

TOWARDS A THEORETICAL FRAMEWORK OF DIGITAL SUPPLY CHAIN INTEGRATION

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ABSTRACT

One of the most significant changes in organizational business models has been that it is not the individual organizations that compete with each other; rather they compete as a network of organizations forming the supply chain. To compete as supply chains in a digital economy organizations invest in digital applications, and IT infrastructure for supply chain integration. They also establish long-term partnerships with supply chain partners based on trust and information sharing. Implementing these structural and relational initiatives presents significant challenges in implementation, while at the same time enabling the integration of resource flows across the supply chain. The paper presents an initial exploration of relationships between critical dimensions of digitalization in supply chains, IT infrastructure, relational orientation of the firm with its partners, supply chain integration and performance. The presentation is non-traditional and attempts to provide insights at a lower level of granularity by combining descriptive analysis with more traditional statistical techniques. Exploratory analysis suggests that digitization of supply chains, when accompanied by an integrated IT infrastructure and partnerships with supply chain members can enable organizations to integrate physical, financial and informational resource flows for differential impact on different dimensions of organizational performance.

1. INTRODUCTION

In February 2001 Nike announced that it expected a shortfall in earnings in the third quarter. It expected a revenue shortfall of over \$100 million. Not only did Nike blame the slowing economy for the slump in demand for its products, but also blamed i2's supply chain management software. Dell on the other hand has successfully gained market share by maintaining its strategy of cost reduction. Over the past few years Dell has fine-tuned its supply chain to cut costs and improve margins. It has mandated that all its suppliers use i2's supply chain management software. The point is not about the strengths or weakness or i2's supply chain management software, but to illustrate the importance of supply chain integration in determining the success of firms in today's marketplace. In fact, several B2B applications, e-markets and third- and fourth-party logistics solutions are now available in the marketplace. Leading firms in the technology and logistics industries are getting poised to offer full suite offerings for their different customer segments.

Perhaps one of the most significant changes in organizational business models has been that it is not the individual organizations that compete with each other; rather they compete as a network of organizations forming the supply chain (Evans and Wurster, 1999; Lambert, et al., 1998). The new business paradigm calls for managing the extended enterprise, where success is determined by how effectively the organization manages its supply chain. In recent years, practitioners and researchers alike are paying considerable attention to supply chain management for meeting a variety of organizational objectives; from reducing costs to leveraging the skills of their supply chain partners for competitive advantage (Ramdas and Spekman, 2000). The Global Supply Chain Forum defines supply chain management as "the integration of key business processes from end user through original suppliers that provides products, services, and information that add value to customer and other stakeholders," (Lambert, et al., 1998). The emphasis is on moving away from the traditional focus of logistics on managing the flow of goods to an outlook that focuses on integration of physical, financial and information flows, and one that emphasizes managing relationships with supply chain partners.

As with many organizational initiatives today, information technology (IT) plays a critical role in realizing supply chain management objectives. Successful organizations such as Wal-Mart, Dell, Honda, etc. are cutting their inventory holdings down by substituting information for inventory. Supply chain integration is supported by new technologies that enable instant connectivity and visibility across the supply chain (Parekh, 2001). The ability to execute inter-organizational transactions and sharing of access to data across the supply chain are some of the functionalities provided by IT. The overall market for supply chain management software will reach US\$12.5 billion by 2004, a compound annual growth rate of 28 percent from 1999, say researchers with Datamonitor (Supply Chain Advisor 2001).

The objective of this paper is to present an exploratory analysis of the relationship between key supply chain variables. The approach is one of blending descriptive analysis with some inferential statistics in order to obtain some insights into current supply chain management practices. Compared to conventional model testing with aggregated measures, this approach offers the advantage of focusing at lower levels of aggregation without entirely sacrificing statistical rigor. We systematically explore the relationship between key variables using descriptive techniques and support our inferences with inferential techniques. The analysis presents preliminary results of a large-scale study that examines supply chain capabilities of organizations. The manuscript first examines the extent to which organizations have moved to digitize their supply chain. Subsequent sections explore the relationship between IT infrastructure integration, digitization, trust in supply chain partnership, resource flow integration in the supply chain and different aspects of organizational performance. The next section provides a brief overview of the data collection approach used.

2. DATA COLLECTION METHODS

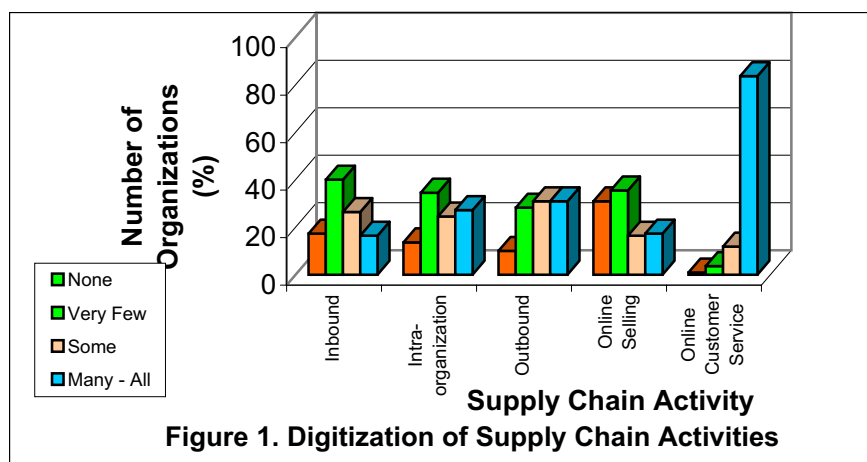
Data was collected by means of a self-administered survey of senior to middle-level supply chain managers in US organizations. The data collection instrument was carefully developed using an approach similar to previously published empirical studies in IS. Items for each of the study variables were either developed specifically for the study and where possible anchored in prior research. The list of items on which the analysis is based in this paper is reported in the Appendix. The survey instrument was subjected to a two stage pilot test with IS researchers and supply chain and logistics managers. The questionnaire was then first mailed to 432 manufacturing and retail organizations in US, and then made available on a web site. The effective mail-out was 360 after removing returned surveys and emails that bounced back. A total of 110 responses resulted from the conventional mail-out and subsequent electronic submissions based on e-mail follow up. This yielded an effective response rate of 30.55% for the study. The data was tested for non-response bias and method bias on key demographic variables and did not indicate any concerns as to the validity of the data collected in the study.

3. THE STATE OF DIGITIZATION

The term digitization as used in this study refers to the extent to which supply chain activities and transactions are conducted online. While there isn't a specific definition for what it means to be 'online' it is used in the commonly accepted sense that activities and transactions are captured, transmitted, and cascaded across the supply chain in a digital form. The drive towards digitization is enabled by the Internet and associated net-centric and web technologies and supply chain applications. Digitization can help organizations to overcome the drawbacks associated with fragmented and incompatible IT infrastructure that may be present across the supply chain. With digitization, organizations can leverage the relational capital inherent in supply chain partnerships to coordinate physical, and financial flows across the supply chain. Web enabling supply chain activities removes the barriers to information sharing. It is expected that the online channels for procurement, manufacturing, distribution, and sales can have a significant impact on supply chain integration and performance. For instance, organizations that shift a majority of their product transactions online are likely to reap the benefits of rapid response, and detailed quality of information about their customer base. Online procurement enables organizations to reduce processing costs, and remove delays across the supply chain. Thus, digitization of key supply chain activities can enable organizations to reduce delays and costs, improve information sharing and enable resource coordination across time and space boundaries. Given the potential benefits from conducting supply chain activities online, what is the extent to which organizations are digitizing their supply chain activities?

We asked respondents to indicate the extent to which they conducted various supply chain activities online. Overall levels of digitization were generally at the lower end of the scale. In our study sample 38% of the respondents did not realize any revenue from online sales, 50% realized less than 20% of their revenue from online sales, and only 12% realized 20% or more of their revenues from online sales. The extent to which organizations in the study sample have digitized their supply chain activities is shown in Figure 1. Descriptive analysis suggests that organizations are digitizing more intra-organization and outbound supply chain activities in comparison with their inbound supply chain activities. The proportion is slightly higher for outbound activities, where around 62% of the organization reports that they are conducting some to all of their outbound supply chain activities online, as compared to around 52% for intra-organizational activities. This may be attributed in part to the level of sophistication in logistics management and/or greater emphasis organization place on servicing markets. Perhaps the most interesting finding is that although the organization are limited in their online selling activities, the level of digitization of customer services is remarkably high. As many as 84% of the respondents conduct most or all of their customer service activities online. This suggests that online channels such as web pages, e-mail, bulletin boards, etc., are becoming the primary medium for servicing customers. It is conceivable that online methods of customer support

are increasingly being used to support routine inquiries, while knowledgeable customer service agents are handling complex, unstructured interactions. Given that a majority of customer service requests tend to be routine in nature, significant economies of scale can be achieved by online processing of these transactions.



Because of the high level of digitization in customer service activities we further analyzed this aspect of the supply chain. We found that organizations that realized most of their revenues online were more likely to conduct online selling and customer service activities. The sophistication of online customer service, such as the ability to modify orders, and handle returns is higher for organizations that realize more of their revenues from online sales. We also examined the impact of conducting customer service online on the organizations performance in its relationship with customers. There is a commonly held notion that online customer service is inherently inferior to 'live' customer service. Our analysis suggested that there was no relation between the extent of customer service activities conducted online and perceived strength and continuity of the bond with an organizations customers. Thus, even though moving customer service activities online does not appear to improve relationship with customers, a negative impact is not detected. Quite likely, it may have an impact on mediating variables not considered here, which, in turn, impact customer relationship outcomes.

4. ROLE OF IT INFRASTRUCTURE INTEGRATION IN SUPPLY CHAIN DIGITIZATION

The IT infrastructure of an organization serves as the launching pad for deployment of its IT capabilities. It provides an organization with two types of benefits, economies of scale and capabilities of scale (Mckay and Brockway, 1989). Scale economies originate from the ability to consolidate and rationalize infrastructure investments. As a corollary, infrastructure investments reduce the marginal costs of investing in new business projects. Furthermore, it is IT infrastructure that connects, and integrates systems within and across organizational boundaries thus enabling improvements in organizational communication, decision-making, and innovation. It can not only reduce the time delays along the value chain but also enable the organization to source and distribute its products and services anytime and anywhere. The IT infrastructure of the organization is also an important consideration in its ability to design and implement new business process applications to respond to emerging business opportunities (Mckay and Brockway, 1989; Weill and Broadbent, 1998). An integrated IT infrastructure enables the seamless flow of information, within and across organizational boundaries. It implies that the organization has already established physical and logical channels, such as connected applications and common data definitions for the smooth flow of information. In this study the level of IT integration is considered in terms of the level of data and application integration between a firm and its supply chain partners.

We examined the relationship of the level of integration of the IT infrastructure with level of digitization in supply chain activities. The analysis was done both at the level of individual groups of activities (for example inbound supply chain activities) as well as the overall level of digitization by aggregating the level of digitization across different categories of activities. Analysis of significance was done by simple one-way analysis of variance across different levels of IT infrastructure integration. Table 1 presents the results of the analysis. The results confirm that higher levels of IT infrastructure integration are associated with higher levels of digitization. Interestingly, level of integration is not a factor in digitization of selling and customer service activities. This finding fits with our previous results on digitization, suggesting that online selling and customer service are currently being developed and managed independent of the rest of the supply chain activities. Considering that the initial response of most organizations to the e-business phenomena was to develop an online presence on the web, usually by allowing customers to contact the company or buy its products online, the results confirm this notion.

An interesting contrast is presented between data integration and application integration. When we examine aggregate levels of digitization, we find that there are no differences in the level of digitization across different levels of data integration, but there are significant differences in application integration. Performing contrasts and comparing means of groups confirmed the direction of differences i.e. higher levels of integration with higher levels of digitization. Differences in application integration have a greater impact on digitization capabilities than differences in data integration. Quite likely, the ability of applications to communicate with each other in real-time is a greater enabler of digitization, because it allows for the linking of digital applications with enterprise-wide back-office legacy applications. Problems associated with fragmented data such as lack of common data definitions, data formats and inconsistency of distributed data can in some ways be overcome by browser based front-ends that provide a common platform for distributed, incompatible and legacy data. We further found that higher levels of application integration accompanied the more sophisticated levels of digitization, such as the ability to modify orders and product features. We can hypothesize that the digital impacts of high levels of data integration are more likely to be seen not in the level of digitization but in the organizations ability to leverage digital assets for information sharing, responsiveness and improved productivity.

Table 1: Differences in Digitization Across Levels of IT Infrastructure Integration		
	Data Integration (significance)	Application Integration (significance)
Inbound supply chain activities	.021	.017
Intra-organizational supply chain activities	.028	.011
Outbound supply chain activities	.010	.000
Online selling activities	.148	.247
Customer service activities	.332	.065
Overall level of digitization (inbound, intra-organizational, and outbound)	.245	.084

5. IT INFRASTRUCTURE INTEGRATION AND SUPPLY CHAIN INTEGRATION

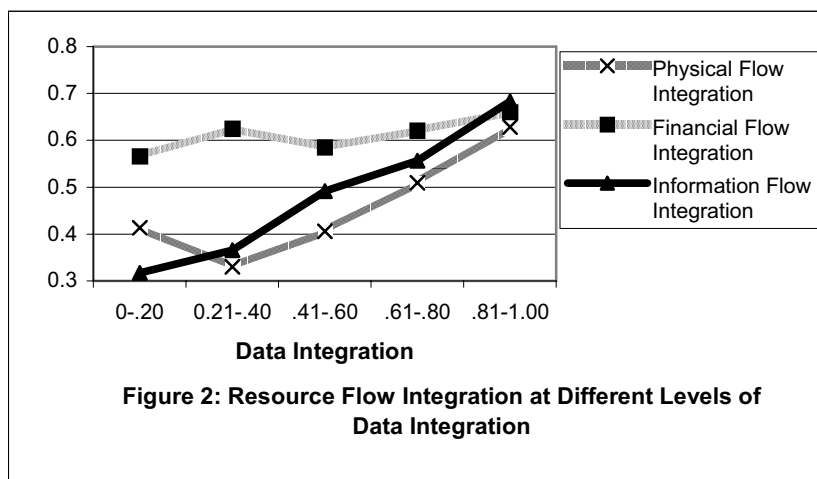
Resource-based view of organizations suggests that firms are a bundle of heterogeneous resources, assets and capabilities (Olavarrieta and Ellinger, 1997; Wernerfelt, 1984). A firm's critical assets may be embedded in the organization or in its supply chain partners. How an organization combines these varied assets in distinctive ways through unique inter-firm resource flows, is the source of organizational value (Dyer and Singh, 1998). Capabilities, such as the ability to coordinate resources

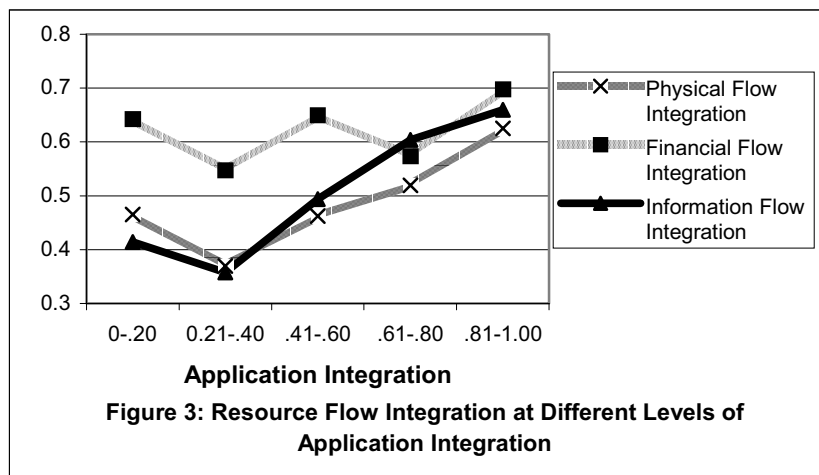
across supply chains, are difficult to imitate because they are path dependent, and based on complex decisions and social processes that are embedded in relationships.

Integration of the supply chain is conceptualized as the integration of material flows (Stevens, 1990), information flows (Lee, et al., 1997) and financial flows. Information flow integration is defined as the sharing of production, delivery and sales information between a firm and its supply chain partners. It includes the actual information shared as well as the timeliness of information exchange between supply chain partners. Sharing of inventory, shipment, order and performance information, ability to engage in collaborative forecasting and visibility of inventory across the supply chain are identified as indicators of information flow integration.

Physical flow integration is defined as the coordination of flows of materials and finished goods between a firm and its supply chain partners. Downstream physical flows consist of raw material, subassemblies and finished goods to the customer, while upstream physical flows consist of returns and repairs. Inventory optimization, just in time deliveries, joint management of inventory, postponement and distribution network configuration are identified as properties that reflect the degree to which a firm's physical flows are integrated with its supply chain partners.

Financial flow integration is defined as the degree to which financial resource flows between a firm and its supply chain partners are event-based and digitally automated. Organizations often do not have accurate information about their financial flows. Some downstream financial flows that need to be managed are prices, invoices and credit terms, while essential upstream financial flows that need to be coordinated are payments and account payables. The importance of better financial flow integration cannot be overemphasized in an era of increased fixed costs and a greater reliance on short-term financial results (Farmer and Van Amstel, 1991). Financial flow integration can enable better working capital and cash flow management through automation of payable and receivable processes on delivery of goods. Automation of financial transaction can enable organizations to reduce delays, and cut down non-value adding activities. It would also improve the availability of cash to ramp up production when demand swings upwards or to explore new product lines, thereby impacting revenue growth of a firm.





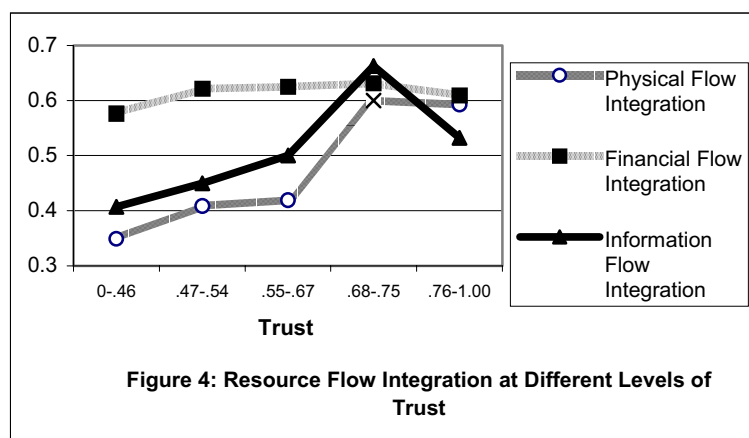
In order to observe the trends in resource flow integration at different levels of IT infrastructure integration we did a comparison of means across different levels of data integration and application integration. This was done by means of one-way ANOVA, and in addition a contrast between the groups at the lowest level versus the groups at the highest levels of data and application integration (separately). The trends are shown graphically in Figures 2 and 3. Higher levels of data and application integration are associated with higher levels of physical and information flow integration. The trend is significant across groups, as well as in the contrast across the low and high group. However, the line for financial flow integration is almost flat. The level of financial flow integration appears to be high and quite similar across levels of IT infrastructure integration. It may well be that financial flow integration is not really dependent on an integrated IT infrastructure, and may be achieved by digital applications. An alternative explanation could be that efficiencies from integration of financial flows may have already been realized by organizations. In early 1990s there were a number of reengineering initiatives in organization and many of them focused on financial processes in organizations, as the returns were visible and significant. Thus, organizations need to improve both physical and information flows across the supply chain to extract performance gains.

6. TRUST IN SUPPLY CHAIN INTEGRATION

A smoothly running supply chain requires effective governance mechanisms in inter-organizational relationships, based on either third-party reinforcement or self-reinforcement agreements. Self-reinforcing agreements can be formal, such a joint investments, or informal based on trust and goodwill. Informal mechanisms are more effective and less costly than formal reinforcement mechanisms (Hill, 1995). They are not bound by time, do not require detailed monitoring and enforcement, and enable the sharing of tacit knowledge that is more likely to create idiosyncratic routines that are source of sustainable value that are difficult to imitate (Dyer and Singh, 1998). High commitment and low opportunism in the buyer supplier relationship requires the development of relational norms, and trust is considered to be the most significant relational norm (Joshi and Stump, 1999).

Trust in supply chain partners is considered an important factor from a number of alternative theoretical perspectives. For instance, trust reduces transaction costs and the risks of opportunism based on the arguments of transaction cost theory. From a social perspective, it enables commitment in relationships, better information sharing and collaboration and joint action. Trust enables the transfer of knowledge and access to proprietary product and process technology thus leading to the development of distinctive organizational competencies. Based on trust, the sharing of actual sales information would discourage the supply chain from using forward buying tactics. In fact it is

generally held that trust among partners across the supply chain is a significant predictor in the development of boundary spanning capabilities. Prior research suggests that inter-organizational trust is positively associated with supplier performance and customer satisfaction (Zaheer, et al., 1998).



A similar analysis, as in the case of IT infrastructure integration was done to explore the relationship of trust with resource flow integration in the supply chain. The main difference was in the grouping of respondents on trust. Since most of the summarized score for the response items were around .5 and above, roughly equal size groups were created. A similar trend as in the case of IT integration is observed. Higher levels of trust are associated with improved physical flow and information flow integration. Correlation analysis of trust with resource flow integration showed that while trust (actual scores were used here rather than the ordinal values for groups) was significantly correlated with physical and information flow integration (.483 and .354 significant at the .01 level), it did not have a significant relationship with financial flow integration (.157). Since financial transactions carry an explicit and/or implicit legal agreement, it is probably not surprising that financial flow integration is not significantly associated with development of trust. However, for better visibility across the supply chain and in order to closely coordinate the flow of goods and services, trust appears to play an important role.

7. PERFORMANCE IMPLICATIONS OF SUPPLY CHAIN INTEGRATION

Effective management of the supply chain can potentially influence performance of the organization on a variety of dimensions, ranging from the operational to the strategic. Integration of resource flows across the supply chain is likely to result in such benefits as low cycle time, on-time delivery, high order fill rate, and product-service customization. Improvements in cycle time and operating costs would result in improved working capital productivity. Information flow integration would not only help remove slack from the supply chain but provide better information to the organization about its customers. Combined with improved customer service that can result from integration of physical flows, resource flow integration can positively influence the relationship an organization has with its customers. Finally, apart from improving productivity by cutting costs and cycle time, resource flow integration can provide the organization with the ability to effectively monitor and gain access to new technologies and markets for sustainable growth. We examine efficiency, revenue growth and customer relationships, which are recognized as key elements of a firm's performance (Slywotzky and Morrison, 1997).

Multiple regression analysis was conducted to explore the relationship of supply chain integration with organizational performance. Scores for efficiency, revenue growth and customer relationship performance were computed by aggregating items associated with each of these performance dimensions. Three regression models, one for each organizational performance measure, were analyzed and the results are presented in Table 2. The analysis highlights the differential impact of

different aspects of supply chain integration on organizational performance. Information flow integration is a significant predictor of efficiency. This suggests that organizations can gain performance benefits from integrating information flows across the supply chain and optimizing physical stocks and flows from a supply chain-wide perspective (Daugherty and Stank, 1995). For instance, information about inventory can substitute for actual physical inventory (Milgrom and Roberts, 1988), thereby reducing inventory costs, improving response time and enhancing organizational efficiency.

Table 2: Regression Analysis of Supply Chain Integration with Organizational Performance

Organizational Performance	R ²	Sign.	Physical flow integration		Financial flow integration		Information flow integration	
			Std. β coeff.	t-statistic*	Std. β coeff.	t-statistic	Std. β coeff.	t-statistic
Efficiency	.14	.001	.184	1.681 (<i>p</i> =.048)	.063	.677 (<i>p</i> =.25)	.222	2.044 (<i>p</i> =.021)
Revenue growth	.14	.001	.209	1.914 (<i>p</i> =.026)	.092	.984 (<i>p</i> =.16)	.187	1.717 (<i>p</i> =.044)
Customer relationship	.15	.001	.346	3.185 (<i>p</i> =.001)	.186	1.998 (<i>p</i> =.024)	-.074	-.688 (<i>p</i> =.25)

* one tailed t-test

For organizational revenue growth, financial flow integration does not have a significant coefficient in the regression model, while the one-tailed tests for physical and information flow integration are significant, although all three variables appear to contribute to the variance explained. Information flow integration enables idea generation and organizational learning about new technologies and markets and these are likely to facilitate revenue growth. While physical flow integration enables organizational efficiency, its positive impact on revenue growth is interesting. It suggests that operational measures such as inventory optimization may eventually enable strategic performance improvements through better matching of supply and demand and identification of surplus that can be utilized for new products.

The third regression model, where customer relationship performance is the dependent variable shows very interesting results. There is a strong association of physical flow integration with customer relationships, which is a consistent finding with prior research that has shown that physical flow integration is associated with improvements in customer relationships and customer service (Ellinger, et al., 1999; Gustin, et al., 1995). Apart from the potential productivity impacts of physical flow integration, having the right product at the right time is likely to have a significant impact on customer satisfaction levels. Effective physical flow integration can also enable companies to be more responsive to shifts in market demand and better respond to customer needs by using approaches such as postponement of differentiation. Also, given the low variance in financial flow integration, it is interesting to note that its coefficient is significant in the regression model. This seems to suggest the ability to conduct financial transactions consistently and efficiently plays an important role in improving the organization's relationship with its customers. It is also interesting that information flow integration is not linked to customer relationships. It is likely that majority of information sharing initiatives have been implemented with suppliers rather than customers. It is also likely that availability of information is not as significant as availability of the right product at the right time with simple rather than complex transactional exchange. These capabilities are enabled by physical and

financial flow integration. Further exploration is required to explain the lack of relationship between information flow integration and customer relationships in this analysis.

8. DISCUSSION

Supply chain management is the coordination of physical, financial and information flows across the supply chain for the purpose of providing a product or service. It spans multiple enterprises and has as its foundation the coordination and integration of these flows across networks of suppliers, customers and distributors. Aspects of supply chain management include, in addition to coordination of resource flows, network structure of the supply chain, members of the supply chain, their relationships and their governance structures (Lambert, et al., 1998). In this paper, we present preliminary results on a study that focuses only on supply chain integration capabilities of organizations. The presentation combines descriptive and inferential analysis techniques to explore the relationship between key variables in the study.

Preliminary results indicate that organizations in the study sample are still in the early stages of digitizing their supply chains. Only a few organizations realize a substantial portion of their revenues from online activities. Although the extent of revenue generation from online activities is limited, organizations are looking towards moving more and more of their supply chain activities online. As compared to inbound supply chain activities a greater proportion of intra-organizational and outbound supply chain activities are being conducted online. Not surprisingly, most organizations have a significant online presence for customer service. Examined in conjunction with IT infrastructure integration, it is found that higher levels of digitization are generally associated with higher levels of integration. While data integration appears to provide the foundational platform for digitization, more complex supply chain activities appear to be contingent upon application integration.

Coordination and integration of supply chain wide processes enable organization to respond rapidly to market conditions. Integration of resource flows in the supply chain can help prevent optimization of performance at the subunit level. An integrated supply chain can help in reducing costs as well as improving productivity by reducing costs of production, transportation and warehousing. In many industries, logistics costs account for a substantial portion of total costs. Better sharing of information can reduce delays and enable better matching of supply and demand across the supply chain. Coordination of physical flows can reduce delivery cycle times and provide enhanced delivery performance to customers at reduced costs. Coordination of financial flows can result in more satisfied customers through automated invoicing and payment processes that reduce delays and paperwork. More accurate information on costs can enable better pricing and optimal decisions about product-market strategies.

The case of financial flow integration is intriguing. There appears to be very little variance in the sample, as most organizations appear to indicate high levels of integration. This may have been the legacy of business trends in the earlier part of the decade such as reengineering and sophistication of the financial services market. Our results also show that physical, financial, and information flow integration, when considered together in a regression model, impact different aspects of organizational performance. Whereas information flow integration has a positive direct impact on organizational efficiency, physical and financial flows have a positive direct impact on customer relationships. We also examine the social aspects of the supply chain management, by examining the role of trust in supply chain integration. The results indicate that while trust is very important for integration of physical and information flows across the supply chain, it does not appear to play a significant role in financial flow integration. It is feasible that norms and business practices are well established for the conduct of routine financial transactions. A more elaborate framing of financial integration that differentiates between routine and non-routine financial integration may provide some interesting insights in terms of associations with relational norms.

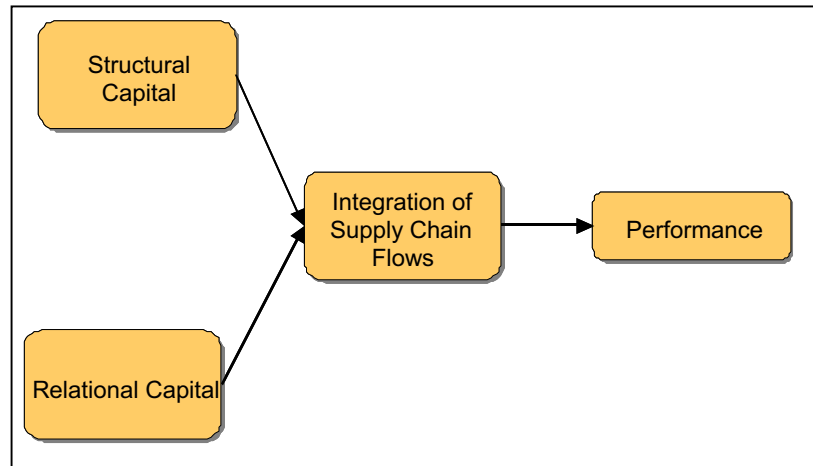


Figure 5: Research Framework

Putting together the results of our analysis we propose a framework for IT-enabled supply chain integration (Figure 5). IT infrastructure impacts organizational performance through an intermediate impact on supply chain resource flows. It also enables the digitization of supply chain activities. Organizations are better able to share information within and across boundaries with appropriate IT infrastructure capabilities. While IT infrastructure and digitization represent the structural capital, supply chain partnerships represent the relational capital of the supply chain. Organizations can leverage their structural and relational capital to enhance their resource flow integration with supply chain partners and improve their performance. The effect of structural and relational capital on organizational performance is mediated by the extent to which organizations are able to integrate physical, financial, and information flows across the supply chain.

The paper presents an initial exploration of relationships between IT variables, relational orientation of the firm with its partners, supply chain integration and performance. The presentation is non-traditional and attempts to provide insights at a lower level of granularity by combining descriptive analysis with more traditional statistical techniques. There are inherent limitations associated with the survey method of data collection. Our analytical approach was oriented to generate insights, as opposed to provide confirmatory evidence of pre-specified theoretical positions. The analysis specifies a linear view of relationships and does not examine complex interactions between variables. For instance, the fact that information flow integration is not significant in its prediction of customer relationship performance can arise due to the fact that information flow integration enables physical flow integration which in turn then impacts customer relationships. We hope that the research framework provides a platform to orient future research and discussion on IT-enabled supply chain integration.

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APPENDIX

Survey Items from the Questionnaire

Digitization

In responding to the questions in this part, please select your organization's primary product(s) or product line(s). **Primary product(s) or product line(s)** commands a significant proportion of company revenues, usually 15 to 20 percent, or greater, of revenues.

- | | | | | | | |
|---|------|----------|--------|--------|--------|-------|
| • Proportion of REVENUES from online sales. | none | <20% | 20-40% | 40-60% | 60-80% | > 80% |
| • Proportion of INBOUND supply chain activities managed online (e.g. procurement, warehousing, payments). | none | very few | some | many | most | all |
| • Proportion of INTRA- ORGANIZATION supply chain activities managed online (e.g. manufacturing, material requirement planning, product planning). | none | very few | some | many | most | all |
| • Proportion of OUTBOUND supply chain activities managed online (e.g. orders received, billing, distribution, tracking). | none | very few | some | many | most | all |
| • Products and services SOLD online. | none | very few | some | many | most | all |
| • CUSTOMER SERVICE activities conducted online (e.g. answering questions, complaints, live chat). | none | very few | some | many | most | all |

Please use the following scale to indicate the extent of your agreement with each statement below.

Strongly Agree	Agree	Slightly Agree	Neutral	Disagree Slightly	Disagree	Strongly Disagree
SA	A	AS	N	DS	D	SD

Data Integration in IT Infrastructure

- | | | | | | | | |
|--|----|---|----|---|----|---|----|
| • Automatic data capture systems are used (e.g. bar code) across the supply chain. | SA | A | AS | N | DS | D | SD |
| • Definitions of key data elements (e.g. customer, order, part number) are common across the supply chain. | SA | A | AS | N | DS | D | SD |
| • Same data (e.g. order status) stored in different databases across the supply chain is consistent. | SA | A | AS | N | DS | D | SD |
| • Same data needs to be reentered in the computer at each step in the supply chain. | SA | A | AS | N | DS | D | SD |

Application Integration in IT Infrastructure

The following applications communicate in real-time:	SA	A	AS	N	DS	D	SD
• Supply chain planning applications(e.g. Demand planning, transportation planning, manufacturing planning).	SA	A	AS	N	DS	D	SD
• Supply chain transaction applications (Order management, procurement, manufacturing and distribution).	SA	A	AS	N	DS	D	SD
• Supply chain applications with internal applications of our organization (such as enterprise resource planning).	SA	A	AS	N	DS	D	SD
• Customer relationship applications with internal applications of our organization.	SA	A	AS	N	DS	D	SD

Physical Flow Integration

• Inventory holdings are minimized across the supply chain.	SA	A	AS	N	DS	D	SD
• Supply chain wide inventory is jointly managed with suppliers and logistics partners (e.g. UPS, FedEx).	SA	A	AS	N	DS	D	SD
• Suppliers and logistics partners deliver products and materials just in time.	SA	A	AS	N	DS	D	SD
• Distribution networks are configured to minimize total supply chain –wide inventory costs.	SA	A	AS	N	DS	D	SD

Financial Flow Integration

• Capital efficiency, working and fixed, is maximized across the supply chain.	SA	A	AS	N	DS	D	SD
• Account receivables processes are automatically triggered when we ship to our customers.	SA	A	AS	N	DS	D	SD
• Account payable processes are automatically triggered when we receive supplies from our suppliers.	SA	A	AS	N	DS	D	SD
• We use activity based costing for key supply chain processes (e.g. inventory, storage, transportation).	SA	A	AS	N	DS	D	SD

Information Flow Integration

- Production and delivery schedules are shared across the supply chain. SA A AS N DS D SD
- Performance metrics are shared across the supply chain. SA A AS N DS D SD
- Supply chain members collaborate in arriving at demand forecasts. SA A AS N DS D SD
- Our downstream partners (e.g. distributors, wholesalers, retailers) share their actual sales data with us. SA A AS N DS D SD
- Inventory data are visible at all steps across the supply chain. SA A AS N DS D SD
- Order fulfillment and shipment status are tracked at each step across the supply chain. SA A AS N DS D SD

Trust

- We have long-term relationships with strategic partners. SA A AS N DS D SD
- In key partner relationships, trust and goodwill have the same, or greater, significance as formal contracts. SA A AS N DS D SD
- Both sides in the relationship do not make any demands that can hurt the relationship. SA A AS N DS D SD
- In key partner relationships, information about procedures and cost structures are shared. SA A AS N DS D SD

Organizational Performance

Much better than Average	Better than Average	Same as Competitors-Average	Slightly Less than Average	Much Less than Average
1	2	3	4	5

Efficiency

- Product delivery cycle time. 1 2 3 4 5
- Timeliness of after sales service. 1 2 3 4 5
- Productivity improvements (e.g. assets, operating costs, labor costs). 1 2 3 4 5

Revenue Growth

- Increasing sales of existing products. 1 2 3 4 5
- Finding new revenue streams (e.g. new products, new markets). 1 2 3 4 5

Customer Relationship

- Strong and continuous bond with customers. 1 2 3 4 5
- Precise knowledge of customer buying patterns. 1 2 3 4 5