Supply Chain Integration: Its Antecedents and Impact on Firm's Operational Performance

by

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LIST OF ABBREVIATIONS

AVE	Average variance extracted
CFA	Cross-functional applications
CI	Customer integration
CR	Composite reliability
CRM	Customer relationship management
CS	Customer service
CUS_ICT	Customer information and communication technology
CUS_INT	Customer integration
D	Delivery
DC	Data consistency
DU	Demand uncertainty
EDI	Electronic data interchange
ERP	Enterprise resource planning
EU	Environmental uncertainty
EXT_ICT	External information and communication technology
EXT_INT	External integration
FOP	Firm's operational performance
ICT	Information and communication technology
II	Internal integration
IL	Inventory level
INTER_ICT	Internal information and communication technology
INTER_INT	Internal integration
IT	Information technology
Nfs	Fail-safe number
OVER_ICT	Overall information and communication technology
OVER_INT	Overall integration
PC	Production cost
PLS	Partial least square
PMF	Product-mix flexibility
Q	Quality
RBV	Resource-based view
RFID	Radio-frequency identification
RV	Relational view
SCA	Supply chain applications
SCI	Supply chain integration
SCM	Supply chain management
SEM	Structural equation model
SI	Supplier integration
SU	Supply uncertainty
SUP_ICT	Supplier information and communication technology
SUP_INT	Supplier integration
TU	Technology uncertainty

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Chapter 1. Introduction

1.1 RESEARCH MOTIVATION

Supply chain integration (SCI) is considered to be a core concept of supply chain management (Pagell 2004) and it has become one of the most popular concepts discussed by researchers and practitioners from diverse fields of management as logistics, operations, information systems and organizational behavior.

The past literature suggests that SCI is a key factorin achieving improvements and competitive advantage (Van der Vaart and van Donk 2008). And it is often believed that the higher the integration level the better for firm's and supply chain performance(Droge, Jayaram, and Vickery 2004, Frohlich and Westbrook 2001, Gimenez and Ventura 2005) by practitioners and researchers.

On the other hand, researchers conducted enormous amount of study in an attempt to explore the factors (antecedents) that facilitate SCI. Among these factors are information and communication technologies(Bharadwaj 2000, Grover and Malhotra 1999, Kearns and Lederer 2003, Sanders 2007b), organizational behavior-related concepts such as trust, power, commitments(Zhao et al. 2008), and environmental factors such as uncertainty, market volatility and competition(Paulraj and Chen 2007a).

The findings from the existing literature on the relationship between SCI and performance,and therelationship between above-stated SCI antecedents and SCI report inconsistent conclusions, calling for further empirical evidence. Possible reasons for these inconsistencies can be lack of clear definitions and/or understanding of concepts, and use of different instruments for measuring constructs.

As such, thisdissertation(hereafter "this study") empirically examines relationships between supply chain integration, firm's operational performance, information technology capabilities and environmental uncertainty. These concepts are defined, classified and operationalized based on the previous literature.

FollowingZhao et al. (2008), supply chain integration (SCI) in this study is defined as the degree to which a firm strategically collaborates with its supply chain partners and collaboratively manages intra- and inter-organizational resources to achieve effective and efficient flow of products, services, information, money and decisions, with the objective of providing maximum value to its customers. We consider SCI as comprising of three dimensions: internal, supplier and internal integration (Flynn, Huo, and Zhao 2010).

Further, uncertainty is defined as the inability to assign probabilities to future events (Duncan 1972) or the difficulties to accurately predict the outcomes of decisions(Downey, Hellriegel, and Slocum Jr 1975, Duncan 1972) due to incomplete information or changing conditions(Germain, Claycomb, and Dröge 2008). We classify environmental uncertainty based on three sources, i.e. supply uncertainty, customer or demand uncertainty, and technology uncertainty.

Next, IT capability is defined as technological capability used to acquire, process, and transmit information for more effective decision making(Grover and Malhotra 1999), and to facilitate communication, coordination and collaboration between multiple parties along the supply chain. We suggest that IT capabilities can be classified into three types of (1) cross-functional applications capabilityand (2) supply chain applications capability, corresponding to the typology of SCI, internal integration and external integration, and (3) data consistency as a common data definition across these integrative applications.

Lastly, we measure operational performance by sixdimensionsof product-mix flexibility, quality, delivery, production cost, inventory level, and customer service.

Further the existing literature on SCI shows that there are a plenty of empirical evidence based on US manufacturing organizations and a small number of studies that empirically investigated relationship between IT capabilities, environmental uncertainty, SCI, and operational performance based on Japanese manufacturing organizations case.

1.2 RESEARCH OBJECTIVE AND QUESTIONS

In an attempt to address the issues of inconsistent findings and gaps in the literature and to contribute to the knowledge base, drawing on operations management and organizational theories of *resource based view*(Barney 1991), *relational view*(Dyer and Singh 1998), and *resource dependence theory*(Pfeffer and Salancik 1978) and findings from the previous literature in the areas supply chain management, operations management and information and communication technology, this study aims:

- to empirically test the relationship between multiple dimensions of SCI and firm's operational performance;
- to comprehensively and quantitatively review empirical studies on the relationship between ICT and SCI through meta-analysis;
- to empirically test the relationship between multiple dimensions of IT capability and supply chain integration (SCI);
- to empirically examine the role of supply chain integration dimensions in reducing different sources of environmental uncertainties;
- to empirically examine the above investigated relationships between antecedents of SCI (environmental uncertainties and IT capabilities) and SCI, and between SCI and firm's operational performance dimensions in a single research model.

In doing so, this study contributes to the existing theory and practice and attempts to answer the following research questions:

- How three distinct types of supply chain integration (internal, supplier and customer integration) can be enabled by three dimensions of IT capabilities (cross-functional applications, supply chain applications, and data consistency capability)?
- How these technological (IT capability) and relationship (SCI) factors can mitigate or reduce three distinct sources of environmental uncertainty (demand, supply, and technology uncertainties) in the context of supply chain?

- ➢ How these SCI types can improve the above-mentioned six dimensions of firm's operational performance?

1.3 STRUCTURE OF THE DISSERTATION

The structure of the study is as follows. First, summary of the literature on empirical studies on the relationships between SCI and operational performance, between IT and SCI, and between environmental uncertainty and SCI is provided in **Chapter 2**.Construct dimensions, the relationships between constructs, sample description, research methodology, and their findings are presented in an easy to compare table-forms.

Next, **Chapter 3** provides a general research design in terms of sampling, data collections, and data analysis procedure for measurement items and structural equation model (SEM) analysis.

In **Chapter 4**, an empirical study on the relationship between supply chain integration and firm's operational performance is documented.

Chapter 5 exhibits a meta-analysis on the relationship between information and communication technology and supply chain integration.

Chapter 6 presents an empirical study on the relationship between information technology capability and supply chain integration.

Chapter 7 documents an empirical study on the relationship between environmental uncertainty and supply chain integration.

In **Chapter 8**, the relationship between environmental uncertainty, information technology capability, supply chain integration, and firm's operational performance is examined in a combined research model.

Lastly, conclusions, practical and theoretical implications, research limitations and future research ideas are presented in **Chapter 9**.

Chapter 2. Literature review

Supply chain integration (SCI) is considered to bea core concept and as one of the key practices for performance improvement, in the area of supply chain management (Leuschner, Rogers, and Charvet 2013, Van der Vaart and van Donk 2008). There is a large amount of literature on how much critical role SCI plays in firm's or entire supply chain's performance and what factors can contribute to a better SCI.

Following the objective of this study, this chapter provides selective lists of the past literature that empirically examined the relationships between SCI and operational performance, between information technology (IT) and SCI, and between environmental uncertainty (EU) and SCI, in order to exhibit a foundation for further research framework and hypotheses development, and discussion on the study results as well.

2.1 Literature on the relationship between SCI and operational performance

Table 1 provides the list of representative studies on the relationship between SCI and operational performance, their sample description, methodology and main findings on the relationships. As shown in Table 1, studies classify SCI as internal and external integration (Danese 2013, Sanders 2007a), or some consider customer and supplier integration as separate dimensions (Devaraj, Krajewski, and Wei 2007, Narasimhan, Swink, and Viswanathan 2010), another examine SCI in terms of internal, customer and supplier integration dimensions (Flynn, Huo, and Zhao 2010). There are studies that examined impact of only one of external integration dimensions, i.e. supplier integration (Prajogo and Olhager 2012) or customer integration (Closs and Savitskie 2003) on operational performance construct. On the other hand, operational performance construct has been considered mostly as a single dimension, expect for couple of studies (Frohlich and Westbrook 2001, Narasimhan, Swink, and Viswanathan 2010). In terms of sample description, five studies were conducted in US, two studies targeted multiple countries (Danese 2013, Frohlich and Westbrook 2001), another two studies examined samples from

China (Flynn, Huo, and Zhao 2010) and Australia (Prajogo and Olhager 2012) each. All studies' samples represented the manufacturing industry.

2.2 Literature on antecedents of SCI

2.2.1 IT-SCI relationship

Table 2 shows the list of representative studies on the relationship between IT and SCI, along with their methodology and main findings about the relationships. As exhibited in Table 2, the studies range widely on both IT and SCI dimensions, and their samples represent mostly US manufacturing firms (Devaraj, Krajewski, and Wei 2007, Rai, Patnayakuni, and Seth 2006, Paulraj, Lado, and Chen 2008), with a study by Li et al. (2009) representing sample from China, and a study by Prajogo and Olhager (2012) targeting sample from Australia.

An extensive quantitative review of the previous literature in a form of meta-analysis is provided in Chapter 5.

2.2.2 EU-SCI relationship

Table 3 shows the list of studies on the relationship between environmental uncertainty (EU) and SCI, along with their sample description, research methodology, and main findings about the relationships. As shown in the table, to the best of our knowledge, only two studies were found which examined the relationship between EU and SCI empirically with respect to similarity of these constructs' dimensions to our study.

Table 1 Studies on the relationship between SCI and operational performance

Author	Dimensions of SCI	Dimensions of operational performance	Sample	Methodology	Main findings
Danese (2013)	Internal integration and external integration (separate constructs)	On-time delivery, fast delivery, product-mix flexibility, volume flexibility (single construct)	266 manufacturing plants from Finland, US, Japan, Germany, Sweden, Italy, Austria, Spain, Korea	Empirical study, hierarchical regression procedure	Both internal and external integration are found to impact performance
Devaraj, Krajewski, and Wei (2007)	Customer and supplier integration (separate constructs)	Quality, delivery speed & reliability, production costs, production lead time, inventory turns, process flexibility (single construct)	120 manufacturing firms in US	Empirical study, SEM	Supplier integration positively impacted performance, while customer integration was not found to impact performance
Frohlich and Westbrook (2001)	Customer and supplier integration (arcs of integration)	Inventory turnover, customer service, conformance quality, product variety, on-time delivery, number of new products developed, product development speed (separate constructs)	322 manufacturing firms from 23 countries	Emprical study, ANOVA method	All performance measures are found to be significantly improved
Flynn, Huo, and Zhao (2010)	Internal integration, customer integration, supplier integration (separate constructs)	Product-mix flexibility, on-time delivery, lead time, customer service (one construct)	617 manufacturing firms in China	Empirical study, hierarchical regression procedure	Internal and customer integration were found to be significantly impacting operational performance, while supplier integration was not found to impact operational performance
Prajogo and Olhager (2012)	Logistics integration with suppliers (single construct)	Delivery speed, volume flexibility, product variety, productions costs, final products performance (single construct)	232 Australian manufacturing firms	Empirical study, structural model	Positive and significant relationship between supplier logistics integration and performance
Sanders (2007a)	Internal and external integration (separate constructs)	Quality, cost improvement, new product introduction time, delivery speed (one construct)	245 manufacturing firms in US	Emprical study, SEM	Examined only impact of internal integration on performance which was supported

Author	Dimensions of SCI	Dimensions of operational performance	Sample	Methodology	Main findings
Closs and Savitskie (2003)	Customer integration (single construct)	Customer service performance: Delivery speed, responsiveness to key customers, order fill capacity, delivery time flexibility, customer satisfactions (single construct)	306 manufacturing, wholesale/distributing, retail industries in US	Empirical study, SEM	Positive and significant relationship between customer integration and customer service performance
Narasimhan, Swink, and Viswanathan (2010)	Strategic customer integration, strategic supplier integration (separate constructs)	Cost, quality, delivery, process flexibility, new product flexibility (separate constructs)	224 manufacturing plants in US	Empirical study, standardized regression analysis	No significant impact from strategic customer integration on performance dimensions. Strategic supplier integration has negative impact on quality and positive impact on process flexibility. No impact from strategic supplier integration on cost, delivery, and product flexibility performance.
Vickery et al. (2003)	Supplier partnering, closer customer relationships, cross-functional teams (single construct)	Customer service: pre-sale customer service, product support, responsiveness to customers, delivery speed, delivery dependability (single construct)	57 automotive firms in US	Empirical study, SEM	Positive and significant relationship between overall SCI and customer service performance

Table 2 Studies on the relationship between IT and SCI

Author	Dimensions of IT	Dimensions of SCI	Sample	Methodology	Main findings
Devaraj, Krajewski, and Wei (2007)	eBusiness capabilities (1) customer, (2) purchasing, (3) collaboration (separate constructs)	Customer and supplier integration (separate constructs)	120 manufacturing firms in US	Empirical study, SEM	Purchasing eBusiness capability was found to impact both supplier and customer integration. Collaboration eBusiness capabily was found to impact both customer and supplier integration. Customer eBusiness capabilities did not significantly impact integration with suppliers and customers
Rai, Patnayakuni, and Seth (2006)	IT infrastructure for SCM composed of data consistency and cross-functional application integration (formative one construct)	Process integration capability: in terms of information, material and money flows with supply chain partners (formative one construct)	110 manufacturing and retail firms in US	Empirical study, SEM PLS	Positive impact between IT infrastructure for SCM and SC process integration
Li et al. (2009)	IT implementation (EDI, supply chain applications etc.)	Internal and external integration (single construct)	182 manufacturing firms in China	Empirical study, SEM	Positive and significant relationship between IT implementation and SCI
Sanders and Premus (2005)	IT capability (single construct)	Internal and external integration (separate construct)	245 US manufacturing firms	Empirical study, SEM	Both internal and external integration was positively and significantly influenced by IT capability
Prajogo and Olhager (2012)	Information technology (single construct)	Logistics integration with suppliers (single construct)	232 Australian manufacturing firms	Empirical study, SEM	Significant and positive relationship between IT and logistics integration with suppliers
Hill and Scudder (2002)	EDI use (single construct)	Customer coordination and supplier coordination (separate constructs)	185 food manufacturing and distributor firms in US	Empirical study, correlation analysis	EDI is not used for customer coordination, but EDI is most likely to be used for supplier coordination
Paulraj and Chen (2007a)	IT for transaction, coordination of actions through SC (single construct)	Inter-organizational communication (with customers and suppliers) (single construct)	221 US manufacturing firms	Empirical study, SEM	Significant and positive relationship between IT and Inter-organizational communication

Table 3 Studies on the relationship between environmental uncertainty (EU) and SCI

Author	Dimensions of EU	Dimensions of SCI	Sample	Methodology	Main findings
Wong and Boon-itt (2008)	Supply uncertainty, customer uncertainty, technology uncertainty (separate constructs)	Internal integration, customer integration, supplier integration	Seven automotive companies inThailand	Case study	Overall high EU is associated with high level of SCI. High customer uncertainty => high customer integration; high level of technology uncertainty => high level of integration with customers and suppliers
Paulraj and Chen (2007a)	Supply uncertainty, demand uncertainty, technology uncertainty (separate constructs)	Strategic supply management as formative construct consisting of strategic purchasing, long-term relationship with suppliers, inter-firm communication, cross-functional teams, and supplier integration	221 US manufacturing firms	Empirical study, SEM	Demand uncertainty did not influence the strategic supply management; technology uncertainty and supply uncertainty were found to significantly influence strategic supply management
Li and Lin (2006)	Customer uncertainty, supplier uncertainty, technology uncertainty (separate constructs)	Information sharing with supply chain partners (single construct)	196 manufacturing and logistics firms in US	Empirical study, regression analysis	Supplier uncertainty was found negatively and significantly influence information sharing. Other uncertainties were not found to influence information sharing significantly

Chapter 3. Research design and measurement analyses for survey study

This research employs two types of methodology. Firstly, an empirical study is conducted using path analysis in order to test an analytical framework, its three variations, and their hypotheses, which are developed based on theories and previous literature. Secondly, a meta-analysis is used in order to examine the relationship between two constructs (information and communication technology and supply chain integration) of the study through comprehensive and quantitative reviewing of past empirical studies.

This chapter broadly discusses on the empirical part of the study. Sampling and data collection procedure, overall research framework, general research methodology in terms of measurement model and structural equation model (SEM) with partial least square (PLS) technique are described in this chapter.

Meta-analysis procedures and its results are introducedin Chapter 5.

3.1 Sampling and Data Collection

Data for the empirical research for this study were collected through a survey of manufacturing firms in Japan during September through October in 2013. The survey instrument was mailed to 815 large manufacturing companies, which are listed in the First Section of the Tokyo Stock Exchange. This study focused on large firms generally considered as "leaders in innovative practices, such as IT and SCM" (Sanders et al. 2005: 6).

As the information targeted in this research is strategic in nature, and concerns relationship management and integration with internal functions, customers and suppliers within the supply chain; the survey instrument was sent to the highest ranking manager, a key informant, who is knowledgeable in supply chain management, and is familiar with internal processes, processes for purchasing and distribution,and customer and suppliers relationship management. This is supported by a study by Phillips (1981) that shows high ranking informants tend to be more reliable sources of information than low ranking. The target key informants included supply chain managers, CEO, presidents, senior executives, vice presidents, senior directors and senior managers. The name and contact information of the most suitable informant was identified from the latest annual financial statement of each company.

Table 4 Sample profile

Metrics	Number	%	Metrics	Number	%
Industry			**Number of employees**		
Metal, mechanical and engineering	24	22.2	< 50	1	0.9
Chemicals and petrochemical	22	20.3	100-199	1	0.9
Electronics and electrical	21	19.4	200-499	10	9.3
Transportation equipment	10	9.2	500-999	20	18.5
Textiles and apparel	8	7.4	1,000-4,999	47	43.5
Rubber and plastics	4	3.7	> 5,000	28	25.9
Food, beverage and alcohol	4	3.7	n.a.	1	0.9
Pharmaceutical and medical	4	3.7	Total	108	100%
Wood and furniture	3	2.7			
Ceramic	3	2.7	**Sales volume (Year 2011)**		
Building materials	2	1.8	20-50 mln USD	1	0.9
Pulp and paper	2	1.8	50-100 mln USD	3	2.8
Jewelry	1	0.9	Over 100 mln USD	104	96.3
Total	108	100%	Total	108	100%

The mailing included the survey instrument, a return envelope with deferred postage, and a cover letter, which contained objectives of the research and a web-link for the web survey.

Follow-up telephone calls were made after approximately 30 days to increase the response rate. This resulted in total of 117 responses yielding a response rate of 14.36%, of which 95 responses were received by mail and 22 responses through the web-survey interface.

Of 117 responses, nine incomplete responses were discarded. Accordingly, the analysis that follows and all reported statistics were based on a sample of 108manufacturing firms. However the response rate is low, the rate is similar to other surveys that targeted senior managers (Sanders et al. 2005; Wisner 2003).

Table 4 shows the demographic profiles of the sample. A wide variety of industries are represented, with around 22.2% companies representing the metal, mechanical and engineering industry, and another around 20.3% standing for the chemical and petrochemicals industry sector, followed by around 19.4% coming from the electronics and electrical sector.

3.1.1 Non-response Bias

Non-response bias is a concern for every survey methodology. We compared the responses between the early and late respondents using an independent t-test (Armstrong et al. 1977) for fixed assets, annual sales, and number of employees (Handfield et al. 2002; Stank et al. 2001a; Zhao et al. 2011). Early respondents were those who had completed and returned the questionnaires within the given deadline for survey response; late respondents refer to those who returned the questionnaires after the deadline. The t-tests show no significant differences ($p<0.05$), suggesting that non-response bias does not appear to present in the data.

3.2 OVERALL RESEARCH FRAMEWORK

The research examines impact of environmental uncertainty (EU) on information technology (IT) capability, and impacts of EU and IT capability on supply chain integration (SCI), and impact of SCI on firm's operational performance (FOP). Figure 1 shows the overall framework of the study.

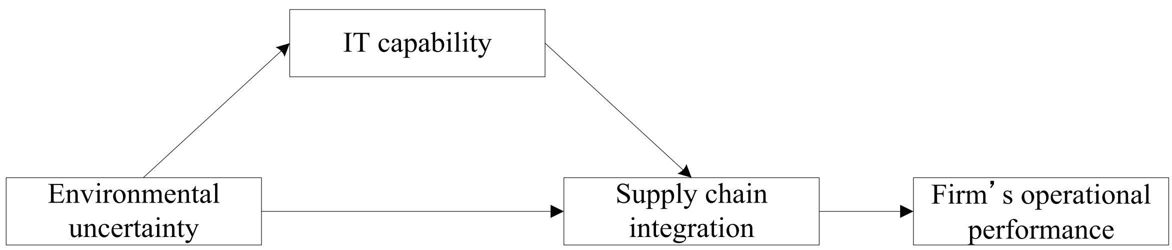

Figure 1 Overall analytical framework

The following chapters of this dissertation consider these relationships in pairs, developing regarding hypotheses based on the theoretical background provided in the previous literature. In total, four different research models are tested: (1) SCI and FOP, (2) IT capability and SCI, (3) EU and SCI, (4) EU, IT capability, SCI and FOP.

3.3 DATA ANALYSIS USING PLS

The partial least square approach is used for structural equation modeling in this study. The reason for choosing PLS is that it requires smaller sample size than LISREL (Chin et al. 2003) and AMOS do. The software SmartPLS version 3.1.3 was exploited for data analysis. All items are standardized to zero mean and unit variance. To estimate the significance of path coefficients and item loadings, we use a bootstrapping approach, where 500 random samples of observations with replacements are generated from the original dataset (Chin 1998; Efron et al. 1993).

3.3.1 Measurement validation

The measurement items for four research models are extracted from the previous literature, which has extensively exploited these items and confirmed their content validity (Chen et al. 2004). Each of previously stated concepts from the overall analytical framework (Figure 1) comprises different constructs. Supply chain integration (SCI) consists of (1) internal integration (II), (2) customer integration (CI), and (3) supplier integration (SI) constructs. Next, information technology (IT) capability is classified into (1) data consistency (DC), (2) cross-functional applications (CFA), and (3) supply chain applications (SCA) constructs. Further, environmental uncertainty (EU) is measured in terms of its sources: (1) demand uncertainty (DU), (2) supply uncertainty (SU), (3) technological uncertainty (TU). Last, firm’s operational performance (FOP) is measured in term of (1) product-mix flexibility (PMF), (2) delivery (D), (3) production cost (PC), (4) quality (Q), (5) inventory level (IL), (6) customer service (CS) dimensions. Appendix D shows measurement items and their respective sources.

Measurement instruments are examined in terms of reliability, unidimensionality, convergent and discriminant validity and described in chapters they are considered in.

Reliability of the scales is tested by Cronbach's alpha value. The scales demonstrating Cronbach's alpha value of greater than 0.60 are considered to be reliable (Flynn et al. 1990; Nunnally et al. 1991). Unidimensionality of the scale items is examined using factor analysis. Convergent validity is proven by analyzing composite reliability (CR), average variance extracted (AVE), and significance of item loadings. For convergent validity, CR and AVE are required to be greater than the threshold values of 0.60 and 0.50 respectively (Bagozzi et al. 1988; Fornell et al. 1981; Hair et al. 1998; Nunnally et al. 1991). Following Fornell et al. (1981) approach, a measurement model demonstrates discriminant validity if all the scales demonstrate considerably higher square root of AVE values compared to the correlations with other constructs.

3.3.2 SEM testing

The four research models are tested using PLS method. Since PLS method does not directly provide significance tests and confidence interval estimates of path coefficients in the research model, a bootstrapping technique is used in order to estimate the significance of path coefficients. One-tailed bootstrap analysis with 500 subsamples is carried out and path coefficients are re-estimated using each of these samples. The vector of parameter estimates is used to compute parameter means, standard errors, significance of path coefficients (Rai et al. 2006). This approach is consistent with recommended practices for estimating significance of path coefficients and indicator loadings (Lohmöller 1989).

Chapter 4. Impact of supply chain integration on firm's operational performance

4.1 INTRODUCTION

Broad range of study has been conducted on supply chain integration (SCI), as one of the key practices for performance improvement, in the area of supply chain management (Leuschner, Rogers, and Charvet 2013, Van der Vaart and van Donk 2008). And it is often believed that the more integration the better (Droge, Jayaram, and Vickery 2004, Frohlich and Westbrook 2001, Gimenez and Ventura 2005) by practitioners and researchers. However, researchers report contradictory findings on "promised benefits and still limited evidence of extensive implementation…" from supply chain integration (Power 2005). Extensive range of reasons is provided for this contradiction, among which are lack of clear definitions and conceptualization of SCI (Fabbe-Costes and Jahre 2008), and the way how performance is measured in the literature. For instance, SCI has mostly been considered as a single construct (Armistead and Mapes 1993), or classified into internal and external integration (Campbell and Sankaran* 2005, Hill and Scudder 2002)or multiple constructs (Childerhouse et al. 2003, Gimenez and Ventura 2005). On the other hand, performance constructs exhibit different measures such as operational, financial and market performance.

These diverse approaches in explaining the link between SCI and performance have resulted in the lack of understanding the implications of SCI for both researchers and practitioners. Hence, there has been a call for further empirical evidence on the relationship between SCI and performance (Stank, Keller, and Closs 2001, Wisner 2003). In trying to address this call and contribute to the theory and practice in operations and supply chain management, this chapter aims to explain the link between SCI and firm's operational performance by empirically testing the relationship between multiple dimensions of both SCI and firm's operational performance. Thus, the research questions of this chapter are: (1) Do internal integration (II), supplier integration (SI), customer integration (CI) impact operational performance of a firm in terms of product-mix flexibility, delivery, production cost, quality, inventory, and customer service? (2) Does internal integration impact the external integration in terms of supplier integration (SI) and customer integration (CU)? (3) Do the relationships vary between different dimensions of SCI and firm's operational performance?

4.2 Analytical Framework: Theoretical foundation and hypotheses development

4.2.1 Supply Chain Integration

Supply chain integration (SCI) is defined as "the degree to which an organization strategically collaborates with its main supply chain partners and manages intra- and inter-organization processes to achieve effective and efficient flows of products, services, information, money and decisions, with the objective of providing maximum value to its customers" (Zhao et al. 2008)(p. 7). According to Lee, Padmanabhan, and Whang (2004) there are different types of SCI distinguished in the current literature, with the majority of authors considering SCI as a unidimensional construct (Armistead and Mapes 1993, Crespo Marquez, Bianchi, and Gupta 2004, Miller 1992), other researchers classified SCI into external and internal integration (Campbell and Sankaran* 2005, Hill and Scudder 2002, Morash and Clinton 1998, Pagell 2004, Stank, Keller, and Closs 2001, Stanley and Wisner 2001, Zailani and Rajagopal 2005), while some authors considered multiple dimensions of SCI (Childerhouse et al. 2003, Gimenez and Ventura 2005, Narasimhan and Kim 2002, Stank, Keller, and Closs 2001, Vickery et al. 2003).

In this study, we consider three distinct types of SCI, namely, customer integration, supplier integration and internal integration. Customer integration and supplier integration are regarded by researchers as an external integration, which is defined as the degree to which a focal organization can partner with its key supply chain members (suppliers and customers) to structure their inter-organizational strategies, practices and processes into collaborative, synchronized processes (Lee, Padmanabhan, and Whang 2004, Stank, Keller, and Daugherty 2001). However these two integration types are called as an external integration, each of them pertains to various activities depending on whether it's supplier integration or customer integration, because the context of the relationship between suppliers and customers is different.

Supplier integration involves communication and coordination activities, information sharing, and participation by suppliers in a focal organization's procurement and production processes. On the contrary, customer integration includes such activities as communication and contact with customers, sharing of market and inventory information, and follow-up with customers for feedback of its services and products.

Internal integration is defined as the degree to which a firm structures its own organizational strategies, practices and processes into collaborative, synchronized processes, with the aim to fulfill its customers' requirements (Cespedes 1996, Kahn and Mentzer 1996, Kingman-Brundage, George, and Bowen 1995, Lee, Padmanabhan, and Whang 2004). Internal integration mostly includes information sharing between internal functions, strategic cross-functional cooperation and collaboration.

4.2.2 Impact of Internal Integration on Customer Integration and Supplier Integration

In spite of inconsistent findings on the relationship between internal integration and external integration in the existing literature, we argue that internal integration has a positive impact on customer integration and supplier integration. From the perspective of organizational capability, it is argued that when a firm has a high level of internal communication and coordination capabilities, it will be more competent to achieve a high level of customer and supplier integration (Zhao et al. 2011). Barua et al. (2004) found that internal information sharing between functional departments of a firm is positively related to external cooperation with partners. Strategic cooperation literature also suggests that internal integration based on communication, information sharing and cross-functional teamwork is especially important for establishing and maintaining the firm's alliance with its customers and suppliers.

Bowersox (1989)and (Peteraf 1993) suggests that the process of supply chain integration should progress from the integration on internal logistics processes to external integration with suppliers and customers, implying that the higher internal integration can lead to higher customer and supplier integration, respectively (Kanter 1994). Therefore, we argue that firms with higher level of internal integration are more likely integrate with their customers and suppliers.

Hypotheses: Internal integration has a direct and positive impact on customer integration (H1a), supplier integration (H1b).

4.2.3 Firm's Operational Performance

A growing number of empirical evidences suggest that the higher level of integration along the supply chain is positively associated with greater prospective benefits for firm's operational performance(Frohlich and Westbrook 2001). Yet, some also document inconsistent findings on the impact of SCI on operational performance (Gimenez and Ventura 2005, Koufteros, Vonderembse, and Jayaram 2005). And we consider that these inconsistencies partly may be due to the fact that different operational performance measures were combined into a single construct in research models of the previous literature. For instance, Devaraj, Krajewski, and Wei (2007) examined the impact of supply chain integration, based on production information integration and enabled by eBusiness capabilities, on firm's operational performance as a single construct consisting of cost, quality, flexibility and delivery. While investigating the various types of barriers in introducing e-integration initiatives with suppliers and customer, and eBusiness and operational performance, Frohlich (2002) also measured operational performance as a construct which comprises inventory, transaction cost, and delivery items. Ranganathan, Teo, and Dhaliwal (2011), in analyzing the role of key antecedents that contribute to web-enabled supply chain management efforts, and the impact of these efforts on performance construct encompassing not only such operational constructs as customer service, inventory control, operations costs, cycle time, but also relationship and competitive advantage items.

Hence, regarding the operational performance measures separately as different dimensions is crucial in making clear the impact of every type of SCI (internal, supplier and customer) on these dimensions, providing fine-grain insight into the evidence and useful implications to the theory and practice.

In this study, we measure operational performance by sixdimensionsof product-mix flexibility (PMF), quality (Q), delivery (D), production cost (PC), inventory level (IL), and customer service (CS). In doing so, this study can contribute to the existing theory and practice, clarifying in which way three distinct types of supply chain integration (internal, supplier and customer integration) can improve these performance dimensions. Product-mix flexibility is measured in terms of product modification and new product introduction for meeting changing customer needs. Delivery is measured with regard to reliability and timeliness of delivery. Production cost measures to which extent the costs related to the products are lower. Quality is measured in terms of production defect rate and product return rate. Inventory measure asks how low the firm's inventory level is. And finally, customer service measure solicits about the perceived level of customer service by the firm.

4.2.4 Impact of Internal Integration on Operational Performance

With regard to the relationship between internal integration and operational performance dimensions, not all the findings in the literature seem to be consistent. Some authors found no direct relationship between these constructs (Bharadwaj 2000), others found a positive relationship between internal integration and operational performance, including process efficiency (Saeed, Malhotra, and Grover 2005). Thus we argue that internal integration is positively related to product-mix flexibility, quality, delivery, production cost, inventory level, and customer service.

Hypotheses: Internal integration has a direct and positive impact on product-mix flexibility (H3a), delivery (H3b), production cost (H3c), quality (H3d), inventory (H3e), and customer service (H3f).

4.2.5 Impact of Customer and Supplier Integration on Operational Performance

The literature suggests mixed results on the relationship between SCI and business performance (Downey, Hellriegel, and Slocum Jr 1975, Lee, Padmanabhan, and Whang 2004, Merschmann and Thonemann 2011, Stonebraker and Liao 2006), and it is not easy to draw generalized conclusions. Barua et al. (2004) regard customer integration as one of the most instrumental factors of overall firm performance besides internal integration. Devaraj et al. (2007) found a positive relationship between supplier production integration and firm's operational performance. We propose that both customer integration and supplier integration positively influence firm's operational performance dimensions of product-mix flexibility, delivery, production cost, quality, inventory, and customer service.

Hypotheses: Customer integration has a direct and positive impact on product-mix flexibility (H2a), delivery (H2b), production cost (H2c), quality (H2d), inventory (H2e), and customer service (H2f).

Hypotheses: Supplier integration has a direct and positive impact on product-mix flexibility (H4a), delivery (H4b), production cost (H4c), quality (H4d), inventory (H4e), and customer service (H4f).

Following the existing literature on SCI and operational performance, ouranalytical framework was developed as shown in Figure 2,with the research hypotheses described above.

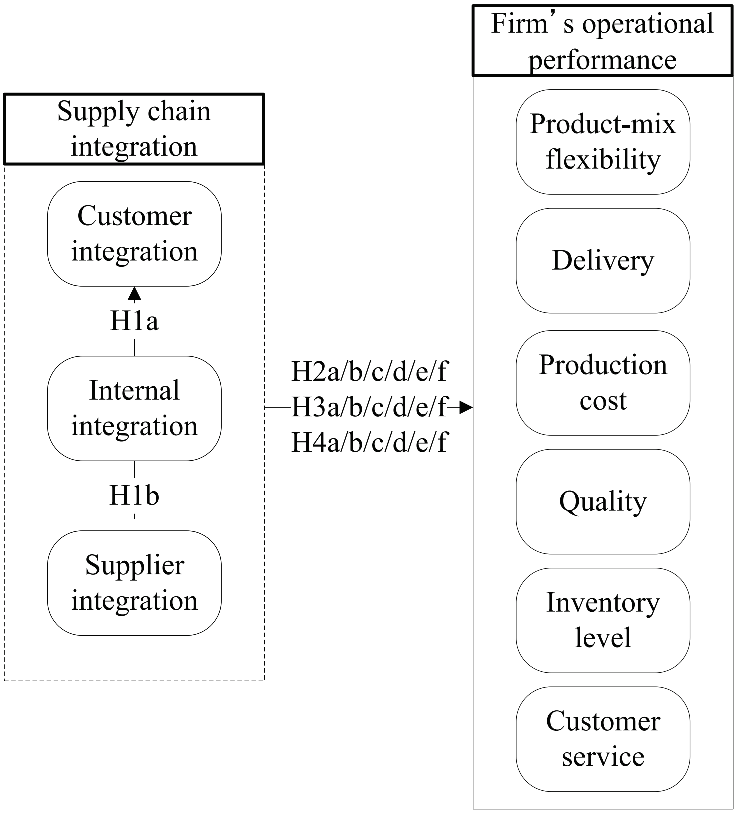

Figure 2 Analytical framework for "SCI - FOP" model

4.3 MEASUREMENT VALIDATION

The model of this chapter examines the impact of three types supply chain integration (SCI) (internal integration (II), customer integration (CI) and supplier integration (SI)) on six dimensions of firm's operational performance (FOP) (product-mix flexibility (PMF), delivery (D), quality (Q), production costs (PC), inventory level (IL), customer service (CS)).

Table 5 shows the factor loadings and Cronbach's alpha values for each construct. The scales are all reliable with alpha values ranging between 0.623 ~ 0.922, thereby exceeding the generally agreed lower limit for Cronbach's alpha of 0.60 (Flynn et al. 1990, Nunnally and Bernstein 1991). The scales' unidimensionalityis examined using factor analysis. As a result, one item from customer integration (CI) and one item from supplier integration (SI) are removed due to low factor loadings. The repeated factor analysis confirmed the unidimensionality for all six factors as the respective items load on only one factor each. All of the factor loadings are greater than 0.68 and the t-values are significantly greater than 8.06 (Table 5).

Table 5 Factor loadings and reliability values of measurement items for "SCI - FOP" model

	II	CI	SI	PMF	D	Q	PC	IL	CS	Cronbach's α	t-values
II1	0.715									0.922	9.33
II2	0.845										24.10
II3	0.878										36.01
II4	0.888										31.71
II5	0.913										54.53
II6	0.848										30.23
CI1		0.683								0.872	9.63
CI2		0.778									18.12
CI3		0.821									19.88
CI5		0.780									14.95
CI6		0.812									16.88
CI7		0.805									20.95
SI1			0.819							0.910	16.79
SI2			0.843								22.80
SI3			0.793								16.46
SI4			0.862								29.61
SI5			0.834								19.82
SI7			0.756								12.08
SI8			0.731								9.26
PMF1				0.840						0.880	18.19
PMF2				0.929							46.96
PMF3				0.920							35.83
D1					0.963					0.904	91.74
D2					0.946						41.60
Q1						0.767				0.623	8.06
Q2						0.919					20.01
PC1							1			1	
IL1								1		1	
CS1									1	1	

Further, to test convergent validity, we analyze composite reliability (CR), average variance extracted (AVE), significance of item loadings. As shown in Table 6, CR and AVE values are greater than threshold values of 0.60 and 0.50 respectively (Bagozzi and Yi 1988, Fornell and Larcker 1981, Hair et al. 1998, Nunnally and Bernstein 1991) indicating convergent validity. Moreover, significant t-values of item loadings at level $p<0.001$ contribute to the convergent validity of measurement scales.

Following Fornell and Larcker (1981) approach, we examined the measurement model for discriminant validity. As illustrated in Table 6, all the scales demonstrate considerably higher square root of AVE values (figures acrossthe diagonal) compared to the correlations with other constructs, suggesting the support for discriminant validity.

Table 6 Constructs' values for mean, SD, correlations, composite reliability, average variance extracted for "SCI – FOP" model

	Mean	SD	CR	AVE	CI	CS	D	II	IL	PC	PMF	Q	SI
CI	4.29	0.90	0.904	0.610	**0.781**								
CS	5.74	1.07	1	1	0.452	**1**							
D	5.71	1.03	0.954	0.911	0.335	0.604	**0.955**						
II	4.33	1.04	0.940	0.723	0.427	0.311	0.337	**0.85**					
IL	4.42	1.40	1	1	0.365	0.403	0.312	0.313	**1**				
PC	4.39	1.24	1	1	0.388	0.401	0.452	0.344	0.445	**1**			
PMF	5.02	1.18	0.925	0.805	0.381	0.496	0.470	0.274	0.466	0.498	**0.897**		
Q	5.58	0.89	0.834	0.717	0.370	0.449	0.576	0.236	0.448	0.468	0.376	**0.847**	
SI	3.83	1.11	0.929	0.651	0.305	0.142	0.307	0.455	0.273	0.238	0.242	0.158	**0.807**

4.4 Hypotheses testing

Figure 3shows the results of the PLS analysis. The predictive power of path model is explained by examining the explained variance or R^2 values (Barclay, Higgins, and Thompson 1995, Chin and Gopal 1995). R^2 values indicate the amount of variance in the construct that is explained by the path model (Barclay, Higgins, and Thompson 1995). Accordingly, the results show that the model explains 16.9% of variance in product-mix flexibility, 17.9% of variance in delivery, 19.3% of variance in production cost, 14.4% of variance in quality, 17.6% of variance in inventory level, 22.4% of variance in customer service representing a good overall model fit. In the same way, 18.2% of variance in customer integration, and 20.7% of variance in supplier integration were explained by internal integration.

We found that 12 specified paths out of 20 paths between constructs in the research model show significant path coefficients, supporting their corresponding hypotheses. The positive and significant paths from internal integration to customer integration ($\beta=0.427$, $t=5.761$, $p=0.000$) and to supplier integration ($\beta=0.455$, $t=5.281$, $p=0.000$) provide support for hypotheses H1a and H1b. All hypothesized paths from customer integration to every performance dimension of product-mix flexibility ($\beta=0.308$, $t=2.429$, $p=0.008$), delivery ($\beta=0.211$, $t=2.246$, $p=0.013$), production cost ($\beta=0.287$, $t=3.052$, $p=0.001$), quality (β=0.326, t=3.684, p=0.000), inventory level (β=0.266, t=2.669, p=0.004), customer service (β=0.398, t=3.269, p=0.001) arepositive and significant providing support for hypotheses H2a, H2b, H2c, H2d, H2e, H2f. Next, the positive and significant paths from internal integration to delivery (β=0.172, t=1.464, p=0.072) and to production cost (β=0.193, t=1.769, p=0.039) provide support for hypotheses H3b and H3c. Lastly, the positive and significant path coefficients from supplier integration to delivery (β=0.164, t=1.568, p=0.059) and to inventory level (β=0.128, t=1.380, p=0.084) provide support for hypotheses H4b and H4e respectively (Table7). Discussions about these results and implications based on them are provided in the next section.

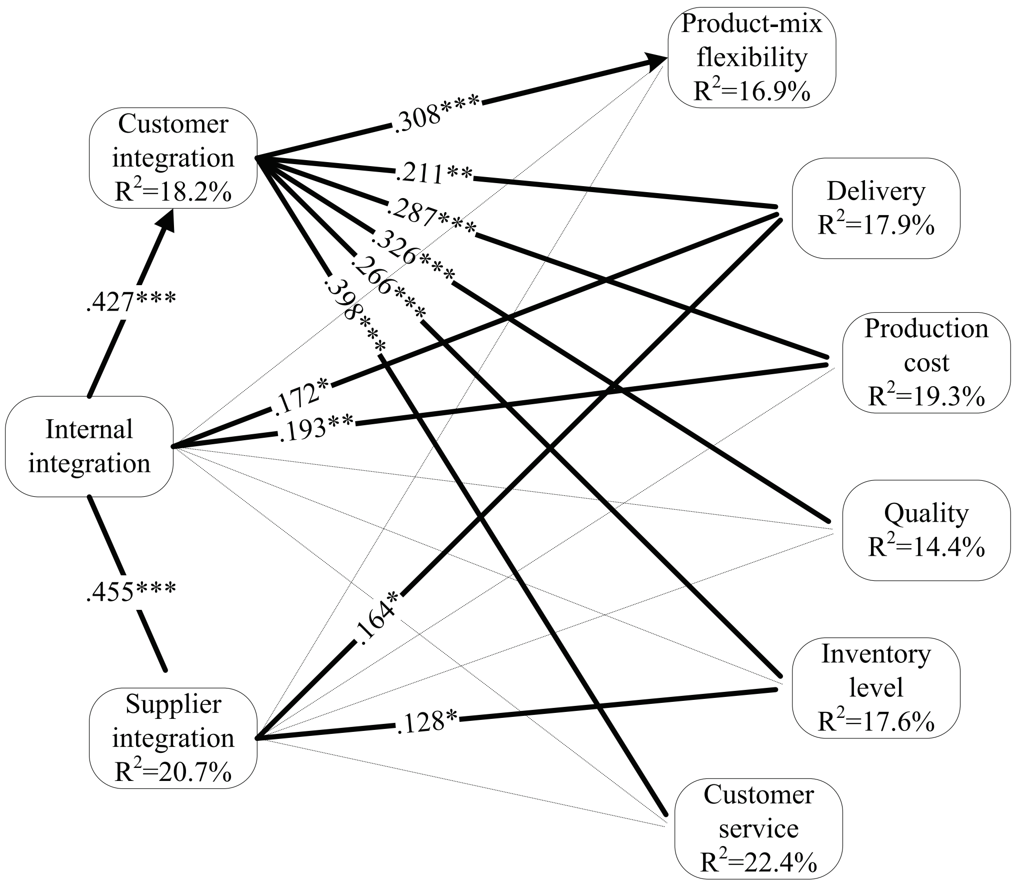

Figure 3 Path analysis results for "SCI - FOP" model

Table 7 Path coefficients for "SCI - FOP" model

	Path coeff. (β)	Sample Mean	Stand. Error	t-value	p values	Hypo-theses	Support for Hyp.
CI -> CS	0.398	0.388	0.122	3.269	0.001	H2f	Supported***
CI -> DEL	0.211	0.212	0.094	2.246	0.013	H2b	Supported**
CI -> INV	0.266	0.263	0.1	2.669	0.004	H2e	Supported***
CI -> PC	0.287	0.281	0.094	3.052	0.001	H2c	Supported***
CI -> PMF	0.308	0.304	0.127	2.429	0.008	H2a	Supported***
CI -> QUAL	0.326	0.33	0.089	3.684	0.000	H2d	Supported***
II -> CI	0.427	0.427	0.074	5.761	0.000	H1a	Supported***
II -> CS	0.165	0.162	0.139	1.187	0.118	H3f	Not supported
II -> DEL	0.172	0.177	0.118	1.464	0.072	H3b	Supported*
II -> INV	0.14	0.137	0.112	1.259	0.104	H3e	Not supported
II -> PC	0.193	0.195	0.109	1.769	0.039	H3c	Supported**
II -> PMF	0.095	0.091	0.099	0.958	0.169	H3a	Not supported
II -> QUAL	0.088	0.084	0.102	0.858	0.196	H3d	Not supported
II -> SI	0.455	0.467	0.086	5.281	0.000	H1b	Supported***
SI -> CS	-0.054	-0.042	0.109	0.5	0.309	H4f	Not supported
SI -> DEL	0.164	0.16	0.105	1.568	0.059	H4b	Supported*
SI -> INV	0.128	0.134	0.093	1.38	0.084	H4e	Supported*
SI -> PC	0.063	0.064	0.095	0.658	0.255	H4c	Not supported
SI -> PMF	0.105	0.117	0.11	0.952	0.171	H4a	Not supported
SI -> QUAL	0.019	0.028	0.115	0.164	0.435	H4d	Not supported

4.5 Discussion and Implications

With regard to relationship between internal integration and external integration, both of customer and supplier integration are positively related with internal integration. This finding is fully in line with the findings from the study of Zhao et al. (2011). Itunderscores the importance of high internal integrative capabilities. From the perspective of organizational learning, the organization is likely to learn more from external partners and understand the partner's business to facilitate external integration, when it possesses a high level of absorptive capability to process the external knowledge acquired from its partners(Zhao et al. 2011). Similarly, highly collaborative nature inside of the organization will improve the external integration enabling frequent contact with the customer and supplier organizations and sharing transactional and strategic information with them.

Next, it is found that different SCI initiatives have different impacts on firm's operational performance dimensions. This shows the significance of considering both SCI and firm's operational performance constructs as represented by different dimensions.

Customer integration is found to highly impact all six operational measures. One reason to this result may be explained by the objective of SCI, which is to provide maximum value to the customer (Flynn, Huo, and Zhao 2010). Therefore, frequent communication and collaboration, sharing of market information and demand forecast are likely to result in improved product-mix flexibility, quality, customer service, delivery and in reduced inventory level and production cost. These findings are in line with findings by Flynn, Huo, and Zhao (2010), Closs and Savitskie (2003), but contradict the results from Devaraj, Krajewski, and Wei (2007) study.

Internal integration shows significant and positive impact in lowering production costs and improving delivery performance. Internal coordination and information sharing among various departments as production, procurement and sales on such information as sales forecast will improve the production planning which in turn is likely to result in decreasing of production costs. In a similar way,on-time and reliable delivery to customer is dependent on frequent sharing of production planning information between internal departments of the organization.

Contrary to findings of Devaraj, Krajewski, and Wei (2007) and Prajogo and Olhager (2012) who found that supplier integration improves operational performance as a single construct representing such items as quality, delivery speed, delivery reliability, production costs, inventory turns, product variety, our results show that supplier integration may improve firm's delivery performance and decrease inventory level. The tighter the production and procurementactivities are coordinated with supplier organizations, the more the possibilities are that the focal firm is likely to perform well on delivering products reliability and on time to customers. And tight coordination of activities and sharing of information on inventory availability and production planning with suppliers are likely to significantlyinfluencethereductionofinventory level.

4.6 CONCLUSIONS

This chapter examined the impact of three SCI types (internal integration, customer integration, supplier integration) on firm's operational performance with the purpose to reveal if supply chain integration dimensions impact firm's operational performance dimensions, and if these relationships differ. The findings of this chapter support the hypotheses earlier developed in this chapter and contribute to the existing literature on SCI and operational performance in several major ways.

First, it extends the literature by empirically testing how internal, customer and supplier integration can improve firm's operational dimensions in terms of product-mix flexibility, delivery, production cost, quality, inventory, and customer service.

Second, the study extends the literature by indicating the importance of differentiating three types of SCI (internal, supplier and customer integration) and six dimensions of operational performance (product-mix flexibility, delivery, production cost, quality, inventory, and customer service), as these SCI initiatives are found to differently influence operational performance dimensions.

Chapter 5. Meta-analysis on the relationship between information and communication technology and supply chain integration

5.1 INTRODUCTION

The critical importance of Information and Communication Technology (ICT) as a backbone of supply chain structure – not only the tool that supports information sharing and process integration among supply chain partners, but also the means that facilitates synchronous decision-making – has long been argued by researchers(Sanders and Premus 2005). Most of the literature recognizes ICT as a part of supply chain integration (SCI) initiative, at the same time, the literature reports different and opposing results about the impact of ICT and SCI on performance, which proves their distinction as different concepts to be reasonable (Wognum, Fisscher, and Weenink 2002).

This discrepancy is mostly explained by the different measurement instruments for both of two target constructs, ICT and SCI, adopted by researchers across the extant supply chain literature (Zhang, van Donk, and van der Vaart 2011), and their differing dimensions. For instance, some researchers consider ICT on investment or adoption level (Sanders 2007a, Heim and Peng 2010, Power and Singh 2007), others consider it as overall IT integration along the supply chain (Vickery et al. 2003, Chang 2009), and there are studies which examine ICT on internal (Daugherty et al. 2009, Cagliano, Caniato, and Spina 2006) and external (Kim, Cavusgil, and Calantone 2006, Ye and Wang 2013, Saraf, Langdon, and Gosain 2007) levels. From other perspective, SCI has been regarded as a single construct of overall SCI (Lee et al. 2010, Vickery et al. 2003), or customer integration (Closs and Savitskie 2003), or supplier integration (Cagliano, Caniato, and Spina 2006), or overall external integration (Power and Singh 2007). Or some studies classified SCI as multi-dimensional construct of internal and external integration (Agan 2012), or internal, customer, and supplier integration (Chang 2009, Stank, Keller, and Closs 2001), or customer and supplier integration (Narasimhan, Swink, and Viswanathan 2010, Devaraj, Krajewski, and Wei 2007). Reflecting on these classifications of ICT and SCI from the previous literature we examine ICT in terms of ICT adoption, internal ICT integration, external ICT integration. On the other hand, SCI is examined in terms of overall, internal, external, supplier, and customer integration.

These arguments point to an importance of combining the results of previous research that could generalize their findings in a rigorous way and clarify mixed findings that currently exist. The overall premise of our research is to test whether higher extent of ICT leads to better SCI.

Provided a few qualitative reviews on the relationship between ICT and SCI can be found (Zhang, van Donk, and van der Vaart 2011) and they substantially contribute to the knowledge base, yet they do suffer from inherent disadvantages since it is challenging to draw generalized conclusions on the previous literature. On the contrary, meta-analysis can be used to quantitatively synthesize and combine the results from different studies in order to draw a unified single conclusion. Meta-analysis technique provides procedure for combining relevant information taken from studies designed to answer essentially the same research question, with the purpose of enlarging the base for the synthesis, compared to the base provided by a single study (Forza and Di Nuzzo 1998). Therefore, aggregating several studies into a meta-analysis is of essential importance in order to draw conclusions that are valid beyond the limited situations in which they were obtained and make empirical generalizations (Leuschner, Rogers, and Charvet 2013, Leone and Schultz 1980).

Therefore, the purpose of this chapter is to comprehensively and quantitatively review empirical studies on the relationship between ICT and SCI in the supply chain management discipline through meta-analysis.

The main research questions of the study are: (1) Is there any proof of a positive correlation between ICT and SCI? (2) Does the correlation between ICT and SCI vary across different dimensions and instruments of ICT? And (3) Does the correlation between ICT and SCI vary across different dimensions and instruments of SCI?

5.2 THEORETICAL FOUNDATION

Achieving and maintaining higher level of integration in the supply chain is a complicated process and it may demand unwarranted resources (Leuschner, Rogers, and Charvet 2013). While trying to explain the performance improvements of a particular organization or a whole supply chain through the impact of ICT and SCI, researchers have grounded their studies in a range of organizational theories. An overview of the most commonly used theoretical bases is highlighted in Table8.

Table 8 Theoretical foundations for "ICT - SCI" relationship (meta-analysis)

Theory	Description	Authors
Resource-based view (RBV) (Barney 1991)	Ability of a firm to internally develop and exploit new technologies and organizational processes will lead to sustainable competitive advantage.	[1], [2], [7], [8], [10], [17], [18], [26]
Transaction cost economics (Williamson 1975, Coase 1937)	Use of IT technologies can enable interaction within and between organizations reducing costs incurred in searching for and accessing information.	[13], [16], [21], [22], [26], [27]
Knowledge-based view (Grant 1996)	A high level of IS integration across firms forms the basis of a critical organizational capability for acquiring, transforming, mixing, and matching knowledge objects across firms and business partners	[16], [22]
Resource dependence theory (Pfeffer and Salancik 2003)	A supply chain partner's resources such as technology and data communication capabilities can affect efforts to foster cooperation and collaboration.	[16], [26]
Relational view (Dyer and Singh 1998)	A firm's critical resources may span its boundaries and be embedded in inter-firm resources and relationships.	[8]
Theory of swift, even flow (Schmenner and Swink 1998)	Strong IT capabilities lead to better (process, physical flow) integration with supply chain partners.	[8]
Socio-technical systems (Mumford and Weir 1979)	Focus on the need for social and technical systems to be developed together with supply chain partners, rather than independent of each other.	[16]

For […], please refer to Appendix (the list of sample papers)

This study focuses on the *resource-based view* and *relational view*, which are broadly applied in explaining relationship between ICT and SCI within and between organizations. The resource-based view (RBV) is based on the idea that a firm' sustained competitive advantage and performance are dependent on its unique resources and capabilities that are difficult to imitate (Barney 1991). Studies have acknowledged that ability of a firm to develop and utilize new technologies and organizational processes will lead to sustainable competitive advantages (Daugherty et al. 2009), for instance, internal/cross-functional integration capability. While the RBV theory is likely to focus on the firm and its competitive advantage from within-firm resource perspective, the relational view concentrates on relationships and processes between organizations. The relational view posits that a firm's critical resources may span its boundaries and be rooted in inter-firm resources and relationships (Dyer and Singh 1998). Integrated ICT resources or capabilities between firms can enhance the integration between supply chain partners resulting in win-win situation where the total supply chain benefits are increased due to hard to imitate unique technologies and skills. Based on these theories, respective hypotheses are formulated in the following section.

5.3General concepts and hypothesis development

Based on the RBV and relational view theories, we posit that inimitable ICT resources and capabilities, that are embedded and well integrated not only within a firm, but also in the relationship with its supply chain partners, improve sustainable advantage as SCI. Therefore, the following overall hypothesis can be formulated:

H1: Information and communication technology is positively related to supply chain integration.

Provided broad divergence in definitions, dimensions and measurement items for examining ICT and SCI constructs in our sample studies, an aggregate view of each ICT and SCI is important for further generalization of the relationship between these two constructs.

5.3.1Dimensions of ICT

From a broad perspective, ICT is defined as a "family of technologies used to process, store, and disseminate information, facilitating the performance of information-human activities, provided by, and serving both the public at-large as well as the institutional and business sectors"(Salomon, Cohen, and Nijkamp 1999). Following the suggestion of Zhang, van Donk, and van der Vaart (2011) and grounding on the RBV theory, in this study we distinguish ICT construct according to two main criteria: the ICT stage and the ICT types. Two ICT stages of (1) ICT use or adoption and (2) ICT capability, five ICT types of (1) overall ICT, (2) internal ICT, (3) external ICT, (4) supplier ICT, and (5) customer ICT are distinguished.

ICT use or adoption is a stage when ICT is introduced and adopted in a firm. Next stage, ICT capability, is when a firm has adopted the ICT technology and it has been well blended with the firm's internal business processes. Therefore the latter five types of ICT can be considered as ICT capability. Therefore, we use in total the following six dimensions of ICT in our study: (1) ICT use, (2) overall ICT, (3) internal ICT, (4) external ICT, (5) supplier ICT, and (6) customer ICT. Sample studies for meta-analysis are classified to these six types according to our classification.

ICT use dimension is defined by use, adoption or implementation of hardware and software technologies, open and industry standards that facilitate information sharing, data and knowledge management, decision making process (Byrd et al. 2008, Cagliano, Caniato, and Spina 2006, Power and Singh 2007).

Overall ICT integration stands for the internal and external ICT capabilities that are defined by timely, standard, and consistent data, and support not only internal coordination and collaboration, but also connectivity, information sharing, and integrate operational processes with supply chain partners (Agan 2012, Chang 2009, Vickery et al. 2003).

Internal ICT integration represents integrated internal ICT capabilities, ERP systems for instance, that enable internal operational processes, information sharing, communication and coordination, along with standardized, timely, and reliable database capability (Byrd et al. 2008, Daugherty et al. 2009).

External ICT integration denotes integrative ICT capabilities that enable information sharing, collaboration in terms of forecasting, replenishment, scheduling, advanced planning, and coordination of such activities as transaction processing, e-transfer of purchase orders, e-tracking of shipments with suppliers and customers (Closs and Savitskie 2003, Kim, Cavusgil, and Cavusgil 2013, Paulraj, Lado, and Chen 2008).

Customer ICT integration represents integrative ICT (CRM systems) capabilities that aid process integration, transactions, and information exchange on demand, inventory and production planning in real-time with customers (Devaraj, Krajewski, and Wei 2007, Sanders 2008, Saraf, Langdon, and Gosain 2007).

Supplier ICT integration indicates integrative ICT (e-procurement technologies) capabilities that enable such operational activities as planning and execution, decision making, evaluation of delivery and quality performance of suppliers, and collaboration activities with suppliers, and real-time sharing of standardized data with suppliers (Devaraj, Krajewski, and Wei 2007, Saeed, Malhotra, and Grover 2011, Saraf, Langdon, and Gosain 2007).

Following the main hypothesis of the study H1, impact of the above-mentioned six dimensions of ICT on SCI is formulated in the following hypotheses:

H2a: ICT use is positively related to SCI.

H2b: Overall ICT capability is positively related to SCI.

H2c: Internal ICT capability is positively related to SCI.

H2d: External ICT capability is positively related to SCI.

H2e: Customer ICT capability is positively related to SCI.

H2f: Supplier ICT capability is positively related to SCI.

5.3.2Dimensions of SCI

The most widely used definition of SCI is provided by the Council of Logistics Management (1999), stating that SCM/SCI is the systematic, strategic coordination of the traditional business functions and tactics across these business functions within a particular organization and across business within the supply chain for the purposes of improving the long-term performance of the individual organizations and the supply chain as a whole.

As most empirical studies find a significant positive association between ICT and SCI, some also reveal non-significant relationships between these constructs. In order better understand the relationship between ICT and SCI, supply chain integration construct for meta-analysis was classified into five dimensions: (1) overall integration, (2) internal integration, (3) external integration, (4) supplier integration, and (5) customer integration.

Overall integration involves both internal and external supply chain integration, namely, intra-firm integration among internal departments and cross-functional teams, and inter-firm integration with suppliers and customers in terms of information sharing, coordination, collaboration (Chao-Hsiung et al. 2010, Hsu 2013, Li et al. 2009).

Internal integration represents cross-functional integration, unification, and standardization through integrated physical process, information and resource sharing, frequent interaction, coordination and cooperation between employees, managers from different departments (Byrd et al. 2008, Chang 2009, Daugherty et al. 2009).

External integration is defined in terms of operation, tactical, and strategic information sharing, partnership, cooperation, collaboration, strategic planning on demand, production, and new product development with suppliers and customers (Agan 2012, Narasimhan and Soo Wook 2001, Tan et al. 2010).

Supplier integration stands for information sharing or exchange with suppliers on supplier production capacities, the focal firm's sales forecasts, production schedule, inventory status, moreover, knowledge sharing, coordination, coupling and integration of activities with suppliers (Chang 2009, Devaraj, Krajewski, and Wei 2007).

Customer integration denotes information sharing or exchange with customers on such operational information as product availability, order status of customers, sales forecast, production schedule, inventory status of the focal firm, in addition, strategic planning of new product or new product concepts and knowledge sharing on business environment, channel partners, competitors with customer organizations (Chang 2009, Closs and Savitskie 2003, Devaraj, Krajewski, and Wei 2007).

Based on the findings of previous study that suggest ICT is generally related to SCI, we hypothesize that ICT is positively correlated with different dimensions of SCI.

H3a: ICT is positively related to overall integration.

H3b: ICT is positively related to internal integration.

H3c: ICT is positively related to external integration.

H3d: ICT is positively related to supplier integration.

H3e: ICT is positively related to customer integration.

Along with above formulated hypotheses, we have developed hypotheses based on all possible combinations or positive relationships between ICT and SCI constructs ("six ICT" x "five SCI" = 30), which yields in thirty possible combinations, which are regarded as hypotheses.

5.4 Research methodology

5.4.1 Sample selection

In order to test the above formulated 30 hypotheses, we collected relevant studies for the meta-analysis via a literature search using theEBSCO Academic and Business Source database, including the keywords of "information communication technology", "information technology", "information systems", "e-", "supply chain management", "supply chain integration", "supply chain", "empirical study" in the title, keywords, and abstract. We constrained the search result to academic peer-reviewed journals, so that the search results were certainly research articles and not editorials or book reviews. This process yielded 1009 papers. Further, in order to obtain the final sample for our meta-analysis, we adopted the following two-step screening procedure. Firstly, we checked the title and abstract of every individual paper to make sure that the paper was indeed about ICT and SCI and that it employed an empirical research methodology. The first step of screening yielded 201 papers. For the second step of screening we looked into the full content of every paper to confirm that the paper had included at least one measure from

ICT and SCI respectively. The second step provided the final sample of 27 papers for further data analysis. Sample papers are given in Appendix A.

5.4.2 Variable coding

The selected articles were chosen based on our research framework by the two authors. Inconsistent coding or any discrepancies were resolved through discussion. In order to identify and examine the dimensions for ICT and SCI constructs from the papers we conducted thorough assessment of both ICT and SCI scale items to identify: (1) if the scale was consistent with the definitions ofICT or SCI; (2) whether the construct was consistent with ICT or SCI dimensions. ICT constructs' classification, coding and their source is provided in APPENDIX B. SCI constructs' classification, coding and their source is shown in APPENDIX C.

5.4.3 Data analysis

A total of 120 usable relationships were identified from coding the 27 published studies. In case when two or more correlations from one study were found in the same hypothesis group, those were aggregated to form a single correlation representing one study in the hypothesis group. This resulted in final sample of 61 relationships across 22 hypotheses groups out of 30, for data analysis (Table 9).

Researchers widely utilize meta-analysis methods of Hunter and Schmidt (2004), Hedges and Olkin (1985) and Rosenthal (1991). In this research, we use the average plot of product moment correlation r as the fundamental basis of meta-analysis and combined Fisher's Z scores and Fail-safe N (Rosenthal, 1991) for each construct to test the significance of the hypotheses. The population effect size in meta-analysis indicates the extent to which the independent variable affects the dependent variable. It is estimated from correlations published in sample studies, which is different from the effect size estimated in regression analysis (Liang et al., 2010). According to Cohen (1977), the population effect size $r > 0.1$ is known as having low effect; $r > 0.3$ is medium effect, $r > 0.5$ is high effect. The fail-safe N denotes the number of insignificant correlations that would have to be included in the sample to oppose to the conclusion of a significant relationship's existence. Consistent with Rosenthal (1991) suggestion, the significant threshold of fail-safe N in 95 percent confidential level is Nfs> 5*k + 10, where Nfs is the fail-safe N and k is the total number of studies in each pair-wise relationship. Out of 22 relationships, fail-safe N of 10 relationships were not available due to small number of studies, namely 1-2 studies, in the hypnotized group. Finally, 12 relationships were used for hypotheses testing.

5.5 RESULTS AND DISCUSSION

Table 9 shows the meta-analysis results of the relationships between ICT and SCI dimensions. Out of 12 relationships, which were used for meta-analysis, eight hypotheses were supported, three hypotheses were not supported and one hypothesis was weakly supported.

Effect of ICT on overall integration

ICT use was found to impact overall SCI with medium effect size of 0.358 and high Nfs=92 passing its fail-safe N threshold of 30. This indicates that adoption or use of reliable and responsive hardware and software, and process planning and control systems as ERP, CRM, KMS improves overall SCI in terms of intra- and inter-organizational process integration, information sharing, coordination, and collaboration activities.

Table 9 Results from hypotheses testing (meta-analysis)

Hyp.	Correlations	No. of studies	Total sample size	Effect size (*r*)	Combined Z scores	Threshold of Nfs in 0.05	Nfs (p=0.05)	Hypothesis supported
H1	ICT_USE-OVER_INT	4	866	0.358	2.423	30	92	Support
H2	ICT_USE-INTER_INT	3	707	0.214	5.583	25	23	No
H3	ICT_USE-EXT_INT	5	1079	0.327	4.040	35	159	Support
H4	ICT_USE-SUP_INT	2	522	0.204	4.693	20	NA	
H5	ICT_USE-CUS_INT	2	466	0.262	5.762	20	NA	
H6	OVER_ICT-OVER_INT	1	57	0.307	2.334	15	NA	
H7	OVER_ICT-INTER_INT	3	703	0.555	2.812	25	218	Support
H8	OVER_ICT-EXT_INT	2	229	0.325	5.035	20	NA	
H9	OVER_ICT-SUP_INT	5	885	0.320	2.263	35	152	Support
H10	OVER_ICT-CUS_INT	4	640	0.464	2.614	30	196	Support
H11	INTER_ICT-OVER_INT	0						

Hyp.	Correlations	No. of studies	Total sample size	Effect size (r)	Combined Z scores	Threshold of Nfs in 0.05	Nfs (p=0.05)	Hypothesis supported
H12	INTER_ICT-INTER_INT	3	588	0.172	1.453	25	9	No
H13	INTER_ICT-EXT_INT	3	541	0.292	2.538	25	32	Support
H14	INTER_ICT-SUP_INT	2	344	0.253	4.763	20	NA	
H15	INTER_ICT-CUS_INT	3	650	0.257	2.440	25	26	Weak support
H16	EXT_ICT-OVER_INT	0						
H17	EXT_ICT-INTER_INT	1	238	0.200	3.108	15	NA	
H18	EXT_ICT-EXT_INT	4	681	0.323	4.349	30	66	Support
H19	EXT_ICT-SUP_INT	1	120	0.315	3.527	15	NA	
H20	EXT_ICT-CUS_INT	2	426	0.276	5.814	20	NA	
H21	CUS_ICT-OVER_INT	0						
H22	CUS_ICT-INTER_INT	0						
H23	CUS_ICT-EXT_INT	0						
H24	CUS_ICT-SUP_INT	2	183	0.159	1.630	20	NA	
H25	CUS_ICT-CUS_INT	3	424	0.255	2.937	25	18	No
H26	SUP_ICT-OVER_INT	0						
H27	SUP_ICT-INTER_INT	0						
H28	SUP_ICT-EXT_INT	0						
H29	SUP_ICT-SUP_INT	4	370	0.367	3.969	30	49	Support
H30	SUP_ICT-CUS_INT	2	183	0.224	3.031	20	NA	

Note: All combined Z scores are significant at: <0.001 level

Effect of ICT on Internal SCI

Out of three relationships' hypotheses, (1) ICT_USE and INTER_INT, (2) OVER_ICT and INTER_INT, (3) INTER_ICT and INTER_INT, regarding the dependent variable of internal integration, only one hypothesis on the positive relationship between overall ICT and internal integration was supported with a high effect size ($r > 0.5$) and high Nfs (Nfs=218, threshold Nfs=25) too. Surprisingly and against our expectations, firm's internal ICTs such as ERP and standardized database don't seem to improve internal organizational integration in terms of cross-functional teamwork collaboration, information sharing, coordination and cooperation between functional departments. However, the findings suggest that overall ICT capabilities that are developed based on such internal ICT as ERP, computerized production systems and on such external ICT as EDI, SCM applications, and their integrated operation along with timely, standard and consistent database can significantly impact internal organizational integration.

Effect of ICT on External SCI

All three hypotheses with dependent variable of external integration, (1) ICT_USE and EXT_INT, (2) INTER_ICT and EXT_INT, (3) EXT_ICT and EXT_INT, were supported with low-to-medium effect sizes (r>0.1 and$r$>0.3) and high Nfs of 159 (threshold Nfs=35) for ICT_USE–EXT_INT, Nfs=32 (threshold Nfs=25) for INTER_ICT–EXT_INT, Nfs=66 (threshold Nfs=30) for EXT_ICT–EXT_INT relationships. Close look at these relationships' effect sizes reveals that utilization or implementation of ICT and developing ICT capabilities based on internal and external ICT technologies are critical to improving firm's integration with external partners of customers and suppliers. These findings suggest that mere development of external ICT capabilities is not enough for external integration, but internal ICT capabilities also should be well developed for it.

Effect of ICT on Supplier SCI

Results from the two hypotheses which tested impact of ICT on dependent variable of supplier integration, (1) OVER_ICT and SUP_INT, (2) SUP_ICT and SUP_INT, provide supportive outcomes for both relationships with medium effect sizes, r=0.320 for OVER_ICT-SUP_INT, and$r$=0.367 for SUP_ICT-SUP_INT relationships, and Nfs=152 for OVER_ICT - SUP_INT (threshold Nfs=35), Nfs=49 for SUP_ICT-SUP_INT (threshold Nfs=30). It suggests that for development of supplier integration, except for the overall ICT, those ICT capabilities that are developed based on information technologies that are supposed to integrate with suppliers are imperative. This is also supported by slightly higher significant value of Nfs for supplier ICT capability than for overall ICT capability.

Effect of ICT on Customer SCI

Three hypotheses of (1) OVER_ICT-CUS_INT (r=0.464, Nfs=196, threshold Nfs=30) (2) INTER_ICT-CUS_INT (r=0.257, Nfs=26, threshold Nfs=25), and (3) CUS_ICT-CUS_INT (r=0.255, Nfs=18, threshold Nfs=25) showed different results. We found support for the positive relationship between OVER_ICT and CUS_INT, but weak support for the positive relationship between INT_ICT-CUS_INT, and no support for CUS_ICT and CUS_INT. This is also an interesting finding that states that overall ICT integration internally and externally with supply chain partners with standardized database improves information sharing, coordination and integration with customers, rather than the ICT initiatives that are designated to improve customer integration from our study results. Between the two ICT capabilities, overall ICT capability was found to improve customer integration better than the internal integration. These findings can suggest that for customer integration, mere customer integration facilitating information technologies are not enough, and capabilities based on information technologies that support both internal organizational operations and external integrative activities are critical.

Overall findings from data analyses are summarized in Table 10.

Table 10 Data analyses results across dimensions of ICT and SCI (meta-analysis)

		Supply chain integration dimensions				
		Overall SCI	**Internal integration**	**External integration**	**Supplier integration**	**Customer integration**
ICT dimensions	**ICT use**	0.358**	0.214 (NS)	0.327**	nfs-NA	nfs-NA
	Overall ICT	nfs-NA	0.555***	nfs-NA	0.320 **	0.464**
	Internal ICT	-	0.172 (NS)	0.292*	nfs-NA	0.257* (weak sup.)
	External ICT	-	nfs-NA	0.323**	nfs-NA	nfs-NA
	Customer ICT	-	-	-	nfs-NA	0.255 (NS)
	Supplier ICT	-	-	-	0.367**	nfs-NA

5.6 IMPLICATIONS

In an attempt to reveal the relationship between multiple dimension of information and communication technology (ICT) and supply chain integration (SCI) constructs, in this chapter we conducted meta-analysis on the relationship between multiple dimensions of ICT and SCI. The results of the study can be of a valuable importance to not only academicians in further theory development followed by a new series of empirical testing, but also to the practitioners to understand the different types of ICT and their impact and/or importance on various types of SCI in their organizations.

From the theoretical perspective, this study attempted to investigate the impact of ICT on SCI under the lens of Resource-Based View of the firm and the Relational View theories. Our objective for this meta-analysis study was to examine whether ICT as firm's intra- and inter-organizational resource is related to better SCI. In trying to fulfill the research objective and to determine if ICT can be viewed as a competitive source for SCI, we developed a theoretical framework to distinguish between six dimensions of ICT and five dimensions of SCI respectively.

Our results suggest that there is an overall positive and significant relationship between ICT and SCI therefore providing support for both RBV and RV theories. Out of possible for meta-analysis 12 relationships between ICT and SCI, nine relationships or hypotheses were supported. The three non-supported hypotheses were those relationships in which the dependent variables were internal integration and customer integration. Surprisingly both internal ICT capabilities and customer ICT capabilities were not found to support their respective integration variables of internal integration and customer integration. One way to explain these results is there are other factors that might improve internal and customer integration or there are other ways how these ICT capabilities improve their respective integration initiatives.

The literature often states that information and communication technology is a backbone of supply chain integration and implementation of technologies and development of their capabilities require large amount of investments. Therefore, it is critical for managers to recognize in which information and communication technologies to invest in order to improve any of the integration initiatives considered in this study. Our meta-analytical synthesis based on the past empirical studies suggest that adoption or implementation of ICT can improve overall SCI and external integration with supply chain partners. Further, with respect to specific integration types such as internal, supplier and customer integration, our results provide different managerial implications. For the results, it is seen that supplier integration is the easiest to achieve provided the appropriate ICT and ICT capabilities that support supplier connection such as e-procurement technologies are existent in the firm. On the other hand, mere existence and development internal ICT capabilities and customer ICT capabilities are not enough for both internal and customer integration which points that there may be other factors that facilitate these integration initiatives.

5.7 CONCLUSION

This chapter aimed to examine the relationship between information and communication technology and supply chain integrationby quantitatively synthesizing previous empirical evidence. For that, a meta-analysis on 27 published studies was conducted to test the direct relationship between six ICT and five SCI dimensions. Nine out of 12 testable relationships showed support for their respective hypotheses. We have found that internal organizational process integration is not easily achieved merely via cross-functional application implementation or its relative capabilities.Rather an integrative approach to improving overall ICT capability not only within the firm but also with supply chain partners could improve internal integration. Another interesting finding was customer integration. Customer integration also might be quite difficult to reach only through customer relationship management applications, rather overall ICT capability which comprise internal and external integration can be an important factor for attaining effective customer integration. The rest of testable hypotheses were all supported.

These findings can be due to the small number of samples that were available for the meta-analysis. Therefore further analysis with increased sample numbers might provide significant and positive relationship between internal ICT capability and internal integration, and customer ICT capability and customer integration.

Chapter 6. Impact of information technology capability on supply chain integration

6.1 INTRODUCTION

The advent of information technology (IT) has made the way of doing business effective and efficient, and its further development, in the forms of electronic data interchange (EDI), radio-frequency identification (RFID), to Internet and cloud technologies, has played a vital role in facilitating supply chain integration. Supply chain integration, based on collaboration between partnering firms and their collective management of intra- and inter-organizational resources and processes(Flynn, Huo, and Zhao 2010), is intended to bring competitive advantage and performance benefits to organizations (Sanders and Premus 2005).

For supply chain integration to get realized, real-time sharing of transactional and strategic information on operations, inventory status and demand, and coordination of activities along the supply chain are essential elements. Information sharing improves supply chain visibility (Kyu Kim, Yul Ryoo, and Dug Jung 2011)resulting in better inventory management, and provides firms with synchronous decision making and coordination capabilities for enhanced production planning and demand forecasting. This information sharing in a reliable and timely manner is greatly facilitated by integrative information technology (IT) systems. Hence, IT is often considered to be an indispensable enabler of supply chain integration (Grover and Malhotra 1999, Kearns and Lederer 2003, Rai, Patnayakuni, and Seth 2006, Sanders 2007b).

The existing literature has broadly discussed on the critical role of IT capability in managing supply chain activities and partnerships and enhancingfirm'sperformance. While some found a positive impact of overall IT capability on firm performance (Bharadwaj 2000, Kearns and Lederer 2003) many researchers have found no direct link between IT implementation and the expected performance benefits to firms (Brynjolfsson and Hitt 2003). These inconsistencies were associated with various conceptualizations and operationalizations of constructs, organizational factors including the manner IT was used in, management practices, and organizational structures (Lim, Richardson, and Roberts 2004, Sanders 2008, Subramani 2004). As such, previous literature tried to explain how and why IT can improve firmperformanceinthe supply chain context (Devaraj, Krajewski, and Wei 2007, Rai, Patnayakuni, and Seth 2006, Sanders 2008).

On the other hand, the results of the past empirical studies mostly have found that overall IT capability improves supply chain integration (SCI)(Li et al. 2009, Paulraj and Chen 2007b, Singh et al. 2010).

However, most of the existing literature, which has examined the relationship between IT capability and SCI, consider each or one of these concepts as a single or formative construct. Deep insight into these concepts would not only contribute to the theory, but also bring useful implications to practitioners.

We consider IT capabilities as consisting of three dimensions: (1) cross-functional application, (2) supply chain application, (3) data consistency, and supply chain integration as comprised of three dimensions (1) internal integration, (2) supplier integration, (3) customer integration. Considering these concepts in detail with respective typology is helpful in comprehending exactly which integration and/or which IT capability is contributing to a certain SCI dimension.

The goal of this chapter is to contribute to the knowledge by proposing and testing a model on the relationship between the above mentioned dimensions of IT capability and supply chain integration (SCI) drawing on Resource-Based View (Barney 1991) and Relationship View (Dyer and Singh 1998) theories. Thus, we address the following questions in our research:(1) Do IT capabilities of cross-functional application (CFA), supply chain application(SCA),and data consistency (DC)impact supply chain integration (SCI) in terms of internal (II), customer (CU) and supplier integration (SI)? (2) Do the relationships between dimensions of IT capability and SCI differ?

6.2 Analytical Framework: Theoretical foundation and hypotheses development

6.2.1 Supply chain integration

Following(Zhao et al. 2008), supply chain integration (SCI) is defined as the degree to which a firm strategically collaborates with its supply chain partners and collaboratively manages intra- and inter-organizational resources to achieve effective and efficient flow of products, services, information, money and decisions, with the objective of providing maximum value to its customers. We consider SCI as comprising of three dimensions: internal, supplier and internal integration (Flynn, Huo, and Zhao 2010). The consideration of multiple dimensions not only helps address the mixed findings in the literature, but also clarify how different types of SCI can be improved by certain types of IT capabilities.

6.2.1.1 Internal integration

Internal integration is defined as degree to which a firm structures its own organizational strategies, practices and processes into collaborative, synchronized processes across functions, where collaboration across product design, procurement, production, sales and distribution functions takes place to fulfill its customers' requirements at a lower cost (Cespedes 1996, Flynn, Huo, and Zhao 2010, Kahn and Mentzer 1996, Kingman-Brundage, George, and Bowen 1995). Internal integration breaks down functional barriers and facilitates information sharing (Wong, Lai, and Cheng 2011), strategic partnership among departments, which can in turn collaboratively develop and maintain measurement systems and monitor business processes(Flynn, Huo, and Zhao 2010).

6.2.1.2 Supplier integration

Supplier integration comprises strategic partnership between a focal firm and its suppliers in managing procurement and production processes, including information sharing on demand forecast by a focal firm and inventory availability by suppliers, joint product development and so on(Ettlie and Reza 1992, Lai, Wong, and Cheng 2010, Ragatz, Handfield, and Petersen 2002).

6.2.1.3 Customer integration

Customer integration includes communication and frequent contacting between a focal firm and customers, information sharing on market, demand forecast and product/service feedback by customers which aim to improve visibility in supply chain, joint planning with customers and further product/service improvement opportunities by a focal firm(Fisher et al. 1994, Zhao et al. 2008). Customer integration enables deeper understanding of market expectations and opportunities, which contributes to a more accurate and quicker response to customer requirements and needs (Swink, Narasimhan, and Wang 2007, Wong, Lai, and Cheng 2011) by matching supply with demand that reduces "bullwhip effect" in the supply chain(Lee, Padmanabhan, and Whang 1997).

6.2.1.4 Impact of internal integration on customer integration and supplier integration

In spite of inconsistent findings on the relationship between internal integration and external integration in the existing literature, we argue that internal integration has a positive impact on customer integration and supplier integration. From the perspective of organizational capability, it is argued that when a firm has a high level of internal communication and coordination capabilities, it will be more competent to achieve a high level of customer and supplier integration(Zhao et al. 2011). Barua et al. (2004)found that internal information sharing between functional departments of a firm is positively related to external cooperation with partners. Strategic cooperation literature also suggests that internal integration based on communication, information sharing and cross-functional teamwork is especially important for establishing and maintaining the firm's alliance with its customers and suppliers.

Bowersox (1989) and Peteraf (1993)suggest that the process of supply chain integration should progress from the integration on internal logistics processes to external integration with suppliers and customers, implying that the higher internal integration can lead to higher customer and supplier integration, respectively(Kanter 1994). Therefore, we argue that firms with higher level of internal integration are more likely to integrate with their customers and suppliers.

Hypotheses: Internal integration has a direct and positive impact on customer integration (H4a), supplier integration (H4b).

6.2.2 Information technology capability

IT capability is defined as technological capability used to acquire, process, and transmit information for more effective decision making(Grover and Malhotra 1999), and to facilitate communication, coordination and collaboration between multiple parties along the supply chain.

The literature states that IT construct in the context of supply chain management is broadly measured by one general concept(Sanders and Premus 2005, Subramani 2004). On the contrary, other papers measure IT narrowly by one specific type of technology(Sanders 2007a), or with respect to digitization types of supply chain partners(Devaraj, Krajewski, and Wei 2007, Steiger 1990).Zhang, van Donk, and van der Vaart (2011)in their literature review of survey-based research on information and communication technology (ICT) and supply chain management found that majority of observed literature focused on the inter-organizational ICT, whilefeweron the intra-organizational ICT. Broadbent, Weill, and St. Clair (1999)found that higher level IT infrastructure capabilities which constitute a set of infrastructure services spanning organizational boundaries to facilitate information transfer and complex transactions processing between entities are necessary for the development of online linkages to customers and suppliers, while basic level IT infrastructure capabilities which consist of an ample set of infrastructure services to support communication networks and firm-wide applications and databases are crucial to simplifying of business processes in the firm.

As such, we argue that IT capabilities can be classified into three types of (1) cross-functional applicationcapabilityand(2) supply chain application capability, corresponding to the typology of SCI, internal integration and external integration, and (3) data consistency as a common data definition across these integrative applications.

Cross-functional application (CFA) capabilityfacilitatesintegration of data and information system within a firm through use of enterprise resource planning (ERP), real-time data searching of inventory and operating data, andenablesinformation sharing, communication, and collaboration of functional departments of the firm. Contrary, supply chain application (SCA) capabilityfacilitates interactions between multiple parties in the supply chain,closer coordination between supply chain members and coupling their business activities for the purpose of improving efficiency and effectiveness of business activities, by means of supplier relationship management and customer relationship management applications. Finally, data consistency (DC) ensures common and standardized data definitions across CFA and SCA, and uses automatic data capture systems along the supply chain.

6.2.2.1 Impact of IT capability on SCI

Researchers from information technology and supply chain management areas have widely been using resource-based view (Barney 1991) and relational view (Dyer and Singh 1998) in the support for hypotheses development on the relationship between IT and SCI, and their results prove the applicability of these theories in supporting the role of IT as an enabler for supply chain integration (Devaraj, Krajewski, and Wei 2007). Following the past literature, this chapter exploits Resource-Based View and Relational View theories for the support of the positive impact of three types of IT capabilities on three dimensions of SCI.

The resource-based view is based on the notion that a firm’ sustained competitive advantage and performance are dependent on its unique resources and capabilities that are difficult to imitate (Barney 1991). Studies have acknowledged that ability of a firm to develop and utilize new technologies and organizational processes will lead to sustainable competitive advantages (Daugherty et al. 2009), for instance, internal or cross-functional integration capability. Well-developed internal IT capabilities, namely, cross-functional applications, as a difficult to imitate capabilities can serve as an enabler for intra-organizational integration.

While the resource-based view theory is likely to focus on the firm and its competitive advantage from within-firm resource perspective, the relational view concentrates on relationships and processes between organizations. The relational view posits that a firm's critical resources may span its boundaries and be rooted in inter-firm resources and relationships (Dyer and Singh 1998). Integrated IT resources or capabilities, such as data consistency (DC) and supply chain applications (SCA), between firms can enhance the integration between supply chain partners resulting in win-win situation where the total supply chain benefits are increased due to hard to imitate unique technologies and skills. Hense, based on these theories we argue that the higher level of CFA, SCA and DC capabilities result in a higher level of integration not only among the internal functions in an organization but also with outside customers and suppliers.

Hypotheses: Data consistency capability has a direct and positive impact on customer integration (H1a), internal integration (H1b), supplier integration (H1c).

Hypotheses: Cross-functional application capability has a direct and positive impact on customer integration (H2a), internal integration (H2b), supplier integration (H2c).

Hypotheses: Supply chain application capability has a direct and positive impact on customer integration (H3a), internal integration (H3b), supplier integration (H3c).

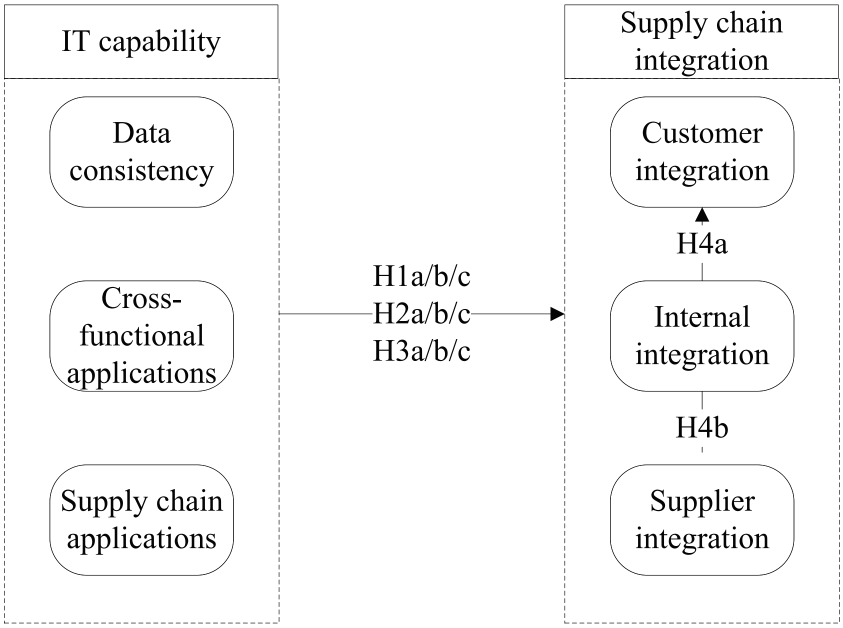

Figure 4 Analytical framework for "IT - SCI" model

6.3 MEASUREMENT VALIDATION

The model of this chapter examines the impact of three types of IT capabilities (data consistency (DC), cross-functional application (CFA) and supply chain application (SCA)) on three types of supply chain integration (SCI) (internal integration (II), customer integration (CI) and supplier integration (SI)).

Table 11 shows the factor loadings and Cronbach's alpha values for each construct. The scales are all reliable with alpha values ranging between 0.771 ~ 0.910, thereby exceeding the generally agreed lower limit for Cronbach's alpha of 0.60(Flynn et al. 1990, Nunnally and Bernstein 1991). The scales' unidimensionalityis examined using factor analysis. As a result, one item from supplier integration (SI) is removed due to low factor loading, and two items from internal integration (II) and one item from cross-functional application (CFA) capability are deleted due to cross-loadings on at least two constructs. The repeated factor analysis confirmed the unidimensionality for all six factors as the respective items load on only one factor each. All of the factor loadings are greater than 0.7 and the t-values are significantly greater than 9.08 (Table 11).

Table 11 Factor loadings and reliability values of measurement items for "IT - SCI" model

	CFA	CI	DC	II	SCA	SI	Cronbach's α	t-values
CFA1	0.846						0.873	26.62
CFA2	0.814							21.77
CFA3	0.907							58.87
CFA4	0.836							27.22
CI1		0.746					0.880	17.63
CI2		0.780						13.47
CI3		0.762						12.98
CI4		0.717						10.52
CI5		0.768						13.42
CI6		0.769						12.64
CI7		0.783						17.11
DC1			0.822				0.771	15.27
DC2			0.825					16.99
DC3			0.834					10.76
II1				0.765			0.885	11.52
II2				0.881				21.86
II3				0.898				47.64
II4				0.902				44.14
SCA1					0.893		0.893	29.58
SCA2					0.908			45.09
SCA3					0.871			27.34
SCA4					0.802			13.10
SI1						0.828	0.910	19.60
SI2						0.842		24.49
SI3						0.801		18.78
SI4						0.860		30.04
SI5						0.831		20.72
SI7						0.749		12.29
SI8						0.729		9.08

Further, to test convergent validity, we analyze composite reliability (CR), average variance extracted (AVE), significance of item loadings. As shown in Table 12, CR and AVE values are greater than threshold values of 0.60 and 0.50 respectively (Bagozzi and Yi 1988, Fornell and Larcker 1981, Hair et al. 1998, Nunnally and Bernstein 1991) indicating convergent validity. Moreover, significant t-values of item loadings at level $p<0.001$ contribute to the convergent validity of measurement scales.

Following Fornell and Larcker (1981)approach, we examined the measurement model for discriminant validity. As illustrated in Table 12, all the scales demonstrate considerably higher square root of AVE values (figures in bold, along the diagonal) compared to the correlations with other constructs, suggesting the support for discriminant validity.

Table 12 Constructs' values for mean, SD, correlations, composite reliability, average variance extracted for "IT - SCI" model

	Mean	SD	CR	AVE	CFA	CI	DC	II	SCA	SI
CFA	4.22	1.08	0.913	0.725	**0.852**					
CI	4.31	0.91	0.906	0.579	0.404	**0.761**				
DC	4.83	1.24	0.867	0.684	0.505	0.409	**0.827**			
II	4.59	1.02	0.921	0.745	0.640	0.424	0.254	**0.863**		
SCA	3.85	1.28	0.925	0.757	0.445	0.408	0.600	0.299	**0.870**	
SI	3.83	1.11	0.929	0.651	0.558	0.353	0.457	0.417	0.539	**0.807**

6.4 Hypotheses testing

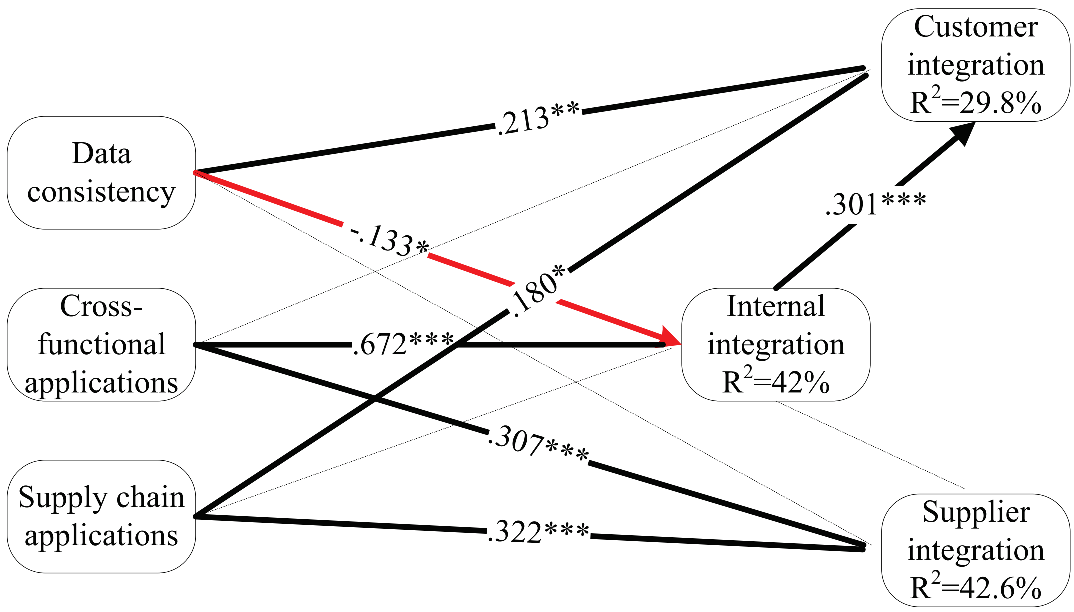

Figure 5 Path analysis results for "IT - SCI" model

Figure 5 shows the results of the PLS analysis. The predictive power of path models is explained by examining the explained variance or R^2 values(Barclay, Higgins, and Thompson 1995, Chin and Gopal 1995). R^2 values indicate the amount of variance in the construct that is explained by the path model(Barclay, Higgins, and Thompson 1995).

Accordingly, the results show that the model explains 29.8% of variance in customer integration and 42.6% of variance in supplier integration were explained by IT capabilities and internal integration.And 42% of variance in internal integration is explained by IT capabilities.

We found that sevenspecified paths out of 11 paths between constructs in the research model show significant path coefficients, supporting their corresponding hypotheses. The positive and significant path coefficients from data consistency to customer integration (β=0.213, t=2.000, p=0.023), from supply chain application to customer integration (β=0.180, t=1.316, p=0.094) provide support for hypothesis H1a and H3a. The positive and significant path coefficient from cross-functional application to internal integration (β=0.672, t=9.338, p=0.000) provides support for hypothesis H2b. However, our positively hypothesized path from data consistency to internal integration (H1b) provides a negative and significant at 10% level path result (β= -0.133, t=1.372, p=0.085). Further, the positive and significant paths from cross-functional application (β=0.307, t=2.441, p=0.008) and supply chain application (β=0.322, t=3.055, p=0.001) to supplier integration provide support for hypotheses H2c and H3c. The positive and significant path from internal integration to customer integration (β=0.301, t=3.218, p=0.001) provides support for hypothesis H4a(Table13).

Table 13 Path coefficients for "IT - SCI" model

	Path coeff.	Sample Mean	Stand. Error	t-value	p values	Hypo-theses	Support for Hyp.
CFA -> CI	0.024	0.037	0.125	0.189	0.425	H2a	Not supported
CFA -> II	0.672	0.667	0.072	9.338	0.000	H2b	Supported***
CFA -> SI	0.307	0.304	0.126	2.441	0.008	H2c	Supported***
DC -> CI	0.213	0.211	0.107	2.000	0.023	H1a	Supported**
DC -> II	-0.133	-0.126	0.097	1.372	0.085	H1b	Supported*
DC -> SI	0.082	0.077	0.120	0.687	0.246	H1c	Not supported
II -> CI	0.301	0.306	0.094	3.218	0.001	H4a	Supported***
II -> SI	0.103	0.115	0.110	0.934	0.175	H4b	Not supported
SCA -> CI	0.180	0.174	0.137	1.316	0.094	H3a	Supported*
SCA -> II	0.079	0.080	0.088	0.905	0.183	H3b	Not supported
SCA -> SI	0.322	0.325	0.105	3.055	0.001	H3c	Supported***

6.5 DISCUSSION AND IMPLICATIONS

The findings from this chapter suggest that different types of IT capabilities have differing impacts on three types of supply chain integration. These results underscore the varieties that exist between IT application capabilities for internal integration (cross-functional applications) and external integration (supply chain applications), and the data consistency capability, and importance of highlighting the differences these capabilities convey in supply chain integration context.

As our results suggest, data consistency significantly improves customer integration. Having highly standardized and consistent data exchanged between supply chain partners along the supply chain is likely to contribute to higher level of customer integration and improve the information exchange and coordination environment for the focal organization with its customers. Surprisingly, data consistency is found to have negative impact on internal integration on a marginal 10% significance level. One explanation to this may be that in cooperating and coordinating activities with customers and suppliers, a focal organization has to adjust their internal data to their partners' data standard. It is extremely difficult to achieve this kind of data standardization for the sake of external integration, specifically, with customers. The more complicated the focal organization's organizational structure and business processes are, the more likely it is that intra-organizational functions are using different data definitions. Hence, common data standards dictated along the supply chain may hinder the efficiency of internal integration.

Further,supply chain application capability improves customer and supplier integration supporting the findings of previous studies(Devaraj, Krajewski, and Wei 2007, Heim and Peng 2010). It can be considered as a natural outcomefrom using of these technologies, since they are generally designed to improve external integration. Supply chain applications as an extension to firm's internal applications engender customer and supplier integration and support these activities.

Similarly, cross-functional application capability significantly improved internal integration. This capability is indispensable to smoothening firm's internal operations, supporting frequent communication, collaboration and articulation of necessary information throughout the organization. However, cross-functional application capability is found to have positive impact on a manufacturer's integration with supplier. This can be explained by the previous literature that suggests that the extent of supplier integration is higher thanthat of customer integration. This also can be interpreted in association with the broadly used concept of "keiretsu" in Japanese industries, which is a type relationship quite similar to vertical integration in supply chains. Specifically, in automobile industry, a focal manufacturer such as Toyota can have greater control over its suppliers for the purpose of shortening lead-time and improving inventory management. Often, in this case, a supplieris regarded as a part of the manufacturing organization. Hence, the cross-functional application integration may extend to suppliers and improve supplier integration. From the perspective of internal cross-functional applications, by nature, these internal systems (MRP, ERP etc.) initially were built to streamline production processes and improveproductionplanningwhichincorporated purchasing functions. In this sense, level of cross-functional application capability is likely to positively influence supplier integration.

With regard to relationship between internal integration and external integration, only customer integration was positively related with internal integration. Surprisingly and contradictory to the results of Chapter 4, where the relationship between SCI and firm's operational performance is examined, internal integration is found to impact both external integration dimensions: customer integration and supplier integration. Similar to Chapter 4 discussion can be used in the support for the positive relationship between internal integration and customer integration. Thisfindingunderscores the importance of high internal integrative capabilities. From the perspective of organizational learning, the organization is likely to learn more from external partners and understand the partner's business to facilitate external integration, when it possesses a high level of absorptive capability to process the external knowledge acquired from its partners. In the same way, highly collaborative nature inside of the organization will improve customer integration enabling frequent contact with the customer organizations and sharing transactional and strategic information with them. Not significant impact of internal integration on supplier integration may mean supplier integration is highly influenced by technological side of integration: cross-functional application and supply chain application capabilities, rather than the organizational integration side of internal integration. This means the focal firm exchanges information and collaborates with its suppliers through well-developed information technologies, however organization's internal integration and its high absorptive capacity is likely not imperative in supplier integration.

6.6 Conclusions

This chapter examined the impact of three IT capability types (data consistency, cross-functional application, supply chain application) on supply chain integration (SCI) with the purpose to reveal if IT capability dimensions impact SCI dimensions, and if these relationships between dimensions of IT capability and SCI differ. The findings of this chapter support the hypotheses earlier developed in this chapter and contribute to the existing literature on SCI and IT in several major ways.

First, the study extends the literature by empirically testing how data consistency, cross-functional applications and supply chain applications can improve SCI in terms of internal integration, supplier integration and customer integration.

Second, the research of this chapter proposes three types of IT capability in SCI settings: data consistency, cross-functional application capability and supply chain application capability.

Third, the study extends the literature by indicating the importance of differentiating three types of IT capability (data consistency, cross-functional application capability, supply chain application capability) and three types of SCI (internal integration, customer integration, supplier integration), as these IT capabilities are found to differently influence SCI initiatives.

Lastly, findings from the study provide support for the applicability of resource-based view and relational view theories in explaining the impact of IT capabilities on SCI dimensions.

Chapter 7. Impact of environmental uncertainty on supply chain integration

7.1 INTRODUCTION

Today's ever-changing business environment is defined to be highly competitive, dynamic and complex, where customers are demanding more variability, better quality, higher reliability and faster delivery(Thomas and Griffin 1996). Moreover, sourcing, manufacturing and distribution activities are becoming global, product life cycle is shortening, product range is expanding, and technological developments are occurring at a faster pace than before.

To respond to and control such uncertain environment, organizations are internalizing fewer resources and capabilities, while increasing their integration with supply chain partners(Krause, Handfield, and Scannell 1998, Osborn and Baughn 1990, Sanchez 1993, Wong and Boon-itt 2008). Supply chain integration, defined as the degree to which a firm strategically collaborates with its supply chain partners and collaboratively manages intra- and inter-organizational resources to achieve effective and efficient flow of products, services, information, money and decisions, with the objective of providing maximum value to its customers(Zhao et al. 2008), has long been considered as a competitive advantage in today's global market.

Drawing on the resource-dependence theory, it is the purpose of this chapter to examine the role of supply chain integration initiative in reducing environmental uncertainties in this chapter. Thus the research question of this chapter is: Do environmental uncertainties in terms of demand uncertainty, supply uncertainty and technology uncertainty directly impact supply chain integration in terms of internal integration, customer integration and supplier integration?

The rest of this chapter is further divided into four sections: literature review where we define our research questions, theoretical foundation and hypotheses development, research methodology, discussion and implications, and conclusion.

7.2 ANALYTICAL FRAMEWORK: THEORETICAL FOUNDATION AND HYPOTHESES DEVELOPMENT

In this section, first come definitions for key theoretical constructs, followed by a theoretical model and hypotheses to explain the relationship between environmental uncertainty and supply chain integration constructs.

7.2.1 Supply chain integration

Following(Zhao et al. 2008), supply chain integration (SCI) is defined as the degree to which a firm strategically collaborates with its supply chain partners and collaboratively manages intra- and inter-organizational resources to achieve effective and efficient flow of products, services, information, money and decisions, with the objective of providing maximum value to its customers. We consider SCI as comprising of three dimensions: internal, supplier and internal integration(Flynn, Huo, and Zhao 2010). The consideration of multiple dimensions not only helps address the mixed findings in the literature, but also addresses the necessity to obtain comprehensive understanding about relationships between contingencies of environmental uncertainty and response alternatives of SCI types.

7.2.1.1 Internal integration

Internal integration is defined as degree to which a firm structures its own organizational strategies, practices and processes into collaborative, synchronized processes across functions, where collaboration across product design, procurement, production, sales and distribution functions takes place to fulfill its customers' requirements at a lower cost(Cespedes 1996, Flynn, Huo, and Zhao 2010, Kahn and Mentzer 1996, Kingman-Brundage, George, and Bowen 1995). Internal integration breaks down functional barriers and facilitates information sharing(Wong, Lai, and Cheng 2011), strategic partnership among departments, which can in turn collaboratively develop and maintain measurement systems and monitor business processes(Flynn, Huo, and Zhao 2010).

7.2.1.2 Supplier integration

Supplier integration comprises strategic partnership between a focal firm and its suppliers in managing procurement and production processes, including information sharing on demand forecast by a focal firm and inventory availability by suppliers, joint product development and so on(Ettlie and Reza 1992, Lai, Wong, and Cheng 2010, Ragatz, Handfield, and Petersen 2002).

7.2.1.3 Customer integration

Customer integration includes communication and frequent contacting between a focal firm and customers, information sharing on market, demand forecast and product/service feedback by customers which aim to improve visibility in supply chain, joint planning with customers and further product/service improvement opportunities by a focal firm(Fisher et al. 1994, Zhao et al. 2008). Customer integration enables deeper understanding of market expectations and opportunities, which contributes to a more accurate and quicker response to customer requirements and needs (Swink, Narasimhan, and Wang 2007, Wong, Lai, and Cheng 2011) by matching supply with demand that reduces "bullwhip effect" in the supply chain(Lee, Padmanabhan, and Whang 1997).

7.2.2 Environmental uncertainty

Uncertainty is defined as the inability to assign probabilities to future events (Duncan 1972) or the difficulties to accurately predict the outcomes of decisions(Downey, Hellriegel, and Slocum Jr 1975, Duncan 1972) due to incomplete information or changing conditions(Germain, Claycomb, and Dröge 2008). FollowingWong, Boon-Itt, and Wong (2011), we title it as *environmental uncertainty*, because we focus on the uncertainty caused by the external environment of a focal firm. In the context of a supply chain, environmental uncertainty is an inherent condition of inter-firm interactions (Miller 1987) and it can bring inefficient processing, unreliable information and non-value adding activities to the supply chain. The presence of uncertainty causes the decision maker to build safety buffers in time, capacity, or inventory to avoid a poor supply chain performance(Van der Vorst and Beulens 2002).

In order to reduce environmental uncertainties, it is important to determine the different sources of uncertainty and their relative impact on a supply chain(Davis 1993). For instance, sources of environmental uncertainty for a focal organization can be the elements of its business environment.

One of the early attempts to characterize organizational environment and categorize the environmental uncertainty was done byDuncan (1972). According toDuncan (1972), business environment consists of two general elements: internal and external environment. Internal environment comprises of organizational personnel, organizational functional and staff unit, and organizational level components; while external environment consists of components such as customers, suppliers, competitors, social-politics and technology. Similarly toDuncan (1972), Beckman, Haunschild, and Phillips (2004)propose two types of uncertainty based on uncertainty level: firm-specific and market based. Firm-specific uncertainty is largely internal, controllable, and unique; market uncertainty is external and shared across a set of firm.

Davis (1993)proposes three types of uncertainty sources that are inherent to supply chains, resulting in excess inventory in the supply chain: supplier performance, manufacturing process, and customer demand. The supplier performance uncertainty stands for a supplier's poor delivery performance due to its machine breakdowns, late shipments, or bad weather conditions that delayed a delivery. Over time, these supplier uncertainties can be tracked based on past data. The second uncertainty, manufacturing processes can include those problems that are internal to a firm, such as machine breakdowns, bottlenecks, line shutdowns and etc. And the third uncertainty source, customer demand, includes irregular purchases or orders. The more variable the customer orders, the more stock requires to reliably meet customer demand. With ever-shortening product life cycles, the customer demand uncertainty is likely to occur more frequently in the supply chain rather than the uncertainties related to supplier performance or manufacturing processes.

Consistent with the above-mentioned studies, we classify environmental uncertainty based on three sources, i.e. supply uncertainty, customer or demand uncertainty, and technology uncertainty. Further we discuss each of these environmental uncertainties.

7.2.2.1 Supply uncertainty

Supply uncertainty is defined as the extent of change and unpredictability of the suppliers' product quality and delivery performance(Li and Lin 2006). Examples of supply uncertainties are supplier's engineering level, lead time, delivery dependability, quality of incoming materials, and so on(Lee and Billington 1992). These uncertainties caused by the supplier might cost the firm postponing or even halting of its production process. Furthermore, these uncertainties will spread through the supply chain in the forms of amplification of ordering variability, which leads to excess stock, increased logistics costs, and inefficient use of resources(Yu, Yan, and Cheng 2001). A supplier who performs poor on its quality and delivery performances can subsequently lead a focal firm to perform poorly on customer service even in a stable environment. If placed in a rapidly changing environment, this manufacturer can get eliminated consequently(Li and Lin 2006).

7.2.2.2 Demand uncertainty

Demand or customer uncertainty refers to the extent of the change and unpredictability of the customer's demands and tastes(Li and Lin 2006). Demand uncertainty is considered to be a major contributor to overall uncertainty(Davis 1993, Germain, Claycomb, and Dröge 2008). The competitive nature of a global market has significantly impacted the traditional nature of the customer choice, as such customer demands for products and services are becoming increasingly volatile and uncertain in terms of volume, mix, timing, and place(Li and Lin 2006). Customers nowadays want more choice, better service, higher quality, and faster delivery(Burgess 1998, Van Hoek 1999).

7.2.2.3 Technology uncertainty

Technology uncertainty is defined as the extent of change and unpredictability of technology development in an organization's industry. Despite its enormous impacts and benefits that information and production technologies brought to business process and supply chain integration, reduction in transaction costs, and speeding up the response to customer orders, there are some threats these technologies bring to individual organizations. Provided the quick obsolescence of technology, organizations need to invest in new technologies (Prasad and Tata 2000)which result in increased cost for the company.

7.2.3 Environmental Uncertainty – SCI relationship

Grounded on the resourcedependence theory(Pfeffer and Salancik 1978), we posit that the business environment with high demand, supply and technology uncertainties is likely to improve a firm's internal cross-functional collaboration and external collaboration with its suppliers and customers. The resource dependence theory states that firms that are confronted with environmental uncertainty will create "negotiated environments" (Cyert and March 1963)and establish inter-organizational relationship as strategic responses to environmental uncertainty(Pfeffer and Nowak 1976). With additional coordination activities with suppliers and customers, more information and control actions will become available to the decision makers in every stage of the chain(Van der Vorst and Beulens 2002).

Considered to be a major and serious source of environmental uncertainty, the demand uncertainty results in a combination of lower quality of customer service, excess capacities in production process, excess inventory, and waste, therefore, increased overall cost(Fisher et al. 1994). Hence, under circumstances of increased demand uncertainty, organizations in the supply chain are likely to engage in collaborative activities with each other in order to stabilize their environment. The collaborative and coordination activities are also imperative to functions and departments internal to a firm, to reduce demand uncertainty. For instance, a firm's manufacturing department can increase its strategic collaboration with the sale's departments in order to improve sales forecasts, reducing excess inventory and decrease the overall cost. Hence we hypothesize:

H1. Higher level of demand uncertainty is positively associated with higher degree of supply chain integration in terms of (a) customer integration, (b) internal integration and (c) supplier integration.

Supply uncertainties which can occur due to suppliers' various manufacturing or logistical problems, incapability of meeting quality and delivery requirements, can be mitigated through supply chain management initiatives such as increased coordination with supply chain partners, and coordination and information sharing among purchasing and manufacturing departments internally. Therefore, high supply uncertainty is hypothesized to be positively associated with high degree of internal and external supply chain integration.

H2. Higher level of supply uncertainty is positively associated with higher degree of supply chain integration in terms of (a) customer integration, (b) internal integration and (c) supplier integration.

Due to uncontrollable technological changes by individual firms, firms form partnership to develop new technologies or products, or to borrow cutting-edge technologies developed by their partners to satisfy customer needs(Mentzer, Min, and Zacharia 2000). Researchers suggest that technology uncertainty can be mitigated through strategic supply chain integration initiatives involving increased communication and collaboration with supply chain partners (Auster 1992) and internal technology integration. Moreover, imperfect information and uncertainty due to technology obsolescence can be alleviated by recognizing resource dependence and promoting collaborative coordination between supply chain partners(Salancik and Pfeffer 1978, Truman 2000). Thus, technology uncertainty is hypothesized as an antecedent of supply chain integration.

H3. Higher level of technology uncertainty is positively associated with higher degree of supply chain integration in terms of (a) customer integration, (b) internal integration and (c) supplier integration.

From the perspective of organizational capability, it is argued that when a firm has a high level of internal communication and coordination capabilities, it will be more competent to achieve a high level of customer and supplier integration(Zhao et al. 2011). Bowersox, Closs, and Stank (1999) found that internal information sharing between functional departments of a firm is positively related to external cooperation with partners. Strategic cooperation literature also suggests that internal integration based on communication, information sharing and cross-functional teamwork is especially important for establishing and maintaining the firm’s alliance with its customers and suppliers. Therefore, we argue that firms with higher level of internal integration are more likely integrate with their customers and suppliers.

H4. Higher degree of internal integration is positively associated with higher degree of (a) customer integration and (b) supplier integration.

Based on the hypotheses grounded on the resource-dependence theory, analytical framework is built and shown in Figure 6.

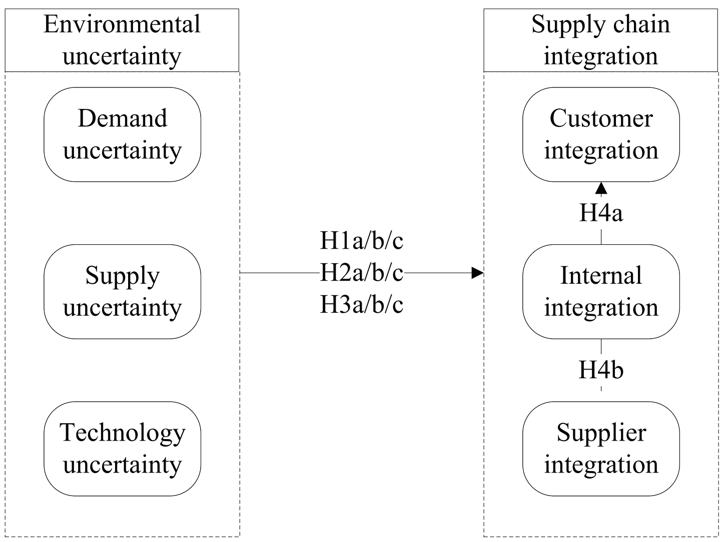

Figure 6 Analytical framework for "EU - SCI" model

7.3 MEASUREMENT VALIDATION

The model of this chapter examines the impact of three types of environmental uncertainty (EU) (demand uncertainty (DU), supply uncertainty (SU) and technological uncertainty (TU)) on three types of supply chain integration (SCI) (internal integration (II), customer integration (CI) and supplier integration (SI)).

Table 14 shows the factor loadings and Cronbach's alpha values for each construct. The scales are all reliable with alpha values ranging between 0.712 ~ 0.911, thereby exceeding the generally agreed lower limit for Cronbach's alpha of 0.60 (Flynn et al. 1990, Nunnally and Bernstein 1991)The scales' unidimensionalityis examined using factor analysis. As a result, one item from internal integration (II), one item from customer integration (CI), two items from supplier integration (SI), three items from supply uncertainty (SU), three items from demand uncertainty (DU) and one item from technological uncertainty (TU) are removed due to low factor loadings. The repeated factor analysis confirmed the unidimensionality for all six factors as the respective items load on only one factor each. All of the factor loadings are greater than 0.68 and the t-values are significantly greater than 3.30 (Table 14).

Table 14 Factor loadings and reliability values of measurement items for "EU - SCI" model

	CI	DU	II	SI	SU	TU	Cronbach's α	t-values
CI2	0.736						0.872	10.39
CI3	0.801							14.71
CI4	0.719							11.29
CI5	0.823							18.99
CI6	0.833							20.68
CI7	0.766							13.22
DU3		0.850					0.796	3.58
DU4		0.693						3.30
DU5		0.936						5.32
II1			0.728				0.911	9.98
II2			0.872					27.17
II3			0.891					37.23
II4			0.904					42.64
II5			0.887					43.80
SI1				0.857			0.904	23.50
SI2				0.852				25.48

	CI	DU	II	SI	SU	TU	Cronbach's α	t-values
SI3				0.813				18.20
SI4				0.876				31.22
SI5				0.851				25.07
SI8				0.679				6.77
SU1					0.946		0.712	22.28
SU2					0.794			8.17
TU1						0.803	0.747	6.66
TU2						0.758		6.63
TU3						0.870		6.35

Further, to test convergent validity, we analyze composite reliability (CR), average variance extracted (AVE), significance of item loadings. As shown in Table 15, CR and AVE values are greater than threshold values of 0.60 and 0.50 respectively (Bagozzi and Yi 1988, Fornell and Larcker 1981, Hair et al. 1998, Nunnally and Bernstein 1991) indicating convergent validity. Moreover, significant t-values of item loadings at level $p<0.001$ contribute to the convergent validity of measurement scales.

Following Fornell and Larcker (1981)approach, we examined the measurement model for discriminant validity. As illustrated in Table 15, all the scales demonstrate considerably higher square root of AVE values (figures in bold, along the diagonal) compared to the correlations with other constructs, suggesting the support for discriminant validity.

Table 15 Constructs values for mean, SD, correlations, composite reliability, average variance extracted for "EU - SCI" model

	Mean	SD	CR	AVE	CI	DU	II	SI	SU	TU
CI	4.39	0.91	0.903	0.610	**0.781**					
DU	3.32	1.16	0.869	0.693	0.074	**0.832**				
II	4.44	1.02	0.933	0.737	0.427	0.112	**0.859**			
SI	3.88	1.13	0.926	0.679	0.273	0.292	0.436	**0.824**		
SU	5.03	0.79	0.864	0.762	0.279	0.105	0.270	0.194	**0.873**	
TU	4.52	1.07	0.852	0.659	0.137	0.318	0.161	0.202	0.162	**0.812**

7.4 HYPOTHESES TESTING

Figure 7 shows the results of the PLS analysis. The predictive power of path models is explained by examining the explained variance or R^2 values(Barclay, Higgins, and Thompson 1995, Chin and Gopal 1995). R^2valuesindicate the amount of variance in the construct that is explained by the path model(Barclay, Higgins, and Thompson 1995). Accordingly, the results show that the model explains 21.3% of the variance in customer integration, 25.7% of the variance in supplier integration, representing a good overall model fit. In the same way, 9.9% of the variance in internal integration was explained by environmental uncertainty.

We found that six specified paths out of 11 paths between constructs in the research model show significant path coefficients, supporting their corresponding hypotheses. The positive and significant path coefficient from demand uncertainty to supplier integration (β=0.229, t=2.235, p=0.013) provides support for hypothesis H1c. Next, the positive and significant paths from supplier uncertainty to internal integration (β=0.242, t=2.611, p=0.005) and customer integration(β=0.173, t=1.567, p=0.059) provide support for hypotheses H2b and H2a. The positive and marginally significant path from technology uncertainty to internal integration (β=0.144, t=1.379, p=0.084) provides support for hypothesis H3b. Lastly, the positive and highly significant at 1% level paths from internal integration to customer integration (β=0.378, t=4.454, p=0.000) and to supplier integration (β=0.384, t=4.317, p=0.000) provide support for hypotheses H4a and H4b respectively (Table 16).

Table 16 Path coefficients for "EU - SCI" model

	Path coefficient	Sample Mean	Stand. Error	t-value	p values	Hypo-theses	Support for Hypotheses
DU -> CI	0.012	0.012	0.168	0.070	0.472	H1a	Not supported
DU -> II	0.052	0.057	0.106	0.495	0.310	H1b	Not supported
DU -> SI	0.229	0.231	0.102	2.235	0.013	H1c	Supported**
II -> CI	0.378	0.393	0.085	4.454	0.000	H4a	Supported ***
II -> SI	0.384	0.388	0.089	4.317	0.000	H4b	Supported ***
SU -> CI	0.173	0.168	0.111	1.567	0.059	H2a	Supported *
SU -> II	0.242	0.236	0.093	2.611	0.005	H2b	Supported ***
SU -> SI	0.058	0.055	0.106	0.546	0.293	H2c	Not supported
TU -> CI	0.011	0.015	0.095	0.119	0.453	H3a	Not supported
TU -> II	0.144	0.161	0.104	1.379	0.084	H3b	Supported *
TU -> SI	0.057	0.057	0.081	0.702	0.242	H3c	Not supported

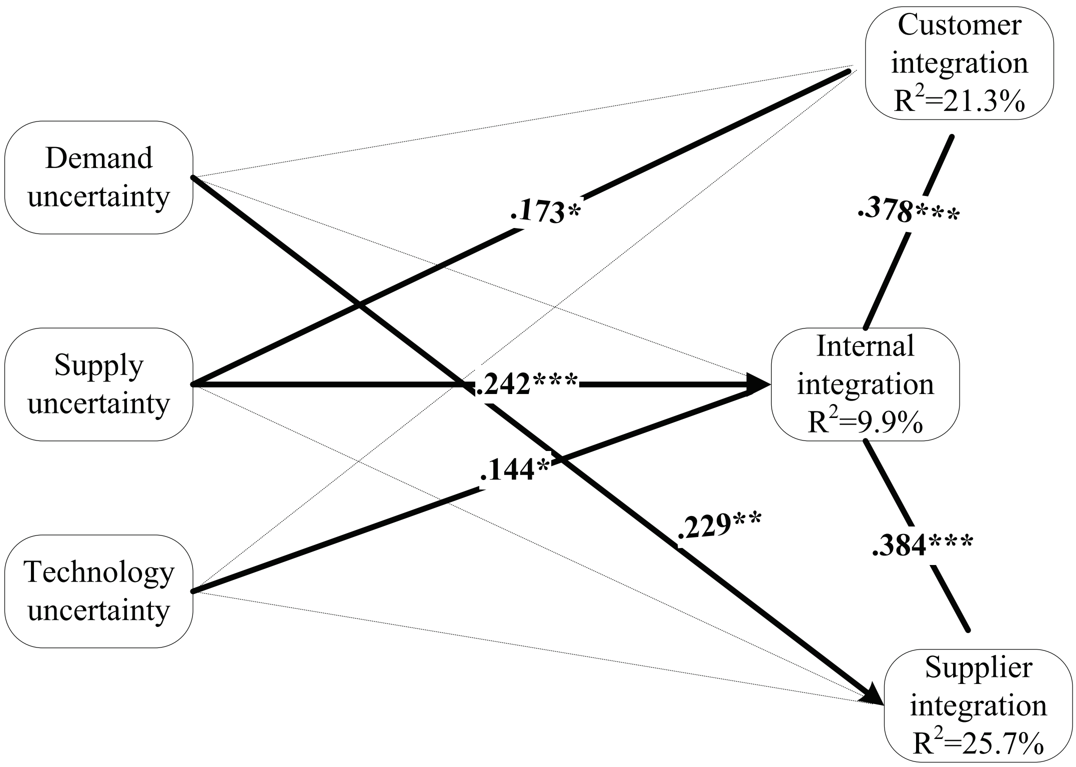

Figure 7 Path analysis results for "EU - SCI" model

**: Significant at $p < 0.05$
***: Significant at $p < 0.001$
→ : Significant relationship
→ : Non-significant relationship

Table 17 Indirect and total effects for "EU - SCI" model

	Indirect effect			Total effect		
	Path coefficient	t-value	p values	Path coefficient	t-value	p values
DU -> CI	0.020	0.433	0.333	0.018	0.115	0.454
DU -> SI	0.021	0.451	0.326	0.244	2.275	0.012**
SU -> CI	0.092	2.012	0.022**	0.263	2.603	0.005***
SU -> SI	0.095	2.013	0.022**	0.152	1.426	0.077*
TU -> CI	0.039	0.781	0.217	0.089	0.827	0.204
TU -> SI	0.040	0.797	0.213	0.100	1.193	0.117

7.5 Discussion and Implications

The findings of positive and significant relationships between environmental uncertainties and supply chain integration represent a significant contribution to and an extension for the existing literature on supply chain management.

Advocates of the resource dependence theory state that under conditions of uncertainty, firms attempt to interact closely with the supply chain partners to manage detrimental outcomes of such uncertainties(Paulraj and Chen 2007a). The findings for hypotheses H1c, H2a, H2b and H3b support this notion of resource dependence theory.

The support for hypothesis H1c implies that under conditions of significant demand uncertainties firms are likely to increase their coordination with key suppliers and introduce their inter-firmrelationship-specific assets. Firms operating under volatile demand uncertainty need to closely monitor demand forecasts and production schedules, and most importantly, coordinate production processes through close collaboration with key suppliers and ensure timely and stable procurement of supplies from those suppliers.

However, the hypothesized relationships between demand uncertainty and customer integration (H1a), demand uncertainty and internal integration (H1b) are not supported. An explanation for these non-significant relationships may be due to the predominance by supplier integration in high demand uncertainty environment. Davis (1993)notes in his case study on Hewlett-Packard, that in order to balance the stock and decrease the inventory cost against environmental uncertainties, at Hewlett-Packard the managers exerted tremendous pressure on suppliers to improve their performance.

The empirical support for hypothesis H2b suggests that in the environment of high supply uncertainties firms are likely to advance their internal cross-functional coordination and collaboration first thing. Enhanced coordination and collaboration between sales, manufacturing and purchasing departments toward comprehensive planning on the level of in house supply inventory may help manufacturers reduce or avoid supply uncertainties. Hypothesis H2a, underlying the impact of supply uncertainty on customer integration, is found to be marginally supported at 10% level. This finding suggests that when faced with uncertainties from supplier side, firms are likely to increase their coordination and collaboration activities with its customers in order to obtain as much information on market and demand forecasts as possible, and try to have the as nearly as possible correct amount of buffer inventory in house in order to match the demand.

The hypothesized direct impact of supply uncertainty on supplier integration (H2c) in our model is not supported. The non-supported hypotheses of H1a (relationship between demand uncertainty and customer integration) and H2c (relationship between supply uncertainty and supplier integration) can imply that the focal firm will try to increase its communication and collaboration with its customer when it encounters uncertainties from its supplier side. Similarly, the focal firm will try to increase its communication and collaboration with its suppliers when it confronts uncertainties from its customer side.

However we could find indirect support for the relationship between supply uncertainty and supplier integration through H4b.

The highly significant relationships between internal integration and customer integration (H4a), internal integration and supplier integration (H4b) are consistent with the findings from the previous literature (Carr and Kaynak 2007, Stank, Keller, and Daugherty 2001, Zhao et al. 2011) in that internal integration based on frequent communication, information sharing and cross-functional teamwork across internal functions within the firm is specifically important for establishing and maintaining the company’s alliances with external customers and suppliers.

Extending the impact of supply uncertainty on internal integration, the path analysis from supply uncertainty on external integration exhibits interesting findings (Table 17). The significant indirect effects from supply uncertainty to customer integration ($\beta=0.092$, $p<0.05$) and to supplier integration ($\beta=0.095$, $p<0.05$) through internal integration indicate that, to mitigate supply uncertainty, first thing firms need to do is improving their internal cross-functional integration and then their external integration with key customers and key suppliers. Sheombar (1997) and Van der Vorst and Beulens (2002) posit that additional coordination activities with suppliers and customers on top of internal integration can contribute to reducing the environmental uncertainty.

Embracing the notion of resource dependence theory, firms under conditions of technology uncertainty can choose to strengthen their coordination with supply chain partners(Paulraj and Chen 2007a). However, the results from path analysisexhibit marginal support for technology uncertainty and internal integration (H3b), except for hypothesized relationships between technology uncertainty and customer (H3a) and supplier (H3c) integration. Opposed to supply and demand uncertainties, firms are likely to tackle technological uncertainties internally. By nature production technologies are "hard" part of an organization. According toWong and Boon-itt (2008), external integration becomes less necessary, if the product technology is less complicated. Our findings can imply that the majority of firms from the study sample are not dealing with high product innovation, and therefore there is a less need for communication with their suppliers and customer in terms of technology uncertainty.

7.6 CONCLUSIONS

This chapter examined the impact of three types of environmental uncertainty (demand uncertainty, supply uncertainty and technology uncertainty) on supply chain integration (SCI) with the purpose to examine the role of supply chain integration initiative in reducing environmental uncertainties. The findings of this chapter support the hypotheses earlier developed and contribute to the existing literature on SCI in several major ways.

First, the study contributes to the growing stream of research in supply chain management by specifically exploring the relationship between dimensions of environmental uncertainty and supply chain integration.

Second, the study results provide empirical support for the resource dependence theory, which proposes a positive link between environmental uncertainties and supply chain integration practices.

Chapter 8. Impact of environmental uncertainty on information technology capability, supply chain integration and firm's operational performance

8.1 INTRODUCTION

In the previous chapters of this study, relationships between SCI and firm's operational performance, information technology (IT) capability and SCI, environmental uncertainty (EU) and SCI were examined separately based on the sample of manufacturing firms in Japan.

Further, there arises a question if these concepts interact with each other, i.e. whether IT capability and environmental uncertainty constructs impact significantly the SCI and SCI in turn impactsfirm's operational performance. As every aspect of the business world is interconnected, revealing their interaction and examining them in a single combined framework would contribute to the theory and practice providing valuable implications to researchers and practitioners.

This chapter's purpose is to examine empirically the previously investigated relationships between antecedents of SCI and SCI itself, and between SCI and firm's operational performance in a single research model based on the sample comprising manufacturing organizations in Japan. In line with the purpose of this chapter, the research questions of this chapter are as follows:

1. Do environmental uncertainties (EU) in terms of demand uncertainty (DU), supply uncertainty (SU) and technology uncertainty (TU) directly impact (a) supply chain integration (SCI) of internal integration (II), customer integration (CI) and supplier integration (SI)?

2. Do environmental uncertainties (EU) in terms of demand uncertainty (DU), supply uncertainty (SU) and technology uncertainty (TU) impact supply chain integration (SCI) of internal integration (II), customer integration (CI) and supplier integration (SI), through information technology (IT) capabilities of data consistency (DC), cross-functional applications (CFA) and supply chain applications (SCA)?Do supply chain integration

(SCI) of internal integration (II), customer integration (CI) and supplier integration (SI) impact firm's operational performance dimensions of product-mix flexibility (PMF), delivery (D), production cost (PC), quality (Q), inventory level (I), and customer service (CS)?

8.2 Analytical Framework: Theoretical foundation and hypotheses development

Figure 8 exhibits the combined framework of this study. Hypotheses from H4 to H13 have already formulated and discussed in previous chapters based on the past literature. Hypotheses H1-H3, which represent the relationships between environmental uncertainties (EU) and IT capabilities, and their development are discussed in this chapter.

By nature, organizations are open social systems that must process information(Mackenzie 1984). According to the literature on organization theory, organizations process information in order to reduce uncertainties that are related to their task environment and thereby attain an acceptable level of performance. Information is processed to accomplish internal organizational tasks, to coordinate diverse activities throughout the organization, and to interpret the external environment(Daft and Lengel 1986). This external environment sometimes can create uncertainties to the organization in the form of lack of or excess amount of information. In order to tackle these uncertainties and improve information processing capabilities, organizations are required to develop lateral relations with their partners and building information systems (Galbraith and Jay 1977, Tushman and Nadler 1978) that are capable of coping with variety, coordination, and an uncertain environment.

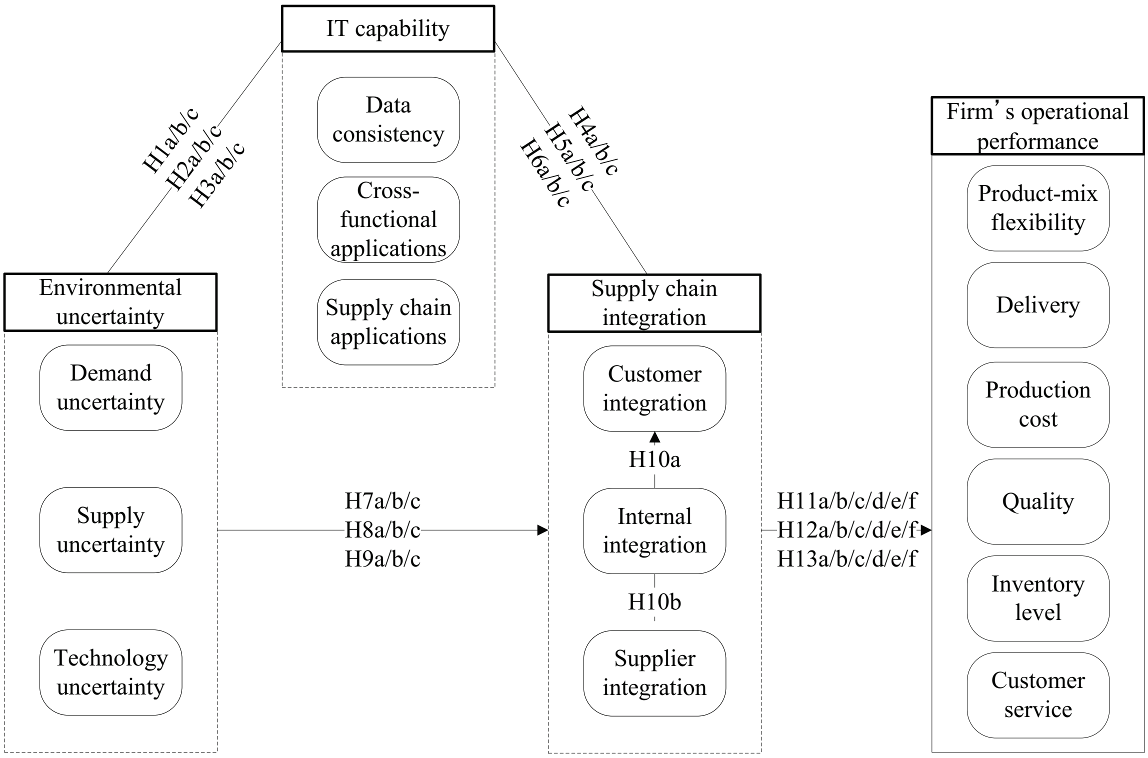

Figure 8 Combined analytical framework

Projecting this fundamental knowledge on environmental uncertainty in supply chain settings, it can be suggested that high environmental uncertainty from demand and supply side, and technological development, can result in lack of information on customer preferences or demand, supplier inventory availability, and on current technological developments for the focal organization, or conversely plentiful information to the degree that it is difficult to synthesize and process. As such high IT capabilities are critical to firms that are capable of capturing and processing information, standardizing it into a common data base, and coordinating the information along the supply chain, in case of available information, or facilitating decision making by predicting the uncertain environment in case of lack of information. And in turn these high IT capabilities will improve the integration of not only internal but external process integration, facilitating the coordination and collaboration between supply chain partners.

Thus, based on these discussions, we hypothesize that:

H1. Higher level of demand uncertainty is positively associated with higher degree of IT capabilities in terms of (a) data consistency, (b) cross-functional applications, and (c) supply chain applications.

H2. Higher level of supply uncertainty is positively associated with higher degree of IT capabilities in terms of (a) data consistency, (b) cross-functional applications, and (c) supply chain applications.

H3. Higher level of technology uncertainty is positively associated with higher degree of IT capabilities in terms of (a) data consistency, (b) cross-functional applications, and (c) supply chain applications.

8.3 MEASUREMENT VALIDATION

The model of this chapter examines relationships between all the constructs considered in previous sections all together. Based on the theoretical findings of previous literature, this study hypothesizes that environmental uncertainty (EU) impacts both IT capability and SCI, and in turn, SCI improves firm's operational performance (FOP). Below, we examined the reliability and validity of three constructs of EU (demand uncertainty (DU), supply uncertainty (SU), technology uncertainty (TU)), three constructs of IT capability (data consistency (DC), cross-functional application (CFA), supply chain application (SCA)), three constructs of SCI (internal integration (II), customer integration (CI), supplier integration (SI)) and six constructs of FOP (product-mix flexibility (PMF), delivery (D), quality (Q), production costs (PC), inventory level (IL), customer service (CS)).

Table 18 shows the factor loadings and Cronbach's alpha values for each construct. The scales are all reliable with alpha values ranging between 0.623 ~ 0.910, thereby exceeding the generally agreed lower limit for Cronbach's alpha of 0.60 (Flynn et al. 1990, Nunnally and Bernstein 1991). The scales' unidimensionalityis examined using factor analysis. As a result, one item from customer integration (CI), one item from supplier integration (SI)), three items from supply uncertainty (SU), three items from demand uncertainty (DU) and one item from technology uncertainty (TU) are removed due to low factor loadings. Further, two items from internal integration (II) and one item from cross-functional application (CFA) capability are deleted due to cross-loadings on at least two constructs. The repeated factor analysis confirmed the unidimensionality for all 15 factors as the respective items load on only one factor each. All of the factor loadings are greater than 0.65 and the t-values are significantly greater than 4.74 (Table 18).

Further, to test convergent validity, we analyze composite reliability (CR), average variance extracted (AVE), significance of item loadings. As shown in Table 19, CR and AVE values are greater than threshold values of 0.60 and 0.50 respectively (Bagozzi and Yi 1988, Fornell and Larcker 1981, Hair et al. 1998, Nunnally and Bernstein 1991) indicating convergent validity. Moreover, significant *t*-values of item loadings at level $p<0.001$ contribute to the convergent validity of measurement scales.

Following Fornell and Larcker (1981)approach, we examined the measurement model for discriminant validity. As illustrated in Table 19, all the scales demonstrate considerably higher square root of AVE values (figures in bold, along the diagonal) compared to the correlations with other constructs, suggesting the support for discriminant validity.

8.4 HYPOTHESES TESTING

Figure 9 shows the results of the PLS analysis. The predictive power of path models is explained by examining the explained variance or R2 values(Barclay et al. 1995; Chin et al. 1995). R^2valuesindicate the amount of variance in the construct that is explained by the path model (Barclay et al. 1995).

Accordingly, the results show that the model explains 17.1% of variance in product-mix flexibility, 17.4% of variance in delivery, 18.8% of variance in production cost, 14.7% of variance in quality, 17.9% of variance in inventory level, and 22.5% of variance in customer service representing a good overall model fit. In a similar way, the model explains 27.5% of variance in customer integration, 44.8% of variance in supplier integration and 44.1% of variance in internal integration. Further, 13.6% variance in data consistency, 8.1% variance in cross-functional applications, and 13.1% variance in supply chain applications are explained by environmental uncertainties.

Table 18 Factor loadings and reliability values of measurement items for the combined model

	CFA	CI	CS	D	DC	DU	II	IL	PC	PMF	Q	SCA	SI	SU	TU	Cronbach's α	t-values
CFA1	0.848															0.873	25.63
CFA2	0.811																22.07
CFA3	0.906																54.35
CFA4	0.838																28.09
CI1		0.692														0.872	9.61
CI2		0.785															18.24
CI3		0.817															20.21
CI5		0.776															15.21
CI6		0.805															16.28
CI7		0.807															21.73
CS1			1													1	
D1				0.963												0.904	94.86
D2				0.946													41.51
DC1					0.805											0.771	14.23
DC2					0.832												18.98
DC3					0.847												13.34
DU3						0.842										0.796	4.74
DU4						0.655											3.60
DU5						0.948											4.99
II1							0.766									0.885	12.84
II2							0.887										30.09
II3							0.894										43.87
II4							0.898										42.93
IL1								1								1	
PC1									1							1	
PMF1										0.841						0.880	18.43
PMF2										0.929							47.50
PMF3										0.920							37.54
Q1											0.778					0.623	8.65
Q2											0.912						17.44

	CFA	CI	CS	D	DC	DU	II	IL	PC	PMF	Q	SCA	SI	SU	TU	Cronbach's α	t-values
SCA1												0.896				0.893	35.88
SCA2												0.907					44.48
SCA3												0.871					27.29
SCA4												0.800					13.21
SI1													0.820			0.910	16.70
SI2													0.841				26.62
SI3													0.796				16.03
SI4													0.859				31.03
SI5													0.832				20.67
SI7													0.755				13.94
SI8													0.737				10.88
SU1														0.937		0.712	34.99
SU2														0.809			9.74
TU1															0.777	0.747	7.08
TU2															0.720		6.52
TU3															0.906		10.85

Table 19 Constructs' values for mean, SD, correlations, composite reliability, average variance extracted for the combined model

	Mean	SD	CR	AVE	CFA	CI	CS	D	DC	DU	II	IL	PC	PMF	Q	SCA	SI	SU	TU
CFA	4.22	1.08	0.913	0.725	**0.852**														
CI	4.29	0.90	0.904	0.611	0.360	**0.781**													
CS	5.74	1.07	1	1	0.250	0.451	**1**												
D	5.71	1.03	0.954	0.911	0.343	0.333	0.604	**0.955**											
DC	4.83	1.24	0.867	0.685	0.504	0.380	0.272	0.313	**0.828**										
DU	3.32	1.16	0.862	0.679	0.178	0.091	0.042	0.045	0.154	**0.824**									
II	4.59	1.02	0.921	0.745	0.640	0.380	0.302	0.309	0.248	0.117	**0.863**								
IL	4.42	1.40	1	1	0.278	0.367	0.403	0.312	0.207	-0.032	0.301	**1**							
PC	4.39	1.24	1	1	0.318	0.388	0.401	0.452	0.306	0.015	0.316	0.445	**1**						
PMF	5.02	1.18	0.925	0.805	0.182	0.381	0.496	0.470	0.244	0.139	0.269	0.466	0.498	**0.897**					
Q	5.58	0.89	0.835	0.719	0.236	0.366	0.452	0.576	0.226	-0.093	0.243	0.448	0.463	0.375	**0.848**				
SCA	3.85	1.28	0.925	0.756	0.446	0.399	0.222	0.236	0.601	0.186	0.300	0.334	0.357	0.255	0.143	**0.870**			
SI	3.83	1.11	0.929	0.651	0.556	0.308	0.143	0.307	0.455	0.278	0.416	0.272	0.236	0.24	0.157	0.541	**0.807**		
SU	5.03	0.79	0.867	0.766	0.212	0.297	0.382	0.363	0.284	0.112	0.256	0.163	0.277	0.278	0.234	0.251	0.192	**0.875**	
TU	4.52	1.07	0.845	0.647	0.185	0.179	0.210	0.221	0.270	0.313	0.149	0.262	0.220	0.463	0.250	0.284	0.177	0.166	**0.805**

We found that 26 specified paths out of 47 paths between constructs in the combined research model show significant path coefficients, supporting their corresponding hypotheses (Table 20).

8.4.1 Environmental uncertainty (EU) – IT capability relationship

Demand uncertainty (DU) is not found to significantly impact all three IT capabilities, therefore H1a, H1b, H1c are not supported.

The paths from supply uncertainty (SU) to all three IT capabilities – data consistency (DC), cross-functional applications (CFA), and supply chain applications (SCA) – are found to be positive and significant supporting hypotheses H2a, H2b, H2b.

Lastly, technology uncertainty (TU) is found to significantly and positively impact data consistency (DC) and supply chain application (SCA), thus supporting H3a and H3c. On the other hand, TU does not significantly influence cross-functional applications, thus H3b is not supported.

8.4.2 Environmental uncertainty (EU) – supply chain integration (SCI) relationship

Demand uncertainty (DU) has positive and significant impact on only supplier integration out of three SCI dimensions, thus supporting H7c and rejecting H7a and H7b.

Next, supply uncertainty (SU) has significant and positive impact on customer integration and internal integration, supporting H8a and H8b. But it is found to not significantly impact supplier integration, providing non-support for H8c.

Last, technology uncertainty (TU) is found not to impact significantly any of SCI dimensions, thus rejecting H9a, H9b and H9c.

8.4.3 IT capabilities – supply chain integration (SCI) relationship

The results of path analysis for the combined research model prove the previous results for the relationship between IT capabilities and SCI dimensions. Thus it provides support for hypothesized paths between: data consistency – customer integration (H4a), cross-functional applications (CFA) – internal integration (II) (H5b), cross-functional applications (CFA) – supplier integration (SI) (H5c), supply chain applications (SCA) –

customer integration (CI) (H6a), supply chain applications (SCA) – supplier integration (SI) (H6c). The rest hypothesized paths – DC – SI (H4c), CFA – CI (H5a), SCA – II (H6b)

– are not supported. However, the path from DC to II shows a significant negative relationship.

8.4.4 Internal integration – external integration

Similarly to results of Chapter 6, internal integration (II) is found to significantly impact customer integration (CI), thus supporting H10a. But internal integration (II) impact on (SI) is not found significant, rejecting H10b.

8.4.5 Supply chain integration (SCI) – firm's operational performance relationship

All significant paths in the combined model show similar results to findings from Chapter 4 except for an additional 10% level-significant positive paths from internal integration (II) to inventory level (IL) and customer service (CS) on top of internal integration (II)'s positive and significant impact on delivery (D) and production costs (PC).

Namely, significant paths from customer integration (CI) to all operational performance dimensions – product-mix flexibility (H11a), delivery (H11b), production cost (H11c), quality (H11d), inventory level (H11e), customer level (H11f) support their respective hypotheses.

Next, the significant paths from internal integration (II) to delivery (H12b), production cost (H12c), inventory level (H12e), customer service (H12f) support their respective hypotheses.

Lastly, the significant paths from supplier integration (SI) to delivery (H13b) and inventory (H13e) show support for the respective hypotheses.

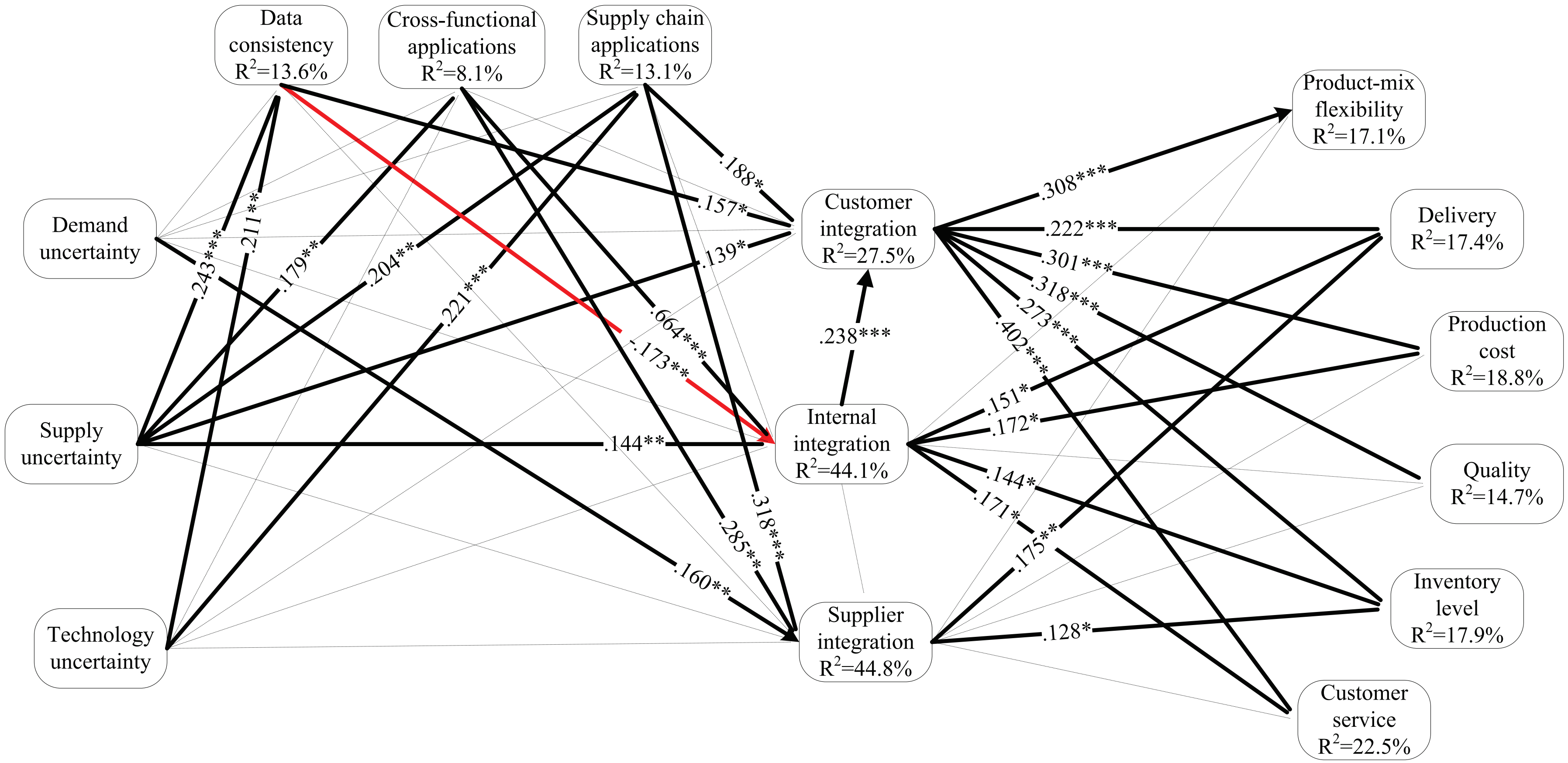

Figure 9 Path analysis results for the combined model

Table 20 Path coefficients for the combined model

	Path coeff.	Sample Mean	Stand. Error	t-value	p values	Hypo-theses	Support for Hyp.
CFA -> CI	0.014	0.020	0.129	0.111	0.456	H5a	Not supported
CFA -> II	0.664	0.662	0.075	8.836	0.000	H5b	Supported***
CFA -> SI	0.285	0.288	0.131	2.173	0.015	H5c	Supported **
CI -> CS	0.402	0.397	0.119	3.365	0.000	H11f	Supported ***
CI -> D	0.222	0.231	0.087	2.549	0.006	H11b	Supported ***
CI -> IL	0.273	0.281	0.105	2.593	0.005	H11e	Supported ***
CI -> PC	0.301	0.305	0.096	3.142	0.001	H11c	Supported ***
CI -> PMF	0.308	0.310	0.127	2.437	0.008	H11a	Supported ***
CI -> Q	0.318	0.335	0.086	3.707	0.000	H11d	Supported ***
DC -> CI	0.157	0.164	0.118	1.330	0.092	H4a	Supported *
DC -> II	-0.173	-0.166	0.103	1.679	0.047**	H4b	Not supported
DC -> SI	0.086	0.084	0.110	0.778	0.219	H4c	Not supported
DU -> CFA	0.121	0.122	0.114	1.060	0.145	H1b	Not supported
DU -> CI	-0.024	-0.020	0.130	0.183	0.428	H7a	Not supported
DU -> DC	0.061	0.060	0.110	0.557	0.289	H1a	Not supported
DU -> II	-0.013	-0.013	0.081	0.165	0.435	H7b	Not supported
DU -> SCA	0.095	0.095	0.124	0.761	0.223	H1c	Not supported
DU -> SI	0.160	0.149	0.080	1.996	0.023	H7c	Supported **
II -> CI	0.238	0.248	0.095	2.506	0.006	H10a	Supported ***
II -> CS	0.171	0.173	0.130	1.311	0.095	H12f	Supported *
II -> D	0.151	0.143	0.113	1.340	0.090	H12b	Supported *
II -> IL	0.144	0.137	0.102	1.412	0.079	H12e	Supported *
II -> PC	0.172	0.159	0.108	1.598	0.055	H12c	Supported *
II -> PMF	0.111	0.103	0.099	1.118	0.132	H12a	Not supported
II -> Q	0.118	0.103	0.108	1.093	0.137	H12d	Not supported
II -> SI	0.110	0.108	0.105	1.045	0.148	H10b	Not supported
SCA -> CI	0.188	0.172	0.135	1.386	0.083	H6a	Supported *
SCA -> II	0.064	0.058	0.099	0.649	0.258	H6b	Not supported
SCA -> SI	0.318	0.310	0.110	2.882	0.002	H6c	Supported ***
SI -> CS	-0.052	-0.036	0.103	0.504	0.307	H13f	Not supported
SI -> D	0.175	0.182	0.104	1.685	0.046	H13b	Supported **
SI -> IL	0.128	0.140	0.092	1.390	0.083	H13e	Supported *
SI -> PC	0.072	0.083	0.097	0.746	0.228	H13c	Not supported
SI -> PMF	0.100	0.114	0.113	0.881	0.189	H13a	Not supported
SI -> Q	0.010	0.014	0.116	0.087	0.465	H13d	Not supported
SU -> CFA	0.179	0.174	0.100	1.790	0.037	H2b	Supported **
SU -> CI	0.139	0.141	0.096	1.446	0.074	H8a	Supported *
SU -> DC	0.243	0.244	0.101	2.397	0.008	H2a	Supported ***
SU -> II	0.144	0.146	0.074	1.950	0.026	H8b	Supported **
SU -> SCA	0.204	0.206	0.095	2.146	0.016	H2c	Supported **
SU -> SI	-0.010	-0.004	0.092	0.105	0.458	H8c	Not supported
TU -> CFA	0.118	0.129	0.106	1.114	0.133	H3b	Not supported
TU -> CI	0.030	0.033	0.102	0.291	0.385	H9a	Not supported
TU -> DC	0.211	0.220	0.097	2.165	0.015	H3a	Supported **
TU -> II	0.035	0.043	0.087	0.403	0.344	H9b	Not supported
TU -> SCA	0.221	0.227	0.093	2.372	0.009	H3c	Supported ***
TU -> SI	-0.054	-0.046	0.079	0.676	0.250	H9c	Not supported

Table 21 Indirect and total effects for the combined model

	Indirect effect			Total effect		
	Path coeff.	t-value	p values	Path coeff.	t-value	p values
DU -> CI	0.044	0.755	0.225	0.02	0.158	0.437
DU -> II	0.076	1.054	0.146	0.063	0.562	0.287
DU -> SI	0.077	1.035	0.151	0.236	2.173	0.015**
DU -> CS	0.007	0.108	0.457	0.007	0.108	0.457
DU -> D	0.055	1.117	0.132	0.055	1.117	0.132
DU -> IL	0.045	0.861	0.195	0.045	0.861	0.195
DU -> PC	0.034	0.644	0.260	0.034	0.644	0.260
DU -> PMF	0.037	0.676	0.250	0.037	0.676	0.250
DU -> Q	0.016	0.302	0.381	0.016	0.302	0.381
SU -> CI	0.135	2.754	0.003***	0.274	2.982	0.002***
SU -> II	0.09	1.294	0.098*	0.234	2.798	0.003***
SU -> SI	0.162	2.903	0.002***	0.153	1.453	0.073*
SU -> CS	0.142	2.329	0.010***	0.142	2.329	0.010***
SU -> D	0.123	2.521	0.006***	0.123	2.521	0.006***
SU -> IL	0.128	2.798	0.003***	0.128	2.798	0.003***
SU -> PC	0.134	2.713	0.003***	0.134	2.713	0.003***
SU -> PMF	0.126	2.488	0.007***	0.126	2.488	0.007***
SU -> Q	0.116	2.76	0.003***	0.116	2.76	0.003***
TU -> CI	0.098	2.047	0.021**	0.127	1.223	0.111
TU -> II	0.056	0.828	0.204	0.091	0.815	0.208
TU -> SI	0.132	2.207	0.014**	0.078	0.962	0.168
TU -> CS	0.063	1.167	0.122	0.063	1.167	0.122
TU -> D	0.056	1.313	0.095*	0.056	1.313	0.095*
TU -> IL	0.058	1.215	0.112	0.058	1.215	0.112
TU -> PC	0.060	1.264	0.103	0.060	1.264	0.103
TU -> PMF	0.057	1.241	0.108	0.057	1.241	0.108
TU -> Q	0.052	1.103	0.135	0.052	1.103	0.135
DC -> CI	-0.041	1.291	0.099*	0.116	0.986	0.162
DC -> IL	0.015	0.297	0.383	0.015	0.297	0.383
DC -> SI	-0.019	0.807	0.210	0.067	0.626	0.266
DC -> CS	0.014	0.225	0.411	0.014	0.225	0.411
DC -> D	0.011	0.213	0.416	0.011	0.213	0.416
DC -> PC	0.010	0.183	0.427	0.010	0.183	0.427
DC -> PMF	0.023	0.442	0.329	0.023	0.442	0.329
DC -> Q	0.017	0.292	0.385	0.017	0.292	0.385
CFA -> CI	0.158	2.394	0.009***	0.172	1.476	0.070*
CFA -> IL	0.189	2.645	0.004***	0.189	2.645	0.004***
CFA -> SI	0.073	1.023	0.153	0.357	3.534	0.000***
CFA -> CS	0.164	1.679	0.047**	0.164	1.679	0.047**
CFA -> D	0.201	3.281	0.001***	0.201	3.281	0.001***
CFA -> PC	0.192	2.505	0.006***	0.192	2.505	0.006***
CFA -> PMF	0.162	2.300	0.011**	0.162	2.30	0.011**
CFA -> Q	0.137	2.165	0.015**	0.137	2.165	0.015**
SCA -> CI	0.015	0.557	0.289	0.203	1.466	0.072*
SCA -> SI	0.007	0.426	0.335	0.325	2.949	0.002***
SCA -> CS	0.075	1.091	0.138	0.075	1.091	0.138
SCA -> D	0.112	2.127	0.017**	0.112	2.127	0.017**
SCA -> IL	0.106	1.888	0.030**	0.106	1.888	0.030**
SCA -> PC	0.095	1.646	0.050**	0.095	1.646	0.050**

	Indirect effect			Total effect		
	Path coeff.	t-value	p values	Path coeff.	t-value	p values
SCA -> PMF	0.102	1.757	0.040**	0.102	1.757	0.040**
SCA -> Q	0.075	1.185	0.118	0.075	1.185	0.118
II -> CS	0.090	1.920	0.028**	0.261	2.072	0.019**
II -> D	0.072	1.786	0.037**	0.223	2.148	0.016**
II -> IL	0.079	1.813	0.035**	0.223	2.341	0.010***
II -> PC	0.080	1.847	0.033**	0.252	2.504	0.006***
II -> PMF	0.084	1.783	0.038**	0.195	2.237	0.013**
II -> Q	0.077	1.723	0.043**	0.195	1.988	0.024**

8.5 DISCUSSION

Most of the findings on the relationships between our study constructs are discussed in preceding chapters: Chapter 4 discussed on the findings from testing the relationship between supply chain integration (SCI) dimensions and firm's operational performance dimensions, Chapter 6 discussed on the findings from the analysis of the relationship between IT capabilities and SCI dimensions, Chapter 7 discussed on the findings from examining the relationships between different sources of environmental uncertainties and SCI dimensions.

However, an overall picture of findings from the combined research model is discussed in this chapter. The findings from this chapter suggest that different sources of environmental uncertainty have differing impacts directly and indirectly through IT capabilities on supply chain integration, which in turn results in the improved operational performance of a focal organization.

In line with the findings from the previous chapters, the central concept of our research, supply chain integration, proves to play an indispensable role as a competitive advantage for improving a focal manufacturing firm's operational performance, supporting the findings from previous research (Flynn, Huo, and Zhao 2010, Frohlich and Westbrook 2001, Vickery et al. 2003, Danese 2013), most of which examined operational performance as a single construct. Firstly, this is realized mostly via customer integration, which impacts all six operational performance dimensions significantly. Particularly, this finding is consistent with previous literature findings by Flynn, Huo, and Zhao (2010), who conducted their study in manufacturing organizations in China. Secondly, after customer integration, internal integration is found to increase delivery, production cost, inventory, and customer service performance. This is also consistent with findings from Flynn, Huo, and Zhao (2010), Sanders (2007b) studies. The least amount of dimensions, namely, delivery and inventory level performance, are positively and significantly affected by supplier integration. It is partly consistent with findings from Devaraj, Krajewski, and Wei (2007), Prajogo and Olhager (2012). In their study based on the sample of 120 manufacturing firms in US, Devaraj, Krajewski, and Wei (2007) found that supplier integration was the only one predictor for operational performance compared to customer integration. But our results suggest that in Japanese manufacturing firms all types of supply chain integration are imperative with the most preference of customer integration followed by internal and supplier integration. As for the impact of internal integration on external integration, similarly to Zhao et al. (2011) findings, internal integration is found to improve customer integration significantly, however, contradictory to their study, internal integration is found not to impact supplier integration significantly when IT capability constructs are introduced in the model. This may imply that for supplier integration, technical side of integration is foremost effective than the efforts produced by internal integration. This finding also may be related to the power distribution along supply chain, where a customer organization is likely to exercise more power on the focal organization rather a supplier organization is likely to exercise on the focal organization (Zhao et al. 2008). As such, for successful customer integration a focal firm is required to deploy rather increased relationship efforts to satisfy and meet customer needs, as for supplier integration a more information technological support is likely to result in better integration with suppliers.

Next, the role of IT capability as a facilitator for supply chain integration was generally supported in our model as well, providing support for previous literature findings (Rai, Patnayakuni, and Seth 2006, Devaraj, Krajewski, and Wei 2007, Li et al. 2009, Sanders and Premus 2005). Our results show that supply chain applications capability significantly improves customer and supplier integration, the latter being enabled at higher significance level (1%) than the former (10%). This result of prevalent impact of IT capability on supplier integration is consistent with findings of Hill and Scudder (2002) study based on the sample of 185 food manufacturing and distributor firms in US. The authors conclude that EDI is likely to be frequently used for supplier coordination, rather for customer coordination. Overall, the results are also consistent with findings from such studies as Devaraj, Krajewski, and Wei (2007), Li et al. (2009). The study results also suggest that internal cross-functional applications integrative capability improves not only intra-organizational integration, but also it is helpful for supplier integration. In addition, data consistency construct is found to improve customer integration, but surprisingly it has negative significant impact on internal integration. From broader perspective, we can suppose that having a consistent and standardized data definition along the supply chain is likely to work best for customer integration. Again, from the power distribution perspective, defining or following customer organization's data standardization methods may cause harm for the internal coordination and sharing of information among internal departments and functions.

Further, we hypothesized that technological (IT capability) and relationship (supply chain integration) factors would function as effective initiatives for a focal firm to reduce and/or avoid environmental uncertainties in the supply chain. The hypotheses are partially supported as results of the data analysis. Our results demonstrate that demand uncertainty from customer organizations, as considered to be one of major sources of uncertainty (Davis 1993), can be controlled through better supplier integration, which is in line with arguments of Davis (1993) and Wong and Boon-itt (2008) . That is, a focal firm may put more pressure on its suppliers to reduce costs and quickly react to any changes in demand. A second source of uncertainty in supply chain, supply uncertainty, is found to be better controlled by all three technological factors (data consistency, cross-functional applications and supply chain applications capabilities) and two relationship factors (customer and internal integration). These findings contradict to Paulraj and Chen (2007a)'s findings from an empirical study targeted 221 US manufacturing firms, which argue that supply uncertainty can trigger strategic supply management as comprised of such sub-constructs as supplier integration and long-term relationship with suppliers. Lastly, our results show that only technological factors of data consistency and supply chain application capability are capable of dealing with technology uncertainty. This may imply that tighter information sharing on recent technology trends with supply chain partners through information technology means is likely to help organizations stay in takt with IT developments and avoid any uncertainties in this field. Overall look at uncertainty management with regard to demand, supply and technology uncertainty demonstrates that of all three uncertainties sources, supply uncertainty is easily managed compared to demand and technology uncertainty.

8.6 IMPLICATIONS

The findings from the research model, which has examined the interaction of all the constructs previously discussed, provide several managerial and theoretical implications.

From the theoretical perspective, grounding on findings and theories from organizational and operational area literature, the study hypothesized and investigated interaction between supply chain integration, firm's operational performance, IT capability and environmental uncertainty constructs and their multiple dimensions in a single research model.

Resource-based view of a firm (Barney 1991) that posits a firm's sustained competitive advantage (internal integration) and performance are dependent on its unique resources and capabilities (cross-functional application capabilities) that are difficult to imitate is found to support our findings. Next, ***relational view theory***(Dyer and Singh 1998), which states a firm's critical resources may span its boundaries and be rooted in inter-firm resources and relationships, is also proven to be applicable in supporting our findings on the relationship between external IT capability (supply chain applications capability) and external integration with suppliers and customers. ***Resource-dependence theory***(Pfeffer and Salancik 1978), that posits firms that are confronted with environmental uncertainty will create "negotiated environments" (Cyert and March 1963) and establish inter-organizational relationships as strategic responses to environmental uncertainties, was also found applicable in explaining the role of relational factors (supply chain integration) in reducing or avoiding demand, supply, and technology uncertainty. A sound reflection of the existing *literature on organization theory and information processing*(Daft and Lengel 1986, Galbraith and Jay 1977, Tushman and Nadler 1978), which argue organizations process information by means of information technologies in order to reduce uncertainties that are related to their task environment and thereby attain an acceptable level of performance, was observed in our findings on positive relationship between supply uncertainty and IT capabilities, and between technology uncertainty and data consistency, and supply chain application capabilities.

From the managerial perspective, the findings from our study suggest that for improving firm's operational performance across all six dimensions considered in our study – product-mix flexibility, delivery, production cost, quality, inventory level, and customer service – it is imperative for the focal firm to improve its customer integration which is largely made available through supply chain application capability and internal integration, the latter in turn is significantly enabled by well developed cross-functional applications.

Among these six operational performance dimensions, delivery and inventory level performance dimensions were found to be improved by all three supply chain integration dimensions: internal integration, customer integration and supplier integration. For achieving excellence in these performance dimensions, it is recommendable for supply chain managers to concentrate on all types on integration. Among them, both supplier and customer integration are likely to be facilitated by supply chain application capabilities, on top of effective internal integration that is important of customer integration.

While, production cost and customer service performance were found to be highly significantly improved by customer integration, and marginally improved by internal integration directly.

On the other hand, for firms operating in high demand uncertainty, our findings suggest to improve their integration with suppliers. When the supply uncertainty is high, internal and customer integration enabled by well developed IT capabilities can be of help in reducing this source of uncertainty. In terms of an environment defined by high technology uncertainty, firms are advised to improve their IT capabilities in terms of data consistency and supply chain applications.

8.7 CONCLUSIONS

The chapter investigated all the constructs which were considered in the previous chapters in a single research framework in order to examine if firms tackle environmental uncertainties building better relationship and/or higher degree of integration along supply chain with the support of well developed IT capabilities, and if supply chain integrative initiatives improve the focal firm's operational performance. The findings of this chapter support the hypotheses earlier developed in this and previous chapters and contribute to the existing literature on SCI, ITand organizational theory in several major ways.

First, the study extends the literature by empirically testing how data consistency, cross-functional applications and supply chain applications can improve SCI in terms of internal integration, supplier integration and customer integration and at the same time they can prevent or reduce uncertainties from demand, supply and technology sources.

Second, the research framework examined a complex model consisting of 47 different relationships between research constructs and provided detailed implications on each and every relationship contributing to the theory and practice.

Second, the study extends the literature by indicating the importance of differentiating three types of IT capability (data consistency, cross-functional application capability, supply chain application capability) and three types of SCI (internal integration, customer integration, supplier integration), three sources of environmental uncertainty (demand uncertainty, supply uncertainty, technology uncertainty), and six dimensions of firm's operational performance (product-mix flexibility, delivery, production cost, quality, inventory level, and customer service), as the former constructs were found to differently influence the latter construct designated by their respective hypotheses.

Chapter 9

9.1 CONCLUSIONS

In an attempt to understand relationshipsbetweenenvironmental uncertainty, IT capabilities, SCI, and operational performance dimensions, this study developed three research models comprising the following pairs of research constructs: (1) supply chain integration and firm's operational performance dimensions, (2) IT capabilities and supply chain integration dimensions, (3) environmental uncertainty and supply chain integration dimensions, and one research model consisting of all research constructs considered in the study: supply chain integration, IT capabilities, environmental uncertainty and firm's operational performance dimensions, and empirically tested all four models based on the sample of 108 Japanese manufacturing organizations.

Hypotheses comprising the research model were developed based on the findings from the past literature on operations management and organizational structure study and on the theories of resource-based view (Barney 1991), relational view (Dyer and Singh 1998), resource dependence theory (Pfeffer and Salancik 1978). The findings of this study support the hypotheses developed in respective chapters and contribute to the existing literature on SCI, ITand organizational theory in several major ways. It was found that firm's operational performance dimensions are improved when the focal firm has better integration with their customers. However, internal integration and supplier integration were found to improve operational performance partly. Our expectations for IT capabilities to facilitate supply chain integration was partly proven by the positive and significant impact of supply chain applications capability on external integration, and by the positive and significant impact of cross-functional applications capability on internal and supplier integration. Although, surprisingly, data consistency construct of IT capability was found to negatively impact internal integration, but positively influence customer integration. Our findings also suggest that Japanese manufacturing firms are likely to highly integrate with their suppliers via technological factors (IT capabilities). On the other hand, these organizations are likely to achieve higher customer integration through higher internal integration. Further, with regard to managing environmental uncertainties, our empirical results show that Japanese manufacturing organizations are likely to deal with demand uncertainties through tighter integration and collaboration with their suppliers. As for the supply side uncertainty, the firms are likely to tackle with them with the support of not only technical factors (all three IT capabilities), but also with the relational factors of increased customer and internal integration. Last, not least, technology uncertainty is found to be reduced through higher data consistency and supply chain applications capabilities.

Moreover, the study tested the findings from past empirical studies on the relationship between information and communication technology (ICT) and supply chain integration through meta-analysis. With regard to our supply chain integration variables of interest – internal integration, customer integration, and supplier integration, - supplier integration is found to be well improved by those information and communication technologies (supplier ICT) that are supposed to facilitate it. Against our expectations, both internal integration and customer integration are not found to be improved when there are high internal ICT and customer ICT.

9.2 THEORETICAL AND PRACTICAL CONTRIBUTIONS

First, this research examined the central concepts of the study as represented by multiple constructs or dimensions. This helps understand the relationship between dimensionsfrom two concepts of concern, providing the "fine-grain" knowledge from the empirical evidence to practitioners and researchers.

Second, support for the study hypotheses developed based on the theories stated above – Resource-Based View (Barney 1991), Relational View (Dyer and Singh 1998), Resource Dependence theory (Pfeffer and Salancik 1978), suggests that theories from operations and strategic management areas are applicable to the context of supply chain integration and management.

Third, to the best of our knowledge, this study is the first of its kind, which examined a complex model consisting of constructs of SCI, IT capabilities, environmental uncertainties and firm's operational performance in the context of Japanese manufacturing firms.

Lastly, this research proposes three types of IT capability in SCI settings: data consistency, cross-functional application capability and supply chain application capability, extending the proposed two constructs (supply chain applications and data consistency) by Rai et al. 2006.

9.3 RESEARCH LIMITATIONS AND FUTURE RESEARCH

There are some limitations to this study and more opportunities for future research.

First, the results from this study may not be generalizable to the whole population in terms of industries other than manufacturing and/or small and medium organizations and in terms of countries other than Japan, even though we could generalize our results to large-sized manufacturing firms that conduct their business in Japan.

Second, the study was conducted from manufacturer's perspective only. Further research can be done to investigate the research constructs and the relationship among them from supplier, manufacturer, and customer perspectives.

Third, the study used cross-sectional data. In the future, longitudinal research should be conducted to examine the dynamics in the development of internal and external integration, advancement of technology capability, and performance improvements.

Finally, lack of supportive findings in the meta-analysis on the relationship between internal ICT and internal integration, customer ICT and customer integration partly can be due to small number of sample studies used in the meta-analysis. Increase of the sample size in the future can reveal different results.

APPENDIX A: LIST OF SAMPLE STUDIES

No.	Sample study references
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No.	Sample study references
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APPENDIX B: CODING OF INFORMATION AND COMMUNICATION TECHNOLOGY

Dimensions	Constructs [source]	Description
ICT use/utilization - "ICT_USE"	Hardware/OS available [2], Communication systems available [2], ERP implementation [3], Information sharing with customers [5], Information integration [5], Process intelligence [9], IT resources [10], IT adoption [11], IT implementation [13], IS utilization for value creation management [14], IS utilization for logistical operations [14], IS utilization for infrastructural support [14], Internet technology application [16], Use of eBusiness technologies [20], Technology use [23]	Use of responsive, reliable, and uptime available hardware software; established open and industry standards; EDI, RFID, XML applications, website, extranet, internet, e-markets; Process planning and control systems such as ERP (internal, supplier, customer integration modules), B2C and B2B, CRM; decision support systems: knowledge management for information sharing, data management systems.
Overall ICT integration - "OVER_ICT"	IT connectivity [1], IT compatibility [1], Technology and planning integration [4], Data consistency [17], Cross-functional SCM application systems integration [17], IT capability [19], IS flexibility [22], Technology and Planning [24], Integrative information technologies [27]	Internal and external integrative ICTs (EDI, computerized production systems, etc.) that are defined by timely, standard, and consistent data and capable of supporting not only internal coordination and collaboration, but also connectivity, information sharing, new business relationships, operational processes (collaborative planning and forecasting) with supply chain partners.
Internal ICT - "INTER_ICT"	IT personal technology management [1], Business application integration [2], Data quality [2], IT department skills and knowledge [2], Internal LIT [6], Information capability [7], Integration intelligence [9], IT appropriation [11]	Integrated internal ICTs (ERP) that enable internal operational processes, information sharing, communication and coordination, with standardized, timely, and reliable database.
External ICT - "EXT_ICT"	External LIT [6], eBUSColl [8], Collaboration intelligence [9], IT alignment [12], Information technology [15], EDI capability [26],	Integrative ICTs (EDI, etc.) that enable information sharing, collaboration (forecast, replenishment, scheduling, advanced planning) and coordination (transaction processing, e-transfer of purchase orders, shipments e-tracking) with suppliers and customers.
Customer ICT- "CUS_ICT"	eBUSCUS [8], IT use for exploitation [21], IT use for exploration [21], IS integration with customers [22]	Integrative ICTs that facilitate process integration and transactions, with customers; and real-time information and data exchange with them.
Supplier ICT - "SUP_ICT"	eBUSPUR [8], Application integration [18], Data compatibility [18], IT systems analytic ability [18], IT systems alertness [18], IT systems evaluation ability [18], IS integration with channel partners [22], Process operation [25], Collaborative operation [25],	Integrative ICTs (e-procurement technologies, etc.) that enable operational activities (planning and execution, decision making, evaluation (delivery and quality performance of suppliers) and collaboration activities with suppliers, and real-time sharing of industry-standardized data with them.

APPENDIX C:CODING OF SUPPLY CHAIN INTEGRATION

Dimensions	Constructs [source]	Description
Overall SC integration - "OVER_INT "	Supply chain integration [5], Business integration capability [10], Supply chain integration [13], SC integration [23], Supply chain integration [27]	Intra-firm integration (BPR and BPI) of cross-functional teams, inter-firm integration (BPR, BPI) with suppliers and customers in terms of information sharing, coordination, collaboration (planning, inventory management, process standardization, online ordering, product customization, etc.)
Internal integration- "INTER_INT "	IT impact on operations [2], Internal process integration [4], Firm-wide integration [7], Integration between functions [9], Functional integration [14], Internal integration [14], Internal collaboration [19], Internal integration [24]	Cross-functional integration, unification, and standardization through integrated physical process, information and resource sharing, interaction, coordination, and cooperation between employees, managers, cross-functional teams in terms of planning, integrated database, etc.
External integration - "EXT_INT"	Returns [1], Collaboration with partners [1], Supply chain participation [5], Cooperation [9], Systems collaboration [11], Strategic collaboration [11], Strategic collaboration [12], External integration [14], Inter-organizational communication [15], Trading partner relationships [16], Physical flow integration [17], Information flow integration [17], Financial flow integration [17], Supply chain information alignment [26], Supply chain relational alignment [26], Buyer-supplier coordination [20]	Information (operational, tactical, strategic) sharing, partnership, cooperation, collaboration, strategic planning on demand, new product developments with suppliers and customers
Supplier integration - "SUP_INT"	Procurement [1], IT impact on inbound [2], Information sharing [3], Redesign and systems coupling [3], Supplier/service integration [4], Supplier integration [8], Strategic integration [18], Operational integration [18], Financial integration [18], Process coupling with channel partners [22], Knowledge sharing with channel partners [22], Supplier integration [24], Information sharing [25], Technology dependence [25], External collaboration [19]	Information sharing/exchange with suppliers (supplier production capacities, the firm's sales forecasts, production schedule, inventory status, etc.), knowledge sharing, coordination, coupling and integration of activities, collaboration (sharing of cost,) with suppliers
Customer integration - "CUS_INT"	Customer service [1], IT impact on outbound [2], Customer integration [4][6][8], Operational coordination [21], Strategic coordination [21], Process coupling with customers [22], Knowledge sharing with customers [22], Customer integration [24]	Information sharing/exchange (operational information: product availability, order status of customers, sales forecast, production schedule, inventory status of the firm), strategic planning (new product or product concept development) and knowledge sharing (business environment, channel partners, competitors, etc.) with customers

APPENDIX D.MEASUREMENT ITEMS AND THEIR SOURCE

Supply chain integration (SCI) constructs:

Internal integration (II)

Source: Flynn, Huo, and Zhao (2010), Narasimhan and Kim (2002), Zhao et al. (2011)

II1	The use of periodic interdepartmental meetings among internal functions
II2	The use of cross functional teams in new product development
II3	The extent of strategic partnership among different internal functions
II4	Different internal functions jointly develop strategic plans in collaboration with each other
II5	Different internal functions monitor business processes together**
II6	Different internal functions jointly develop and maintain measurement systems**

Customer integration (CI)

Source: Flynn, Huo, and Zhao (2010), Narasimhan and Kim (2002), Zhao et al. (2011)

CI1	The extent of our linkage with our major customer through information network*
CI2	The extent of sharing of market information by our major customer
CI3	Our level of communication with our major customer
CI4	The establishment of a quick ordering system with our major customer*
CI5	Our follow-up with our major customer for feedback
CI6	The frequency of our contacts with our major customer
CI7	Our major customer shares demand forecast with us

Supplier integration (SI)

Source: Flynn, Huo, and Zhao (2010), Narasimhan and Kim (2002), Zhao et al. (2011)

SI1	Our level of information exchange with our major supplier through information network
SI2	The establishment of a quick ordering system with our major supplier
SI3	The extent of our strategic partnership with our major supplier
SI4	Stable procurement through networking with our major supplier
SI5	The participation level of our major supplier in our procurement and production processes
SI6	The level of participation by our major supplier in our product design*
SI7	Our major supplier shares its inventory availability with us
SI8	We share our demand forecast with our major supplier

Information technology (IT) capability constructs:

Data consistency (DC)

Source: Rai, Patnayakuni, and Seth (2006)

DC1	Automatic data capture systems are used (e.g., bar code) across the supply chain.
DC2	Definitions of key data elements (e.g., customer, order, part number) are common across the supply chain.
DC3	Same data (e.g., order status) stored in different databases across the supply chain is consistent.

Cross-functional applications (CFA)

Source: Flynn, Huo, and Zhao (2010), Narasimhan and Kim (2002), Zhao et al. (2011)

CFA1	Data integration among internal functions

CFA2	Enterprise application integration among internal functions
CFA3	Integrative inventory management
CFA4	Real-time searching of logistics-related operating data
CFA5	Real-time integration and connection among internal functions from raw material management through production, shipping, and sales**

Supply chain applications (SCA)

Source: Rai, Patnayakuni, and Seth (2006)

SCA1	Supply chain planning applications (e.g., demand planning, transportation planning, manufacturing planning) communicate in real time.
SCA2	Supply chain transaction applications (e.g., order management, procurement, manufacturing and distribution) communicate in real time.
SCA3	Supply chain applications communicate in real time with internal applications of our organization (e.g., ERP).
SCA4	Customer relationship management applications communicate in real time with internal applications of our organization.

Environmental uncertainty (EU) constructs:

Supply uncertainty (SU)

Source: Chen and Paulraj (2004), Qi, Zhao, and Sheu (2011)

SU1	Our suppliers consistently meet our requirements
SU2	Our suppliers provide us with inputs of consistent quality
SU3	The price of our raw materials and component parts has changed frequently*
SU4	We do extensive inspection of incoming critical materials from our suppliers*
SU5	We have a low rejection rate for incoming critical materials from our suppliers*

Demand uncertainty (DU)

Source: Chen and Paulraj (2004), Qi, Zhao, and Sheu (2011)

DU1	Our master production schedule has a high percentage of variation in demand*
DU2	It has been difficult for us to procure raw materials for our major product*
DU3	Our demand fluctuates drastically from week to week
DU4	Customer requirements for our products vary dramatically
DU5	Our supply requirements vary drastically from week to week
DU6	The volume of our customers' demand is difficult to predict*

Technology uncertainty (TU)

Source: Chen and Paulraj (2004), Qi, Zhao, and Sheu (2011)

TU1	Our industry is characterized by rapidly changing technology*
TU2	If we don't keep up with changes in technology, it will be difficult for us to remain competitive
TU3	Our production technology changes frequently
TU4	The rate of technology obsolescence in our industry is high*

APPENDIX D. MEASUREMENT ITEMS AND THEIR SOURCE

Firm's operational performance (FOP) constructs:

Product-mix flexibility (PMF)

Source: Beamon (1999), Flynn, Huo, and Zhao (2010), Frohlich and Westbrook (2001), Vickery et al. (2003)

PMF1 Our company can quickly modify products to meet our customers' requirements

PMF2 Our company can quickly introduce new products into the market

PMF3 Our company can quickly respond to changes in market demand

Delivery (D), Source: Beamon 1999; Flynn et al. 2010; Frohlich et al. 2001; Vickery et al. 2003

D1 Our company has an outstanding record of on-time delivery to our customers

D2 Our company has an outstanding record of reliable delivery to our customers

Quality (Q)

Source: Devaraj, Krajewski, and Wei (2007)

Q1 Percent product returned by our major customer is low

Q2 Percent defects during production is low

Production cost (PC)

Source: Devaraj, Krajewski, and Wei (2007)

PC1 Production costs are low

Inventory level (IL)

Source: Devaraj, Krajewski, and Wei (2007)

IL1 Our company's inventory level is low

Customer service (CS)

Source: Beamon (1999), Flynn, Huo, and Zhao (2010), Frohlich and Westbrook (2001), Vickery et al. (2003)

CS1 Our company provides a high level of customer service to our customers

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