

# Does SOA Improve the Supply Chain? An Empirical Analysis of the Impact of SOA Adoption on Electronic Supply Chain Performance

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## Abstract

*Service Oriented Architecture (“SOA”) has been viewed as a strategic approach to IT that provides increased flexibility. However, there is scant research evidence of SOA adoption leading to tangible performance benefits across a cross section of firms. We fill this research gap by empirically analyzing the impact of SOA adoption on the performance of electronic supply chains for a cross section of large US firms. We find that adoption of SOA does lead to better performance of the electronic supply chain. We also find that SOA moderates firm’s ability to leverage electronically integrated customers to achieve better electronic supply chain performance. Further, we show that the impact of SOA adoption is fully mediated through its moderation effect on the firm’s ability to leverage electronically integrated customers to achieve higher electronic supply chain performance. Lastly, the paper discusses how IT managers can make informed SOA adoption decisions.*

## 1. Introduction

*“We can't say, Do SOA because it will give you a much more flexible set of systems. There's no metric that says if I'm more agile I will save X percent. The number-one difficulty with SOA is that it's hard to get the ROI down to the spreadsheet level.” -- Daniel Sholler, Vice President of Research, Gartner [1]*

While the benefit of Service oriented architecture (“SOA”) in terms of organizational agility is well accepted, IT managers are increasingly becoming concerned about the net performance impact of SOA adoption, as indicated by the quote above. Previous academic research on SOA has not provided any cross-sectional assessment of SOA’s performance impact. We fill this research gap by providing empirical evidence of the positive performance impact of SOA adoption on electronic supply chains for a wide cross-section of US based firms.

SOA is a software architecture approach where the basic element of design and development is a service [2]. Applications communicate with each other in such

architectures through services. Services are self-describing components, which can be recognized by client applications through look up from a registry (such as UDDI: Universal Description, Discovery and Integration). The client application and the service provider communicate via standard protocols (e.g. SOAP, HTTP) and exchange information using standard data formats like XML. SOA has come to prominence as previous software architectures based on object-oriented approaches suffer from a lack of standards when compared to SOA [3]. Attempts for distributed architectures including distributed component architecture (DCOM), remote method invocation (RMI), and the common object resource broker architecture (CORBA) were proprietary and lacked interoperability with vendor applications [3]. This has caused rapid expansion of SOA deployment with claims by vendors of significant improvement in organizational agility and operational efficiency.

According to a recent survey by IDC [4], the worldwide spending on SOA is likely to reach about \$9 billion by 2009. Another survey by Aberdeen group [5] indicates that 45% of companies surveyed have projects underway involving SOA in their supply chain and another 17% plan to start such projects in the next 12 months. Among this rapid growth in SOA deployment, IT managers are faced with concerns about net ROI of their SOA investments. While IT managers have to make a decision on SOA adoption to facilitate migration to new technology platforms and to enable efficient information exchange in their supply chain, they have little information available about organizational impact of SOA adoption, especially about impact of SOA adoption on supply chain performance. Although previous IS research has focused on general benefits from adoption of web technologies [6] and electronic supply chains [7][8], to our knowledge there has been no broad cross-sectional empirical study of supply chain performance impact of adoption of new web technologies or architectural paradigms. We bridge this research gap in this study by empirically analyzing the impact of SOA adoption on performance of electronic supply chains.

Drawing from previous research on supply chains and web technologies, we analyze the impact of SOA adoption on the performance of electronic supply

chains for a broad sample of large US companies. We then study the moderating role of SOA adoption on the firm's capability to leverage electronically integrated customers, suppliers and partners to achieve better electronic supply chain performance. Finally, we synthesize the results to discover the mediating path of the impact of SOA adoption on electronic supply chain performance.

We find empirical support for a positive relationship between SOA adoption and performance of electronic supply chains. We also find that SOA adoption moderates firm's ability to leverage electronically integrated customers to achieve better electronic supply chain performance. Finally, we show that the impact of SOA adoption on performance of electronic supply chain is fully mediated through its moderation effect on firm's ability to leverage electronically integrated customers to achieve better electronic supply chain performance. Thus, we not only show that SOA adoption improves supply chain performance, we also discover the underlying mechanism and the causal path through which this supply chain performance improvement takes place.

This study contributes to both research and practice. On the research side it contributes to the literature on electronic supply chain and empirically establishes the impact of SOA adoption on supply chain performance. On the practice side, we provide IT managers not only with an assessment of the impact of SOA adoption on supply chain performance; we also synthesize our results to develop an SOA adoption framework. Thus, this research, though exploratory in nature at this initial stage, informs both research and practice on organizational impact of SOA adoption and assists IT managers in managing SOA adoption challenges.

The rest of the paper is organized as follows. The next section provides a brief account of previous work on electronic supply chains, enterprise technologies, and inter-organizational systems. This is followed by a section on web services and SOA. The benefits from SOA are outlined along with our hypotheses in Section 4. Section 5 presents the data, methodology and results followed by a discussion, limitations and conclusions in Section 6. Descriptive statistics and the correlation matrix for the data used in the study are provided in the Appendix.

## 2. Background and related work

During the 1990s many companies invested in large specialized information systems that supported complex business functionalities, data analysis and reporting with sophisticated user interfaces. Companies

invested heavily on enterprise resource planning (ERP), supply chain management (SCM), and other organizational systems. Information and knowledge sharing across customer supplier value chains and partners happened via electronic data interchange (EDI) systems. While these systems satisfied important and urgent needs at the time of their introduction, they gradually grew to be information silos with very little data sharing across systems. Even the EDI systems were very specific to the interface and did not provide the flexibility needed by changing business processes. In spite of the many shortcuts and utility programs, companies found these expensive information systems rapidly becoming outdated and constraining. To enable information sharing across organizational departments and information systems a new breed of enterprise and web technologies have emerged which provide a platform for integration.

In recent years, integrating technologies and systems like web services have begun to play an important mediating role in supplier customer relationships. They have also attracted significant research interest especially on inter organizational systems (IOS). The integrating technologies use standardized protocols and data formats for exchanging information across enterprise applications. For example they allow supply chain systems to be integrated with customer relationship management (CRM) systems so that customer information can be shared among different players in the supply chain. By supporting such sharing of information and automation of underlying business processes, these integrating technologies improve performance business agility [8].

Malhotra, Gosain and El Sawy [7] studied the relationship configurations in supply chain relationships and the creation of new knowledge using an absorptive capacity framework. Their work provides important insight into the mechanisms in inter-organizational systems, information exchange and the role of supply chain configurations. Their research however was technology agnostic and instead focused on the interface standards. Subramani investigated the benefits of IT use in supply chains and found that relationship specific deployment of IT played a mediating role on the benefits from supply chain management systems [8]. Chatterjee, Grewal and Sambamurthy [6] have also described the factors affecting the assimilation of web technologies in ecommerce firms.

There is a small but growing body of literature that describes this new technology paradigm including SOA or web services. Sambamurthy, Bharadwaj and Grover [9] provide a theoretical model for analyzing the role of information technology in business strategy and how new technologies are leading to strategic

flexibility in firms. They further encourage a line of inquiry into how firms achieve this agility and what technologies lead to flexible business processes and business models. Their research, while providing solid theoretical foundations, lacked any empirical support that will enlighten managerial decisions to invest in these new technologies including web services and SOA. Chatterjee et. al. [6] also suggest that organizational assimilation of web technologies leads to very useful business process benefits and study the role of top management sponsorship, investment rationale and extent of coordination on such an assimilation of web technologies. These studies point out the need to analyze specific phenomena involving the adoption of web technologies (like SOA) and their impact on organizational performance. The electronic integration and inter organizational systems described above are expected to provide agility and dynamic capabilities and hence improve performance.

A study of SOA in electronic supply chain will have to draw from the two relevant streams of IS research – supply chain management systems and web technologies, as summarized above. In addition, research focusing on the technical details provides insight into the architectural options and the related operational benefits [2], [10], [11]. This third stream of research provides a context for understanding the role of enterprise and web technologies in adding value to supply chain systems. Papazoglou & Georgakopoulos [2] provide an overview of the capabilities of service architectures and present an extended pyramid SOA. Casati et al [10] provide a framework containing a service model, a metric model and a runtime environment for a holistic approach to web service management. A comprehensive model for enabling dynamic business networks through web services was provided in [11]. A framework for analyzing the strategic and technological dimensions of web services in enabling dynamic business networks has also been developed [11]. We draw on this literature to develop a better understanding of the role of SOA in inter-organizational systems and its likely impact on the performance of electronic supply chains.

### 3. SOA based on web services

On the surface, SOA is just another enterprise integration technology, which provides message exchange over the simple object access protocol (SOAP) or hypertext transfer protocol (HTTP). The message format is typically XML. The web services description language (WSDL) provides a way to describe the service that the client should look for and the Universal Description, Discovery and Integration

(UDDI) protocol provides a registry to maintain context for the available services. The real advantage of SOA lies in its ability to provide seamless integration across business units, customers and partners [3]. By exposing the business services that are available in an organization to external customers, SOA offers a way to integrate data and processes across organizations. It also provides a way to combine the business services across partner organizations and offer a unified service to the end user application. Recent surveys have found evidence of SOA platforms being used widely and SOA deployment growing rapidly [12]. However, critics have pointed out that the web services based SOA platform is nothing but another enterprise application integration paradigm, which adds more architectural and operational overhead than solving real problems [12]. Web services and SOA do bring additional maintenance costs with them since they involve customizing the existing interfaces to support the web services application programming interface (API). Extending this line of argument the critics have questioned the real business value of investment in SOA.

#### 3.1. Impact of SOA adoption on electronic supply chain performance

Lim and Wen [3] identify case studies where SOA adoption led to cost savings and increased business efficiency. Many large corporations have had successful implementations of web services in their ecommerce and electronic supply chain channels. For example, Motorola estimated that adopting web services based architecture led to savings of about \$100,000 to \$150,000 [3]. It was estimated that General Motors would be able to reduce operating costs by \$1000 per vehicle by adopting web services [3]. Similar projects in Dell and Dollar-Rent-A-Car provide evidence for the supply chain efficiencies due to SOA [3]. Andrianopoulos [13], Murtaza and Shah [11] also suggest that web services and SOA adoption leads to efficiency in supply chains. Thus, there is a broad agreement that SOA adoption leads to improvement in supply chain performance. Hence, for our research setting of electronic supply chain, we posit our first hypothesis:

**H1:** *SOA adoption leads to better electronic supply chain performance*

We now explore the mechanism or the causal path through which SOA adoption impacts electronic supply chain performance. Subramani [8] has shown that exploring relationship specific investments is important for getting insights into supply chain performance. Hence, we now focus on three main

constituents of an electronic supply chain: customers, suppliers and partners. We can expect that electronic integration of customers, suppliers and partners into the supply chain would significantly affect the performance of the electronic supply chain.

Electronic integration and coordination leads to more real time information exchange. In organizations that use enterprise wide electronic application integration, there are common information databases, which can contain the business objects that will be used by business processes across systems. This provides opportunities for enterprise wide planning and maintenance which leads to cost reduction. Real time transactions also lead to lower cost per transaction. Such integration also eliminates the need for replicating the functionality from one system onto another. All these benefits are well suited to be enhanced by SOA. In many business application systems, especially in customer relationship management (CRM) systems or partner relationship management (PRM) systems there are critical data that are not easily accessible by other enterprise applications [12]. Traditional integration technologies (including COM+, DCOM and CORBA) are cumbersome to use and are not easily accessible via web-based applications. Web services allow applications to be accessed from a platform neutral environment (especially the WWW) using any communication protocol [20]. They are also well suited to abstract the data and programming interfaces in these applications and make the information available to other applications via easy to use XML formats. SOA, using these advantages that web services offers, makes information sharing across silos easier. Thus, while integration of customers, suppliers and partners into the electronic supply chain can be expected to be beneficial on its own, the presence of SOA would further enhance the benefit by making real time communication and information sharing easier because of SOA's inherent standards based interoperability feature. Hence, a firm with SOA would be in a better position to leverage its electronically integrated customers, suppliers or partners to achieve better electronic supply chain performance. Thus, we reach our hypotheses 2, 3 and 4:

**H2:** *SOA adoption increases firm's ability to leverage electronically integrated customers to achieve better electronic supply chain performance.*

**H3:** *SOA adoption increases firm's ability to leverage electronically integrated suppliers to achieve better electronic supply chain performance.*

**H4:** *SOA adoption increases firm's ability to leverage electronically integrated partners to achieve better electronic supply chain performance*

The hypotheses described above are summarized in the research model shown in Figure 1. Hypotheses 1 has been operationalized in the research model as a direct effect while hypotheses 2, 3 and 4 are interaction effects that moderate the relationship between electronic integration of customers, suppliers and partners and electronic supply chain performance. In accordance with previous work in business value of IT (e.g. [16]), we control for firm size and industry.

## 4. Data, Methodology and Results

Data for this paper was collected by the reputed IT industry publication InformationWeek as part of its annual InformationWeek500 ranking of the IT industry for the year 2003. InformationWeek 500 surveys are widely considered a reliable source of data and have been used in many academic studies [14, 15].

407 firms answered the survey. We discarded 19 responses because of missing values or data errors. Thus our final sample consisted of 388 firms, which is an adequate sample size for the analysis and is comparable to previous cross-sectional studies (e.g. Dewan et al. [16] had sample size of 433 firms).

### 4.1. Constructs and Variables

The survey data was used to measure the constructs being studied in the following manner:

**Electronic Supply Chain Effectiveness (*ESupChainEff*):** The survey asked the respondents for the proportion of total revenue that comes from electronic channels. We are taking this measure as a proxy of electronic supply chain performance. We believe this is an appropriate measure since if a company generates higher percentage of its revenue from electronic channels then the company can be considered to have a more effective electronic supply chain compared to a firm with similar characteristics but a lower percentage of revenue coming from electronic channels. Electronic supply chain effectiveness, as defined above, is used as a measure of electronic supply chain performance in this paper. Previous research [21], [22] had identified the multiple types of impact of electronic supply chains on firm performance. For example, Patnayakuni et al. [21] illustrate that the impact of supply chain efficiency can be measured through financial flow integration, physical flow integration and information flow integration. In addition they found that information flow integration has a positive effect on efficiency. Chang and Shaw [22] analyzed the effect of the four types of factors affecting firm performance including direct and indirect technology impact and direct and

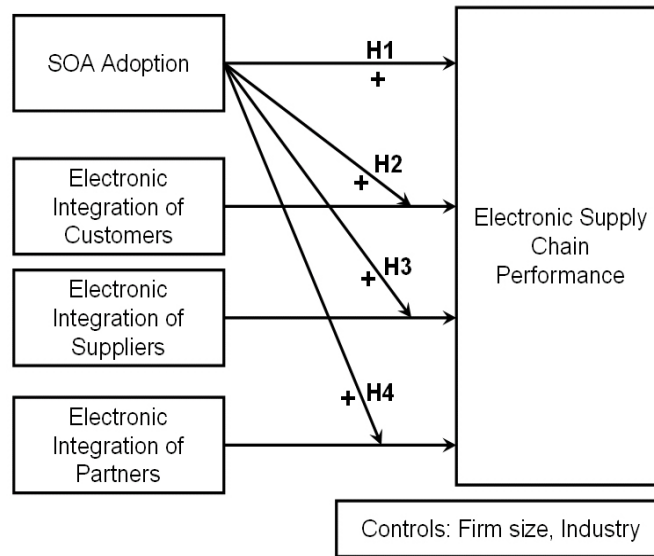


Figure 1: Research Model

indirect process impact. We have deliberately used the term “effectiveness” and not “efficiency” since our measure of performance is a top-line measure (revenue) while efficiency implies a bottom-line measure (both revenue and cost). The previous studies indicate that the proportion of total revenue that these firms get from electronic channels could be a good proxy for measuring supply chain effectiveness.

**Electronic Integration of Customers (ElecCust):** Electronic customer integration of a firm is measured as the percentage of the firm's customers that are included in its electronic supply chain.

**Electronic Integration of Suppliers (ElecSupp):** Electronic supplier integration of a firm is measured as the percentage of the firm's suppliers that are included in its electronic supply chain.

**Electronic Integration of Partners (ElecPart):** Electronic partner integration of a firm is measured as percentage of the firm's partners that are included in its electronic supply chain.

**SOA Adoption (DSOA):** The respondents were asked whether the IT department in their firm has developed and deployed a company wide services-based IT architecture. This variable is coded as a dummy variable with all responses that identified wide scale deployment of SOA were coded 1 while firms that did not report wide scale deployment of SOA were coded as 0. From the survey, organizations with a wide deployment of applications with SOAP, UDDI, and XML were considered to have a widespread services-based architecture.

**Firm Size (FirmSize):** Annual revenue for financial year 2002 (in million dollars) was taken as a measure of firm size.

**Industry (DInd):** Industry choices by the respondents were coded as either Manufacturing or Services. A dummy variable was introduced to capture the information

The descriptive statistics and the variance covariance matrix for variables mentioned above are presented in the Appendix. These statistics show that all the variables have sufficient variance and hence are suitable for empirical analysis.

#### 4.2. Model Specification

Four analysis models were tested using the variables above to test our hypotheses. The first model tests the direct effect of SOA adoption on electronic supply chain effectiveness. Next three models test the interaction effect of SOA adoption on the relationship between electronic supply chain effectiveness and electronic customer integration, electronic supplier integration and electronic partner integration respectively. The interaction effects are tested separately so as to not confound their effects. The four model specifications are detailed below:

**Model 1:** Direct effect of SOA adoption on electronic supply chain effectiveness

$$ESupChainEff = \beta_{10} + \beta_{11} ElecCust + \beta_{12} ElecSupp + \beta_{13} ElecPart + \beta_{14} DSOA + \beta_{15} FirmSize + \beta_{16} DInd + \varepsilon_1$$

**Model 2:** Interaction effect of SOA adoption on relationship between electronic customer integration and electronic supply chain effectiveness

$$ESupChainEff = \beta_{20} + \beta_{21} ElecCust + \beta_{22} ElecSupp + \beta_{23} ElecPart + \beta_{24} DSOA + \beta_{25} FirmSize + \beta_{26} DInd + \beta_{27} ElecCust * DSOA + \varepsilon_2$$

**Model 3:** Interaction effect of SOA adoption on relationship between electronic supplier integration and electronic supply chain effectiveness

$$ESupChainEff = \beta_{30} + \beta_{31} ElecCust + \beta_{32} ElecSupp + \beta_{33} ElecPart + \beta_{34} DSOA + \beta_{35} FirmSize + \beta_{36} DInd + \beta_{37} ElecSupp * DSOA + \varepsilon_3$$

**Model 4:** Interaction effect of SOA adoption on relationship between electronic partner integration and electronic supply chain effectiveness

$$ESupChainEff = \beta_{40} + \beta_{41} ElecCust + \beta_{42} ElecSupp + \beta_{43} ElecPart + \beta_{44} DSOA + \beta_{45} FirmSize + \beta_{46} DInd + \beta_{47} ElecPart * DSOA + \varepsilon_4$$

### 4.3. Results and interpretation

The models above were first tested using Ordinary Least Square (“OLS”) Regression. However, we conducted the Breusch-Pagan / Cook-Weisberg test for heteroskedasticity [17] on the OLS models and found that the null hypothesis of no heteroskedasticity was rejected indicating that the models suffered from significant heteroskedasticity problem. To take care of the problem we conducted OLS analysis with Huber-White robust estimates of the standard errors. We tested these regression models with robust standard errors for multicollinearity and found the variance inflation factors (“VIF”) [18] to be less than 2, well below the acceptable limit of 4. Thus, the models satisfy the conditions for giving unbiased, consistent and efficient estimates of regression coefficients. Results of the OLS regression analysis with robust standard errors are presented in Table 1. The results support our first hypothesis that SOA adoption improves electronic supply chain effectiveness. The coefficient for SOA adoption in Model 1 ( $\beta_{14} = 6.8$ , p-value 0.014) is significant and positive indicating that firms that adopt SOA derive higher proportion of their revenue from electronic channels for the same amount of customer, supplier and partner integration in their electronic supply chain. This is among the first broad based empirical evidence of SOA adoption impacting aspects of firm performance and hence provides support to large investments made by firms in deploying SOA.

In Model 2, the interaction between electronic integration of customers and SOA adoption was found to have a positive and significant relationship with electronic supply chain effectiveness ( $\beta_{27} = 0.178$ , p-

value 0.054), providing support to hypothesis 2 that SOA adoption moderates the capability of the electronic supply chain to leverage electronically integrated customers. The positive coefficient of the interaction term indicates that firms with wide SOA deployment are being able to leverage their electronically integrated customers better to generate higher revenue from electronic channels.

Model 3 and Model 4 failed to support hypotheses 3 and 4 respectively as the coefficients for interaction between SOA adoption and electronic integration of suppliers and partners respectively were not significant. This indicates that adoption of SOA does not significantly impacts firm’s ability to leverage their electronically integrated suppliers and partners to generate higher revenue from electronic channels. Table 2 below summarizes the results of the hypotheses testing.

We can integrate the results above to generate a unified mediation model of the impact of SOA adoption on electronic supply chain effectiveness. In Model 2, the coefficient of the direct effect of SOA adoption on electronic supply chain effectiveness is not significant in the presence of a significant interaction effect between SOA adoption and electronic integration of customers.

As all other interaction terms are not significant, we can conclude that the impact of SOA adoption on electronic supply chain effectiveness is fully mediated through its (interaction) impact on relationship between electronic integration of customers and electronic supply chain effectiveness.

We formally checked for mediation with the Sobel test [19] and found significant evidence of a mediation relationship. Thus we see that the underlying mechanism (or the causal path) of the positive impact of SOA adoption on electronic supply chain performance is in fact the impact of SOA adoption on the relationship between electronic integration of customers and the electronic supply chain performance. The causal path/mechanism of impact of SOA adoption on electronic supply chain performance is shown in Figure 2 below.

The results also show that firm size has a positive and significant relationship with electronic supply chain performance in all the models. This indicates that larger firms are able to realize higher electronic supply chain performance compared to small firms for the same amount of electronically integrated customers, suppliers and partners and SOA adoption. This can be explained by the fact that building and maintaining electronic supply chain requires significant amount of fixed investment and larger firms are better placed to provide such investments.

	Model 1	Model 2	Model 3	Model 4
<b>Electronic integration of customers</b>	<b>0.457 ***</b>	<b>0.322 ***</b>	<b>0.461 ***</b>	<b>0.460 ***</b>
p-value	0.000	0.000	0.000	0.000
<b>Electronic integration of suppliers</b>	<b>-0.082 *</b>	-0.076	<b>-0.151 *</b>	<b>-0.083 *</b>
p-value	0.083	0.112	0.075	0.082
<b>Electronic integration of partners</b>	<b>0.120 **</b>	<b>0.117 **</b>	<b>0.116 **</b>	0.018
p-value	0.021	0.023	0.028	0.854
<b>SOA adoption</b>	<b>6.800 **</b>	0.659	3.355	3.152
p-value	0.014	0.823	0.361	0.283
<b>Firm size</b>	<b>0.0002 ***</b>	<b>0.0002 **</b>	<b>0.0002 ***</b>	<b>0.0002 ***</b>
p-value	0.005	0.011	0.008	0.006
<b>Industry</b>	-2.889	-2.820	-2.736	-2.865
p-value	0.269	0.279	0.300	0.274
<b>(SOA adoption) * (Electronic Interation with customers)</b>		<b>0.178 *</b>		
p-value		0.054		
<b>(SOA adoption) * (Electronic Interation with suppliers)</b>			0.094	
p-value			0.338	
<b>(SOA adoption) * (Electronic Interation with partners)</b>				0.128
p-value				0.194
<b>N</b>	388	388	388	388
<b>Prob &gt; F</b>	0.0000 ***	0.0000 ***	0.0000	0.0000
<b>R-Square</b>	0.3734	0.3808	0.3753	0.3772

Note: \* Significant at 10% level, \*\* Significant at 5% level, \*\*\* Significant at 1% level

**Table 1: Results of the OLS regression with robust standard errors**

Results also indicate that at the broad industry categorization (manufacturing or service) used in this paper, industry affiliation does not have a significant impact on electronic supply chain effectiveness.

One interesting aspect of the results is that while coefficients of electronic integration of customers and electronic integration of partners are both positive and significant in Model 1, the coefficient of electronic integration of suppliers is significant but negative. This indicates that firms with higher electronic integration of suppliers in fact have lower revenue from electronic channels. In contrast, positive and significant coefficients of electronic integration of customers and partners indicate that higher values of customer and partner integration in electronic supply chain leads to higher revenue from electronic channels, as expected. This can be explained by the argument that firms that focus more on the supply side of their operations will be more likely to under-invest in the demand side of their operations. Hence, firms with higher electronic integration of suppliers are likely to pay less emphasis

on generating revenue from electronic channels. Since our measure for electronic supply chain effectiveness focuses on the customer side, such firms show lower electronic supply chain effectiveness than firms that focus more on the customer side.

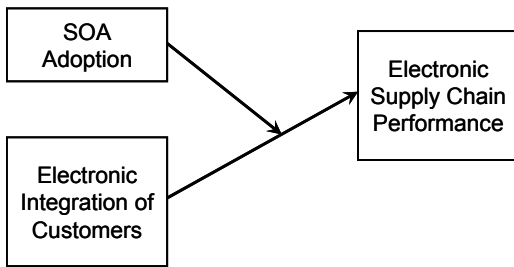
## 5. Discussion, limitations and conclusion

We have presented one of the first empirical supports for a positive performance impact of SOA adoption on electronic supply chain performance. Our results show that SOA adoption improves the customer-side effectiveness of electronic supply chains. These results have important implications for IT managers making SOA adoption decisions. Investment in SOA adoption is likely to prove more beneficial if the adopting firm has integrated most of its customers in its electronic supply chain. If the adopting firm has integrated most of its suppliers and partners in its electronic supply chain but not customers then SOA adoption may even prove

detrimental to electronic supply chain performance as it could draw resources away from beneficial customer oriented investments.

	Hypothesis	Result
1	SOA adoption leads to better electronic supply chain performance.	Supported
2	SOA adoption increases firm's ability to leverage electronically integrated customers to achieve better electronic supply chain performance.	Supported
3	SOA adoption increases firm's ability to leverage electronically integrated suppliers to achieve better electronic supply chain performance.	Not Supported
4	SOA adoption increases firm's ability to leverage electronically integrated partners to achieve better electronic supply chain performance.	Not Supported

**Table 2: Summary of hypotheses testing**



**Figure 2: Causal path/mechanism of impact of SOA adoption on electronic supply chain performance**

Our results hold important implications for web services vendors like IBM and Sun. Though our results provide evidence for tangible business value of SOA, they also suggest that SOA adoption may be ineffective in helping firms leverage electronically integrated suppliers and partners. This needs more careful analysis. As indicated by Subramani [8] and Murtaza & Shah [12] the benefits from supply chain integration could be asymmetrical depending upon the nature of relationship between the players. However, our results suggest that web services vendors are best served by focusing their product development efforts on business-to-business functionalities so that SOA products can start contributing to electronic supply chain performance through supplier and partner relationship sides as well.

The challenge in studying adoption of technology paradigms like SOA is in creating operational measures of the intangible benefits. We have provided

an approach to measuring both the direct effect of SOA adoption and its mediating effect on firm's ability to leverage customer assets for better electronic supply chain performance. SOA adoption is most valuable when the firm uses this approach for architecting both its internal and external operations with a careful focus on integration with customer operations. Managers will benefit by using such a holistic view when formulating an enterprise wide SOA strategy. Rather than adopting it as a technology platform, attention should be paid to understanding the supply chain and operations that SOA can benefit.

**5.1. Limitations and rationale**

This study is limited by the available measures in the data. Even though we have used measures that correspond to operational metrics, since the data was collected through a survey, our measures are perceived measures rather than actual measures. In absence of multiple responses from the same firm, we are unable to make these perceived measures more robust. Our analysis is also prone to single method bias as all the information for the analysis comes from the same source. Further, we have conducted our analysis at the firm level, while it can be argued that a business unit level or even a process level analysis could give better insights into the organizational impact of SOA adoption. In spite of the limitations above, we believe that as one of the early contributors to this research area, this paper provides a strong base for future research to extend our analysis and to take care of the limitations outlined in this section.

Since we have not taken the cost of adopting SOA into account in this paper, though we show that SOA adoption improves electronic supply chain performance, we cannot conclude whether SOA provides positive net financial benefit (bottom-line) to the adopting firm. But we believe the contribution is a step in the right direction.

This paper is based on a cross-sectional data collected at one point in time. We are hence unable to include any longitudinal effects (like learning curve) in our model. SOA adoption, like adoption of other technologies, could very well have a significant time lag before benefits could be realized. A longitudinal analysis could reveal the characteristics of such a time lag and the actual realization of benefits. We hope that future research will be able to use multi-year datasets and will be able to analyze such longitudinal effects.

Cross sectional studies frequently suffer from endogeneity problem as it is difficult to completely reject the possibility of causality in opposite direction. In this paper, however, we can theoretically argue that

causality in the opposite direction is not likely and hence there is no endogeneity problem. Our models posit that SOA adoption causes improvement in electronic supply chain performance. It is unlikely that better supply chain performance will cause a firm to adopt SOA. Thus, we can rule out endogeneity issues.

## 5.2. Future research directions

There are three main areas of future research that will further this line of work on the impact of SOA on organizational performance. First, future researchers can extend our “revenue enhancement” view of benefits from SOA adoption to include the “cost reduction” view as well. Second, our black-box approach to supply chain performance can be improved by explicitly considering the type and nature of supply chains and businesses. Finally, our study can be extended to explicitly include an analysis of the alignment between SOA adoption decision and the firm’s strategic goals. Such alignment (or lack of it) can have significant effect on performance impact of SOA adoption. Research into the contribution of SOA towards organizational flexibility and agility can provide more compelling arguments to support managerial decisions on SOA adoption.

## 5.3. Conclusion

In spite of the billions of dollars being invested by firms every year in developing and deploying SOA, there has been no broad based empirical investigation of the organizational impact of SOA adoption. This study has contributed to a better understanding of the impact of SOA adoption through an empirical study of SOA adoption and electronic supply chain performance for a cross section of large US firms. We found that adoption of SOA leads to better performance of the electronic supply chain. We also found that SOA moderates firm’s ability to leverage electronically integrated customers to achieve better electronic supply chain performance. Further, we have shown that the impact of SOA adoption on electronic supply chain performance is fully mediated through its moderation impact on the ability of the firm to leverage electronically integrated customers. This paper has provided one of first empirical supports for business value of SOA. Our findings provide insights for IT managers to make informed SOA adoption decisions. Although this study has certain limitations, we believe it provides a strong base for future research to further explore the organizational impact of SOA adoption.

## 6. References

- [1] Koch, C. (2006). “The Truth about SOA”, *CIO Insider*, June.
- [2] Papazoglou, M. P., & Georgakopoulos, D. (2003). Service-oriented computing. *Communications of the ACM*, 46(10), p24, 25p.
- [3] Lim, B., & Wen, J. (2003). Web services: An analysis of the technology, its benefits, and implementation difficulties. *Information Systems Management*.
- [4] International Data Corp (2006). “Hot Technologies for 2006”, *Network World*, 06Q1.
- [5] Aberdeen Group (2006). “Statistically Speaking”, *Customer Relationship Management*, 06Q1.
- [6] Chatterjee, D., Grewal, R., Sambamurthy, V. (2002). Shaping up for E-Commerce: Institutional enablers of the organizational assimilation of web technologies. *MIS Quarterly*, 26(2), pp. 65-89.
- [7] Malhotra, A., Gosain, S., El Sawy, Omar A. (2005). Absorptive capacity configurations in supply chains: Gearing for partner-enabled knowledge creation. *MIS Quarterly*, 29(2) pp. 145-187.
- [8] Subramani, M. (2004). How do suppliers benefit from information technology use in supply chain relationships?, *MIS Quarterly*, 28(1) pp. 45-73.
- [9] Sambamurthy, V., Bharadwaj, A., Grover, V. (2003). Shaping agility through digital options: Reconceptualizing the role of information technology in contemporary firms. *MIS Quarterly*, 27(2), pp. 237-263.
- [10] Casati, F., Shan, E., Dayal, U., & Ming-Chien, S. (2003). Business oriented management of web services. *Communications of the ACM*, 46(10), p55, 56p.
- [11] Iyer, B., Freedman, J., Gaynor, M., & Wyner, G. (2003). Web services: Enabling dynamic business networks. *Communications of the Association for Information Systems*, 11, 525-554.
- [12] Murtaza, M. B., & Shah, J. R. (2004). Managing information for effective business partner relationships. *Information Systems Management*.
- [13] Andrianopoulos, A. (2002). The framework behind Web services integration, *EAI Journal*, June, 22-23.
- [14] Kudyba, S. and Diwan, R. (2002). "Research Report: Increasing Returns to Information Technology," *Information Systems Research*, 13 (1), pp. 104-111.
- [15] Santhanam, R. and Hartono, E. (2003). "Issues in linking information technology capability to firm performance," *MIS Quarterly*, pp. 125-153.
- [16] Dewan, S., Michael, S. C. and Min, C. K. (1998). "Firm Characteristics and Investments in Information Technology: Scale and Scope Effects," *Information Systems Research*, 9 (3).
- [17] Hamilton, L. C. (2004). *Statistics with STATA*, Duxbury Thomson Learning.
- [18] Greene, W. H. (1997). *Econometric Analysis*, Prentice Hall.
- [19] Preacher, K. J. & Leonardelli, G. J. (2001). “Calculations for the Sobel Test”, Retrieved from <http://www.unc.edu/~preacher/sobel/sobel.htm>

[20] M. Stal (2002), "Web Services: beyond component-based computing," *Communications of the ACM*, vol. 45, pp. 71-76.

[22] H. Chang, Michael J. Shaw, "Evaluating the Economic Impacts of IT-Enabled Supply Chain Collaboration" (2004), <http://citebm.business.uiuc.edu/RN%20study/PACIS2004.pdf>

[21] R. Patnyakuni, N. Patnyakuni, and A. Rai (2002). Towards a theoretical framework of digital supply chain integration. In *Proceedings of European Conference on Information Systems*.

## Appendix

### Summary Statistics for Variables

Variable	No of Observations	Mean	Standard Deviation	Minimum	Maximum
Electronic Supply Chain Effectiveness	388	26.64	30.89	0	100
Electronic Integration of Customers	388	37.06	34.85	0	100
Electronic Integration of Suppliers	388	40.96	33.74	0	100
Electronic Integration of Partners	388	37.02	37.12	0	100
SOA Adoption	388	0.75	0.44	0	1
Firm Size	388	8260.58	15403.28	1000	186763
Industry	388	0.53	0.50	0	1

Table 3: Summary statistics for variables used

### Correlation Matrix for Variables

	ESupChainEff	ElecCust	ElecSup	ElecPart	DSOA	FirmSize
Electronic Integration of Customers	0.58	1.00				
Electronic Integration of Suppliers	0.18	0.34	1.00			
Electronic Integration of Partners	0.39	0.51	0.51	1.00		
SOA Adoption	0.15	0.06	0.09	0.18	1.00	
Firm Size	0.18	0.14	0.16	0.17	0.08	1.00
Industry	(0.07)	(0.06)	0.10	0.04	0.01	0.10

Table 4: Correlation matrix for variables used