally, member organisations of the Open Group Association are committed to encouraging greater integration of IT resources in their enterprise through an architectural approach. These three samples are therefore representative of companies concerned with improving the integration of IT systems in their organisation.

The response rate was most favourable for the IBM client group (51.8%). This is probably because consultants had direct access to the person in the organisations most interested in taking the survey, and thus were able to follow up with clients on multiple occasions to encourage them to take the survey. Table 1 provides a breakdown of the

response rate by the three groups of respondents. We examined whether there were significant differences in responses among the three sample groups. Our results showed that the IBM client group was more likely to implement SOA. Hence, we included a control variable in our analysis to indicate whether the respondent was from this group. We also conducted a sensitivity test to examine how our results would differ if we used responses only from this group. The results remained unchanged.

Table 1 About Here

We received a total of 112 responses. There were four organisations with two respondents each. We averaged the responses for these four organisations, thus yielding a total of 108 respondents, for a 22.9% response rate. There were 18 incomplete responses, leaving 90 complete and usable responses. In return for their participation, respondents received a benchmarking report that compared their performance in enterprise architecture management against other respondents. Figure 2 shows the breakdown of our respondents' roles. [1] The profile of respondents shows that they have the ability and are in the position to respond adequately to our questions.

Figure 2 About Here

3.2 Operationalisation of Variables

The survey instrument items for testing our hypotheses are in Appendix A. The items used for this study constitute only part of the survey, which included a total of 129 questions. We adapted survey instruments from prior literature where relevant. However, we created new survey items for assessing the implementation of SOA and its outcomes. This is because measures for these constructs in the enterprise context are not available. For example, while there are measures of systems development performance for specific systems under study (e.g., Gopal et al. 1997), we could not locate any measure that assessed the extent to which

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[1] Even for respondents who chose the 'Other' category, ten of the respondents indicated they were either in the consulting role for their organization regarding IT architectural issues, or they were working in the IT department and were responsible for IT architectural issues.

organisations were able to meet their targets in their systems development performance across most of their projects.

Implementation of service-oriented architecture. To assess the extent of SOA implementation, we asked respondents to indicate the extent to which their organisation has: (1) defined the key interfaces of their SOA; (2) identified its key components; and (3) invested time and allocated resources to move towards SOA. In this way we measured both the commitment in moving towards SOA, and concrete architectural progress towards that goal.

Application integration. Respondents were asked what percentage of key application systems supporting the core business processes were integrated using a common middleware approach (e.g. using 'integration bus/hub' or synchronous/ asynchronous messaging). This question gets at the notion of an *enterprise service bus*, common in SOA. We also asked respondents the extent to which functional boundaries of individual applications and components had been clearly defined.

External communication links. To assess the extent to which organisations have used industry standards to create linkages with their business partners, we first asked respondents how much they make use of industry standard XML for communication with external partners. We also asked them how much they made use of a common architecture for communicating across their organisation's distribution channels, supply chain, or business partners. We then assessed the time they required to set up external communication links by asking them the number of months required for their organisation to establish electronic links with new business partners.

Systems development cycle time. We asked respondents to indicate the extent to which their organisation has achieved its targets with respect to: (1) the time taken to process maintenance requests for key systems supporting core business processes; and (2) the time

taken for IT to develop systems to support major new products being introduced to the market. Note that we did not ask for absolute times taken for development, as that varies greatly by task. Instead we asked about their ability to meet target deadlines.

Top management support. We adapted measures of top management support from Aladwani (2002) and Nelson and Shaw (2004), asking respondents to rate the extent to which their top management provides sufficient resources and grants the necessary authority for architecture projects.

Centralisation of IT decision-making. Prior literature generally differentiates between two key aspects of IT management: management of IT infrastructure, and management of IT systems development. As we are focused on the implementation of service-oriented architecture that affects application development, we measured the centralisation of IT decision-making with regard to systems development. We adapted the measures of Kim and Lee (1991) and Olson and Chervany (1980) to determine the extent to which decisions regarding the prioritisation and approval of application development projects, and IT development and implementation, are centralised in a corporate IT unit, or decentralised in individual business units.

Other control variables. We controlled for the size of the organisation by asking respondents about the overall size of the enterprise and the number of IT personnel in their organisation. As about half of our respondents were from the finance and insurance industries, we included a dummy variable to control for these two industries. We also included a control for whether the respondent was from the IBM client group.

3.3 Test of Factors

Content validity was qualitatively assessed through reviews by experts, and through the pre-test. We assessed convergent and discriminant validity through principal components analysis (see Appendix B). All items loaded high in their respective factors (loading > 0.6).

Reliability of the survey instrument's items was also quantitatively validated by calculating Cronbach alphas. Standardised alphas ranged from 0.590 to 0.882 and are itemised in Table 2. The alphas for most constructs are greater than the commonly accepted 0.7 threshold (Nunnally 1978). Exceptions are the external partner communication and development, and maintenance performance constructs. As these are self-developed items, and due to the exploratory nature of the examination of SOA implementation benefits, we feel that these levels are acceptable for our purpose.

Table 2 About Here

Convergent validity is demonstrated if items that measure the same factor correlate highly with one another. The correlation matrix (see Appendix C) shows that correlations of all items measuring the same construct were significantly different from zero at the 0.001 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. An examination of the correlation matrix of items reveals that only 4 (2.23%) of the 179 comparisons of within-factor correlations associate higher with an item outside the factor. Hence, discriminant validity is established (Chau and Tam 1997).

To address possible common method bias effects, we performed Harman's single-factor test (Harman 1967). If a significant amount of common method bias exists in the data, then a factor analysis of all the variables in the model will generate a single factor that accounts for most of the variance. Unrotated factor analysis using the eigenvalue-greater-than-one criterion revealed six factors, and the first factor explained only 27.4 percent of the variance in the data.

4   DATA ANALYSIS AND RESULTS

The research model and hypotheses were tested using partial-least-squares (PLS; Chin et al. 2003). PLS is suitable for estimating multiple and interrelated dependence relationships such as those in our research model. The PLS measurement model provides the loadings of individual items on their variables. Table 3 displays the results of variable loadings analysis in the PLS measurement model for the final set of retained items. The items loaded highly (> 0.6) in their respective constructs. Table 4 displays the descriptive statistics and correlation analysis of the constructs used to test the hypotheses. The highlighted diagonal cells are the square root of Average Variance Extracted and the off-diagonal cells are the correlations between constructs. The values in the diagonal cells are considerably higher than all other cells in the same row, highlighting the high discriminant validity.

Tables 3 and 4 About Here

The structural model of the PLS analysis shows the variance explained (R^2), path coefficients, and significance levels of the path coefficients between latent constructs of the research model (Gefen et al. 2000). Similar to the linear regression, an R^2 in the PLS analysis provides the strength of the model in predicting each dependent variable. Path coefficients in the structural model specify the strength of each individual relationship. The support, or lack thereof, for our hypotheses is provided by the size and direction of the path coefficients and is reported with the p-value (Bollen 1989). The results of the PLS model are provided in Table 5, and summarised in Figure 3.

Table 5 and Figure 3 About Here

We tested hypotheses 1 and 2 by examining the extent to which top management support and centralised IT decision-making affected the extent of SOA implementation. The results of the analyses provide support for H1, but not H2. Our results show that top management support was positively associated with SOA implementation (H1, path

coefficient = 0.284, p< 0.01). The centralisation of IT decision-making appeared to have no significant relationship with the extent of SOA implementation (H2, path coefficient = 0.143, p > 0.10).

Hypotheses 3, 4a, 4b, and 5 were also tested by examining the extent to which SOA implementation affected application integration, communication with external partners, and systems development cycle time. The results supported H3, H4a, and H4b, but not H5. Organisations with a greater extent of SOA implementation had a significantly higher level of application integration (H3, path coefficient = 0.442, p< 0.001). They were also more likely to use a common platform and industry XML standards in establishing external communication linkages with their business partners (H5a, path coefficient = 0.559, p<0.001), and those who did so took significantly less time to set up external communication links (H5b, path coefficient = -0.287, p<0.01). We did not find that the extent of SOA implementation had any significant impact on the systems development cycle time (H6, path coefficient = 0.183, p>0.10).

5 DISCUSSION

Our empirical results provide partial support for our research model. Top management support was a significant organisational enabler for implementing SOA. This shows the importance of obtaining top management support and commitment when organisations are moving towards the implementation of SOA. Senior management is critical in providing the resources and authority to the architecture team or to the Chief Architect to facilitate their work. Some qualitative comments captured in our survey provided further support for this hypothesis: 'If it's going to deliver the benefits to the enterprise it needs the commitment of Senior Management and the sponsorship of a Senior Executive at Board level'. [Quote from Respondent]

The centralisation of IT decision-making was not significantly associated with SOA implementation. This may be because a large part of the value of SOA is directed at business applications. Hence, to reap the benefits of SOA, business unit managers who are the business application owners and those with deep knowledge of the individual applications must be involved. This expertise is often outside the centralised IT shop and within the lines of business. Hence, regardless of whether IT decision-making is centralised or not, implementation of SOA requires the involvement of users and managers. Moreover, as highlighted by Bieberstein et al. (2005) and Cherbakov et al. (2005), there is a series of tasks that organisations can do to ensure the smooth implementation of SOA, even when their IT decision-making is not centralised. These include putting directives in place, setting up steering committees, and establishing various governance mechanisms and standards to help organisations implement SOA.

In terms of the benefits of implementing SOA, we found that organisations that had a well-defined SOA were more likely to have a greater extent of integration across their applications. These organisations were also more likely to handle their external communication links with business partners through consistent standards, which helps them to be more efficient in setting up new external communication links. The association between SOA and using industry standards for external communication is particularly strong (path coefficient = 0.559), providing further support for the argument that many organisations gain benefits from implementing SOA at the edge of the organisation.

The implementation of SOA, however, did not significantly impact systems development cycle time. This is perhaps because shorter systems development cycle time is a long-term benefit that arises from re-use, and many organisations have only recently implemented SOA (Chen et al. 2003b). Re-use of services and components is not something that can be established overnight, as it takes time for organisations to build up the library of

shared services to be re-used across applications. Moreover, there is a significant ramp-up cost in building the initial set of shared services (Kobielus 2005). Finally, the ability to leverage SOA for re-use requires new governance mechanisms. It may be that organisations have not yet put these mechanisms in place, as they move along the learning curve and reflect upon their SOA implementation experience. While our results show that there is a positive relationship between SOA and the development cycle time, the relationship is not sufficiently strong to be statistically significant. Hence, the claims about the ability of SOA to improve organisational agility in responding to changes in the business environment have yet to be proven.

The results concerning the control variables were also interesting. First, bigger organisations were more likely to require more time to set up new linkages with business partners, likely because of more complex requirements and negotiations. Furthermore, we saw that organisations with stronger top management support were more likely to have shorter systems development cycle times. This is likely because these organisations tend to place a significant emphasis on the use of IT; hence they provide more resources for IT development, which shortens the systems development cycle time.

6   CONCLUSION

This paper has examined two key research questions: (1) What are the key managerial factors affecting the implementation of SOA? (2) To what extent does the implementation of SOA provide benefits to organisations? To answer the research questions, we conducted a firm-level cross-sectional survey of 108 organisations. Our results show that top management support was a significant organisational enabler of SOA implementation. Centralisation of IT decision-making did not significantly affect the extent of SOA implementation. In terms of the benefits of implementing SOA, we found that organisations that were further along in their SOA implementation were more likely to have better integration across their

applications. They were also more likely to handle external communication links with their business partners through consistent standards, which in turn helps them to be more efficient in setting up new external communication links. The implementation of SOA, however, did not appear to have a significant impact on the systems development cycle time. These results provide partial support for our research model.

6.1 Contributions and Implications

Our study contributes to the information systems (IS) research literature in several ways. First, there has been only limited research examining managerial issues related to SOA implementation (Chen et al. 2006). In this study, we identified and hypothesised about two key managerial factors that have been widely shown to affect the integration of IT resources. We showed that top management support was a key factor affecting the implementation of SOA. For managers, this shows the importance of obtaining senior management and broad organisational support for moving towards SOA. To be effective, SOA must be an enterprise-level initiative that involves both business units and IT personnel.

We also found that the centralisation of IT decision-making did not appear to have a significant association with organisations' ability to implement SOA. This implies that organisations with a decentralised IT decision-making structure have successfully implemented a SOA. Hence, managers should not be discouraged in pushing for SOA even if their organisation has a decentralised IT decision-making structure, especially since such organisations are the ones who need SOA the most.

In addition, while practitioners have proclaimed many benefits of SOA, empirical evidence supporting these claims is lacking in the literature (Chen et al. 2006). This study used a survey to empirically validate the claims of SOA benefits. We found that organisations implementing SOA gain benefits of improved application integration within their enterprises, and shortened the time required to establish external communication links with business

partners. This implies that SOA indeed appears to have significant business value for organisations that wish to improve the integration of applications within their enterprises, and to better link their systems with strategic business partners.

With the ability of SOA to help organisations integrate their applications and data internally, they will not only be able to reap cost savings from decreased maintenance costs, but also be able to gain strategic benefits from the ability to better manage data across the enterprise (Hamilton 1999; Mische 2002). The effective integration of data and applications will enable organisations to more effectively leverage existing data for decision-making, thus equipping organisations with the capability to respond better to changes in the business environment (Bhatt 2000; Madnick 1995).

The ability of SOA to facilitate systems integration with external partners also has significant implications for the performance of the firm. With rapidly changing business conditions, it is important for new business partners to be connected quickly and in a cost-effective manner (Hagel III 2002). Significant benefits ranging from operational cost savings to strategic benefits arise from connecting business partners with inter-organisational systems (e.g., Chatfield and Bjorn-Andersen 1997; Chwelos and Benbasat 2001; Iacovou et al. 1995). However, if it is expensive to create linkages between trading partners, organisations will lose their flexibility to leave specific business relationships without undue expense or technology investment write-offs (Hagel III 2002). Hence, the ability of SOA to shorten the time to create linkages between business partners will have significant impact on cost savings, and on increasing the flexibility and adaptability of organisations in creating and dropping existing linkages with business partners.

SOA, however, did not have a significant effect on the systems development cycle time, implying that SOA is not mature enough to affect systems development cycle time through re-use. Our results highlight the difficulty in establishing a re-use program in an

organisation. This implies that organisations cannot simply expect to reap the productivity benefits of shorter software development cycle time by implementing SOA, but need to consider other factors that affect software re-use (Kim and Stohr 1998; Sherif and Vinze 2003). In addition, the claims of SOA's positive effect on the agility of the organisation in responding to changes in the business environment appear unproven. Hence, organisations should not expect that SOA implementation will lead to the shortening of systems development cycle time, at least in the short term.

6.2 Limitations and Future Research

We have identified only two key factors affecting the implementation of SOA. There may be others. Building an enterprise SOA requires careful examination of the needs of the business, its daily operations, and its future requirements. Choices must be made as to which business functions to encapsulate behind a service interface, making sure that the SOA aligns with the flexibility required by business, in terms of both its present operations and its expected future needs (Cherbakov et al. 2005). Questions such as the granularity of the service and the quality of service required need to be considered (Brown et al. 2005). The governance model required for the management of SOA must also be considered.

Moreover, due to the exploratory nature of the examination of benefits of SOA, many items we used to measure the extent of SOA implementation and its benefits (e.g., external communication links, systems development cycle time) were self-constructed. Two of our constructs–the external partner communication and the development and maintenance performance constructs–have Cronbach alphas less than the threshold of 0.7 commonly accepted in prior research (Nunnally 1978). Hence, we recommend that future research work focus on improving the measures of IT performance at the enterprise level.

Our results for H2 show that effective SOA implementation does not depend on the centralisation of IT decision making in organisations. This points to the importance of

establishing appropriate governance mechanisms for enterprise-level IT initiatives like SOA implementation (Bieberstein et al. 2005; Cherbakov et al. 2005) as such mechanisms can help organisations in their SOA implementation, even in the absence of a centralised IT decision-making structure. Hence, it is important for future research to examine the types of governance mechanisms organisations should put in place to enable enterprise level IT initiatives such as SOA implementation (Boh and Yellin 2006).

Finally, as SOA is still in its early stages of development, our empirical study likely examines SOA implementation amongst a group of early adopters. As the technology matures and organisations gain more experience with SOA implementation, future research should continue to monitor the key enablers and benefits of using SOA and compare it with the results that we have obtained in this study.

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Figure 1. Overall Research Model
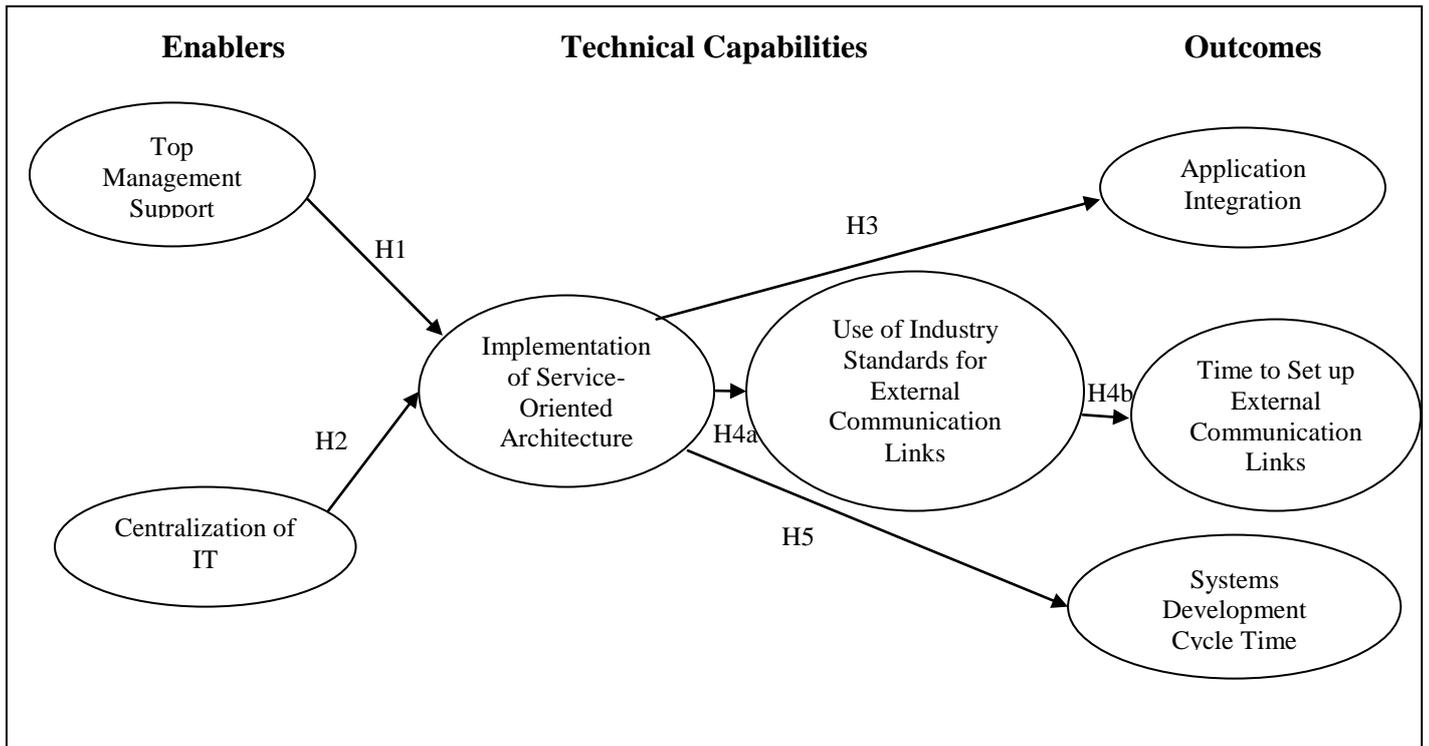
Figure 2. Profile of Respondents
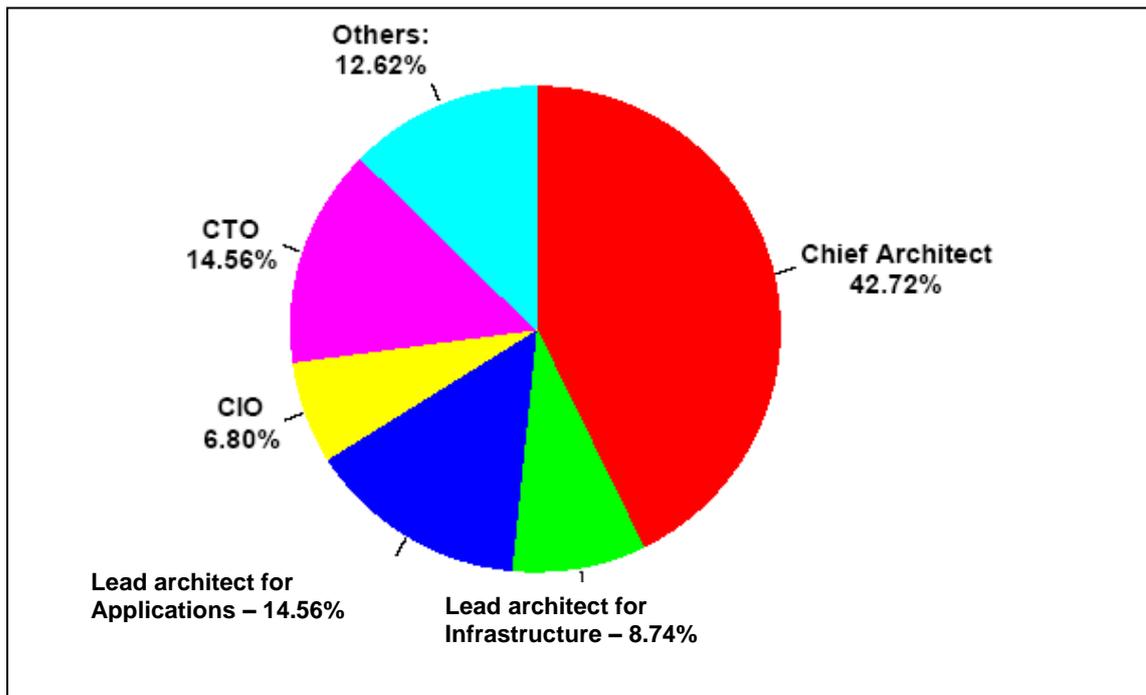
Figure 3. Summary of Results
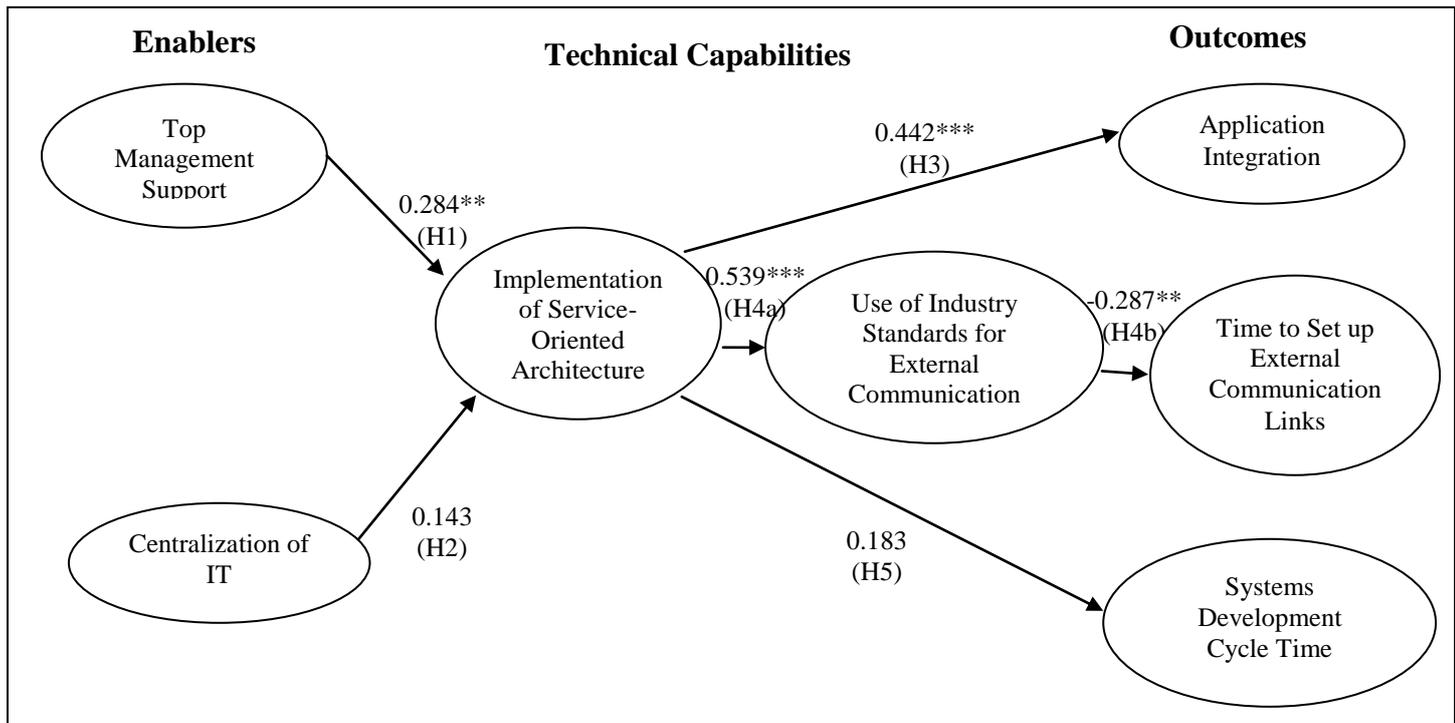
Table 1. Response Rate by Sample Groups

Sample Group	Total No. of Organisations	No. of Respondents	Response Rate
IBM clients	166	86	51.8%
Open group members	170	11	6.5%
Conference participants	135	11	8.1%

Table 2. Reliability of Factors

Construct	Number of Items	Standardised Cronbach Alpha
Application integration	2	0.741
Use of industry standards for external communication	2	0.590
Systems development cycle time	2	0.646
Implementation of service-oriented architecture	3	0.882
Top management support	2	0.743
Centralisation of IT	2	0.706
Organisation size	2	0.872

Table 3. PLS Variable Loadings

Construct Name	Item No.	N	Mean	S.D.	Weight	Loading	ResidVar	Communal	Redun
Application integration	1	86	2.198	1.452	0.599	0.888	0.211	0.789	0.189
	2	90	2.683	0.895	0.535	0.879	0.228	0.773	0.185
Use of industry standards for external communication	1	89	2.961	1.114	1.000	1.000	0.000	1.000	0.196
	2	89	2.899	1.180	0.576	0.848	0.281	0.719	0.253
Time to set up external comm.	1	83	1.771	0.704	0.612	0.850	0.277	0.723	0.254
Systems development cycle time	1	77	2.792	1.218	0.547	0.813	0.340	0.660	0.235
	2	80	3.106	1.250	0.641	0.868	0.247	0.753	0.268
Implementation of service-oriented architecture	1	89	3.000	1.146	0.382	0.919	0.156	0.844	0.202
	2	90	2.728	1.137	0.377	0.918	0.157	0.843	0.202
	3	90	2.589	1.186	0.361	0.839	0.296	0.704	0.168
Top management support	1	90	2.789	1.309	0.561	0.889	0.210	0.790	0.000
	2	90	2.444	1.203	0.563	0.890	0.208	0.792	0.000
Centralisation of IT	1	89	2.713	1.105	0.918	0.993	0.013	0.987	0.000
	2	89	2.511	1.118	0.138	0.640	0.590	0.410	0.000
Organisation Size	1	87	3.983	1.924	0.521	0.938	0.120	0.880	0.000
	2	85	3.035	1.219	0.549	0.940	0.116	0.884	0.000
Banking & insurance industry	1	90	0.467	0.502	1.000	1.000	0.000	1.000	0.000
Sample from IBM clients	1	90	0.889	0.316	1.000	1.000	0.000	1.000	0.000

Table 4. Descriptive Statistics and Correlation

	Composite Reliability	1	2	3	4	5	6	7	8	9
1) Application integration	0.877	.884								
2) Use of industry standards for external communication links	0.828	.360	.840							
3) Time to set up external comm..	NA	-.193	-.233	N.A.						
4) Systems development cycle time	0.838	.411	.409	-.241	.849					
5) Implementation of service-oriented architecture	0.922	.465	.582	-.114	.393	.893				
6) Top management support	0.884	.288	.235	-.143	.482	.363	.889			
7) Centralisation of IT	0.815	.190	.075	-.286	.342	.202	.272	.835		
8) Organisation size	0.937	-.010	.192	.318	.058	.181	-.004	-.327	.939	
9) Banking and insurance industry	NA	.073	.004	-.025	.024	.143	.210	.063	.040	N.A.
10) Respondents from IBM clients	NA	.094	.249	-.060	.270	.340	.182	.183	.227	.199

Table 5. Results of PLS Analysis

	Implementation of SOA	Application Integration	Use of industry standards for external comm.	Time to set up external comm. links	Systems development cycle time
Implementation of SOA		0.442*** (0.092)	0.559*** (0.090)		0.183 (0.115)
Top management support	0.284** (0.091)	0.141 (0.099)			0.362** (0.127)
Centralisation of IT	0.143 (0.103)				0.221 (0.153)
Organisation size	0.178+ (0.105)		0.083 (0.107)	0.392*** (0.099)	0.078 (0.118)
Banking and insurance industry			-0.092 (0.101)	0	-0.116 (0.095)
Respondents from IBM clients	0.221* (0.088)	-0.076 (0.075)	0.059 (0.115)	-0.078 (0.074)	0.104 (0.126)
Use of industry standards for external comm.				-0.287** (0.109)	
R-square	0.239	0.239	0.356	0.196	0.352

Note: Relationships between control variables and key dependent variables that were highly insignificant were not included in the final model.

Appendix A. Constructs, Measurement Scaling and Sources, and Items

Construct	Type of Scale	Sources	Items
Applications integration	Select the appropriate range for Q 1. 5-point scale; bounded by: strongly agree / strongly disagree for Q 2.		(1) What percentage of the key applications systems are integrated by a common middleware approach (e.g. using 'integration bus/hub' or synchronous / asynchronous messaging). (2) The functional boundaries of individual applications and components have been clearly defined.
Use of industry standards for external communication links			(1) To what extent do you make use of industry standard XML for communication with external partners? • We have no plans to use industry standard XML at the moment • Currently planning to begin discussions for using industry standard XML within the next 2-3 years • Currently in discussions with external partners to make use of industry standard XML for communication • Currently using industry standard XML for communication with some external partners (2) To what extent do you make use of a common architecture for communicating across your company's distribution channels / supply chain / business partners? • Not at all, and we do not have plans to do that within the next 2-3 years. • Not for the moment, but we have plans to do that within the next 2-3 years. • Currently in the process of implementing a common architecture for communicating with business partners. • A common architecture is currently in use for communication with some business partners. • A common architecture is currently in use for communication with all business partners.
Time to set up external communication links	Scale: - 0-2 months - 3-6 months - 6-12 months - >12 months		How long does it take your company to establish electronic links with new business partners?
Systems development cycle time	5 point scale: - Exceeds target - On target - 1-5% below target - 6-10% below target - >10% below target		Please rate the extent to which your company has achieved its target in each of the following areas: (1) Time taken to process maintenance requests for key systems supporting core business processes (2) Time taken for IT to develop systems to support major new products being introduced to the market

Construct	Type of Scale	Sources	Items
Implementation of Service-oriented architecture	5-point scale; bounded by: strongly agree / strongly disagree		Service-oriented architecture: A service-oriented architecture is a collection of IT services supporting an enterprise. A service is an interface encapsulating a well-defined unit of functionality. The implementation of the service can change without affecting the clients of that service. Services can be composed to create aggregate services. This composition is often accomplished by orchestration, which defines the sequencing of calls to services, and holds persistent data. Please rate the extent to which you agree with the following statements about your company: (1) My company has defined the key interfaces of a service-oriented architecture. (2) My company has identified the key components of a service-oriented architecture. (3) My company has invested time and allocated resources to move towards a service-oriented architecture.
Top management support	5-point scale; bounded by: strongly agree / strongly disagree	(Kim and Lee 1991; Olson and Chervany 1980)	To what extent do you agree with the following statements about your company (top management in this question refers to the top executives in lines of businesses or in the corporate office): (1) Top management provides sufficient resources to the architecture team. (2) Top management has granted the architecture team the necessary authority concerning architecture projects and work.
Centralisation of IT	5-point scale; bounded by: Centralised in Corporate IT Group / Decentralised in Lines of Business		To Measure Extent of Centralisation for IT Applications Development and Planning: What is the extent of centralisation for the following IT services in your company? (1) Application development projects prioritisation and approval (2) IT development and implementation
Organisational size			(1) How many people are working in your company? (2) How many people are working in the IT function in your company?

Appendix B. Results of Exploratory Factor Analysis

Construct Name	Item No.	App. Integ.	Develop. Time	External Comm. Link	Set Up Extl. Comm. Link	SOA	Mgt. Support	IT Central-isation	Org. Size
Application integration	1	.845	-.008	.101	-.052	-.283	-.100	.005	-.024
	2	.814	-.255	.093	-.066	-.154	-.084	-.015	-.026
Systems devlt. cycle time	1	-.278	.653	-.125	-.153	-.013	.428	.267	.019
	2	-.140	.806	-.063	.250	.281	.133	-.096	-.089
Use of industry stds. for external comm.	1	.231	-.002	.803	-.032	-.267	-.115	.176	.151
	2	-.002	-.429	.619	-.199	-.378	.032	-.204	.032
Time to set up external comm.	1	-.093	.124	-.099	.916	.042	.065	.092	.224
Implementation of service-oriented architecture	1	-.203	.141	-.122	.082	.885	.097	.071	-.013
	2	-.126	.149	-.158	.062	.890	.066	-.012	-.132
	3	-.265	.007	-.222	-.119	.695	.268	.174	-.125
Top management support	1	-.173	.106	-.044	.198	.048	.882	.034	-.173
	2	-.001	.174	-.039	-.100	.305	.799	.062	.213
Centralisation of IT	1	.089	-.104	-.056	-.035	.058	-.003	.907	.191
	2	-.153	.277	.186	.215	.131	.165	.740	.170
Organisation size	1	-.073	-.099	.022	.132	-.079	-.023	.221	.903
	2	.026	.031	.125	.093	-.116	.026	.100	.915

Appendix C. Correlation Matrix for Survey Items

Construct Name	Item No.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Application integration	1															
	2	.59														
Systems devlt. cycle time	1	.29	.33													
	2	.26	.35	.48												
Use of industry stds. for external comm.	1	.35	.28	.12	.25											
	2	.20	.30	.29	.44	.42										
Time to set up external comm.	1	-.15	-.19	-.11	-.31	-.07	-.30									
Implementation of SOA	1	.43	.32	.27	.42	.38	.46	-.16								
	2	.37	.29	.22	.41	.42	.47	-.12	.84							
	3	.40	.34	.32	.28	.34	.40	-.04	.66	.63						
Top management support	1	.24	.25	.49	.32	.18	.13	-.19	.26	.21	.32					
	2	.17	.22	.40	.33	.12	.21	-.06	.32	.31	.41	.59				
Centralisation of IT	1	-.03	-.08	.16	-.11	-.16	.13	-.09	.10	.03	.14	-.01	.12			
	2	.16	.23	.37	.25	-.10	.20	-.29	.24	.13	.18	.21	.29	.55		
Organisation size	1	-.03	-.05	-.01	.12	.21	.05	.32	.03	.20	.11	.11	-.14	-.35	-.31	
	2	.03	.04	-.07	.10	.28	.12	.28	.10	.20	.19	.08	-.11	-.27	-.27	.77