DEVELOPMENT OF A UNIFIED OPEN E-LOGISTICS STANDARDS DIFFUSION MODEL FOR MANUFACTURING SUPPLY CHAIN INTEGRATIONS

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PhD

The Hong Kong Polytechnic University

2019

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Development of a Unified Open E-Logistics Standards Diffusion Model for Manufacturing Supply Chain Integrations

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A thesis submitted in partial fulfilment of the requirements for the degree of Doctor of Philosophy

August 2018

CERTIFICATE OF ORIGINALITY

I hereby declare that this thesis is my own work and that, to the best of my knowledge and belief, it reproduces no material previously published or written, nor material that has been accepted for the award of any other degree or diploma, except where due acknowledgement has been made in the text.

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ABSTRACT

The most respected manufacturing firms are those that have a tightly integrated, collaborative supply network. An important web technology which facilitates the integration of the supply chain is Open E-Logistics Standards (OELS). In OELS, the transmission and manipulation of data are governed by open data and process standards that define their format, structure, and the semantics of data flow between trading partners. Unlike traditional proprietary standards, OELS are developed by an open industrial consortium, use open standardized interfaces, and are built on the internet for communications and transactions among supply chain partners. OELS implementation facilitates electronic integration and information sharing in the supply chain, of which, the importance has been recognized by both manufacturing industries and the government. Despites OELS' importance, there remain concerns about OELS' slow development progress and low adoption rates. The potential failure of OELS represents a significant stumbling block for governments and supply chain practitioners who have envisioned a globalized supply chain network electronically enabled by OELS.

This research is motivated by the following questions: *What determines the adoption and diffusion of OELS, and how can OELS be successfully implemented in the manufacturing industry?* OELS are highly complex in their development, and diffusion processes due to the hybrid and complex forms of network interactions and supply chain relationships. Despite its practical and theoretical significance, acknowledgement of the influence of network structures and inter-organizational relationships on OELS is not evident in the literature, which entails an empirical

examination of a unified OELS adoption model incorporating various network and relational factors.

Recognizing the significance of investigating network properties and inter-organizational relationships, this study, drawing on various theoretical frameworks including the structural embeddedness theory, the relational view of the firm, and organizational ambidexterity theory, proposes a research model to examine the influences of two categories of network-level properties: exchange structure (content of exchange, i.e., product complexity and specificity, context of exchange, i.e., market turbulences and technological turbulences) and tie architecture (structural strength and relational strength). In addition, this study also investigates two relational mechanisms –*bridging* (i.e., process adaptability and relationship flexibility) and *bonding* (i.e., process coupling) as the full forces of OELS adoption.

Based on a comprehensive literature review, two versions of questionnaires were designed to collect data from OELS current adopters and potential adopters respectively to investigate OELS actual adoption level and adoption intention. The sampling frame included the list of manufacturing firms belonging to the industry categories within Chinese Industrial Classification (CIC) codes 1311–4290.

The findings reveal that the characteristics of exchange structure and tie architecture, the bridging mechanism (relationship flexibility and process adaptability), and the bonding mechanism (process coupling) influence OELS adoption intention and actual adoption level (internal assimilation and external diffusion) differently. Bonding and bridging mechanisms complement each other to facilitate OELS adoption and assimilation. The findings highlight the distinct roles of the network properties and

relational mechanisms play in determining adoption intention among potential adopters and actual adoption among current adopters. It also shows that a firm will obtain greater financial and operational performance when it assimilates OELS to a greater extent internally and externally.

The key contribution of this study is the development of a robust model to understand the adoption of OELS in manufacturing industries. This study theoretically develops two relational mechanisms pertinent to the context of OELS assimilation and provide the proxies to measure these two mechanisms. By surfacing the complementary effects between bonding mechanism and the two bridging mechanisms on OELS adoption, this study safeguards against the conventional belief that bonding and bridging are substitutes, and demonstrates how these two mechanisms are mutually reinforcing to facilitate the adoption intention and the actual assimilation of OELS. Although OELS is a key technology that provide values to manufacturers to achieve supply chain performance, there is still knowledge gaps with respect to how OELS can help in generating values. This study thus contributes to the inter-organizational systems literature by investigating how network-level properties, specifically, exchange structure and tie architecture, affect the actual OELS adoption level and adoption intention. By comparing different value preferences of potential adopters and existing adopters, this research shows that different diffusion models should be developed to study pre-adoption and post-adoption stages. The findings empirically confirm that OELS enable companies to enjoy durable competitive advantages to pursue higher-order performance by developing bonding and bridging capabilities to continually restructure supply chain processes and respond to external changes.

PUBLICATIONS

Journal Paper

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Pu, X., Chan, F. T. S., Tsiga, Z. D. and Niu, B. (2018) The adoption of Internet-enabled supply chain management systems: Differences between buyer and supplier perspectives, *Industrial Management & Data Systems*. 118(8), pp. 1695-1710. *(SCI, Q1, impact factor: 2.948)*.

Lee, A. B. S., Chan, F. T. S. and **Pu, X.** (2018) Impact of supplier development on supplier's performance, *Industrial Management & Data Systems.* 118(6), pp. 1192-1208. *(SCI, Q1, impact factor: 2.948)*.

Pu, X., Niu, B., Chan, F. T. S. and Chong, A. Y.-L. The Adoption of NFC-based Mobile Payment Services: An Empirical Analysis of Apple Pay in China. *International Journal of Mobile Communications. (SSCI, impact factor: factor1.742). Forthcoming.*

Paper under Review

Pu, X, Wang, Z. X., Chan F.T.S. , Chung, S. H. and Lee, A. B. S. Adoption of Internet-Enabled Supply Chain Management Systems: A Structural Embeddedness Perspective. Submitted to *International Journal of Industrial Engineering: Theory, Applications and Practice.* (1st round review)

Conferences and Presentations

Pu, X. and Chan, F. T. S. (2018) The influence of dependence structure and relational value on the adoption internet-enabled supply chain management systems. *2018 International Conference on Information Resources Management (Conf-IRM 2018)*, Ningbo, China, 4 – 6 June.

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ACKNOWLEDGEMENTS

I would like to express my deepest appreciation to all those who provided me the possibility to complete this thesis. I would like to express my sincere gratitude to my supervisor, Prof. Felix Chan, who has been providing his suggestions and guidance throughout my PhD programme. The great patience, encouragement and knowledge from Prof. Chan has helped me overcome all the challenges and obstacles occurred during my research.

I would also like to thank my co-supervisor, Prof. Alain Chong, for his continuous support of my PhD study and related research, for his insightful comments and suggestions which incented me to widen my research from various perspectives.

Finally, I must express my very profound gratitude to my parents and to my friends for supporting my spiritually throughout my years of study. This accomplishment would not have been possible without them.

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ABBREVIATION

AVE	Average Variance Extracted
CB-SEM	Covariance Based Structural Equation Modelling
CMV	Common Method Variance
DOI	Diffusion of Innovation Theory
EDI	Electronic Information Exchange
eSCM	Internet-enabled Supply Chain Management Systems
IBPS	Inter-Organizational Business Process Standards
IOS	Inter-organizational Systems
OELS	Open E-Logistic Standards
OSIOS	Open Standards-Based Inter-organizational Systems
PLS-SEM	Partial Least Squares Structural Equation Modelling
SCM	Supply Chain Management
SEBIs	Standard Electronic Business Interfaces
TOE	Technology-Organization-Environment Model
VAN	Value Added Network
VIF	Variance Inflation Factor
XML	Extensible Markup Language

CHAPTER 1. INTRODUCTION

This chapter introduces the thrust of this thesis and its research background. The significance of this study will be discussed, which is followed by the proposal of research questions and objectives, and a general discussion of the methodology adopted by this thesis. This chapter also provides the definitions of the key terms employed in this thesis, and delineates the structure of this thesis.

1.1. Research Background

The recent advance of the internet and web technologies has introduced more powerful inter-organizational information systems (IOS) solutions to integrate supply chains and enhance interfirm collaboration (Liu et al., 2010; Venkatesh and Bala, 2012; Chong et al., 2013). With the development of IOS based on Extensible Markup Language (XML) and web services, there has been a growing momentum to move from traditional Electronic Information Exchange (EDI) systems to Open E-Logistic Standards (OELS) information systems (Chou et al., 2004; Zhu et al., 2006a). OELS define the business processes, orchestration of supply chain activities, data formats and semantics, and information sharing standards, and enable information flows to be automated between business partners (Weitzel et al., 2006). Unlike traditional proprietary standards, OELS are developed by an open industrial consortium (Table 1–1), use open standardized interfaces, and are built on the internet for communications and transactions among supply chain partners. With OELS, a firm can greatly enhance its inter-organizational communication and coordination ability, and therefore be more competent in achieving a collaborative supply chain network (Liu et al., 2010). Compared with EDI-based systems, OELS allow for connection with

the broader business community (Gosain et al., 2003; Zhu et al., 2006a) and the exchange of intensive, real-time data (Gosain et al., 2003). With lower installation and operation costs and decreased technical complexity (Zhu et al., 2006a), OELS can alleviate the inextricable trade-off between integration and flexibility which has been the greatest stumbling block preventing the wide diffusion of traditional EDI-based systems. It is therefore expected that there will be more extensive assimilation of OELS and companies can more effectively integrate their supply chain members through implementation in supply chains (Markus et al., 2006; Chong and Bai, 2014).

Table 1–1. Examples of Industrial OELS Initiatives

Industry	Standards Developing Consortia
Agriculture	AgXML (http://www.agxml.org)
Accounting	XBRL
Financial– Insurance	ACORD (http://www.acord.org)
Financial– Mortgage	MISMO (http://www.mismo.org)
Healthcare	CDISC (http://www.cdisc.org) HL7 (http://www.hl7.org)
Manufacturing – Electronics	EIDX (http://eidx.comptia.org)
Manufacturing – Automobile	AIAG (http://www.aiag.org)
Manufacturing - Chemical	CIDX (http://www.cidx.org)
Manufacturing - Paper	PapiNet (http://www.papinet.org)
Manufacturing - Semiconductor, IT, and Electronic Components	RosettaNet (http://www.rosettanet.org)
Transportation	LandXML

Adapted from Zhao et al. (2005)

Despite being widely acknowledged as the generic cure for supply chain management (Boyer and Hult, 2005; Rai et al., 2006), the adoption rate of OELS has been far less than expected. It is suggested that due to power imbalances among supply partners, the consequences of implementing OELS is highly unpredictable (Yao et al., 2007), which has greatly impeded its wide adoption (Ke et al., 2009). In addition, there are various economic, technical and social risks associated with OELS adoption that make

the consequences of OELS adoption and assimilation highly unpredictable (Kumar and van Dissel, 1996).The inadequate adoption and assimilation of OELS present a major obstacle to the successful management of a supply chain (Teo et al., 2003; Ke et al., 2009). It is therefore highly important to investigate the factors that may facilitate or derail the adoption of OELS and to provide insights to promote greater assimilation of OELS.

Past studies have examined IOS adoption based a wide spectrum of factors drawing on various theoretical frameworks which mainly focus on the technological, organizational and environmental aspects of technology adoption (Robey et al., 2008). Yet, sparse efforts have been made to understand how network structures and inter-organizational relationships influence the adoption of OELS. Implementing information systems transcending organizational boundaries requires collaboration and information sharing among the supply chain participants. The networks that a firm is embedded in thus play important roles in affecting decision on IOS adoption (Tang et al., 2011; Chong and Bai, 2014). The hybrid and complex network structures will influence the complexity and uncertainties involved in OELS adoption. In addition, it is suggested that network structures could shape a firm's expectations and the purported relational value it intend to gain from implementing IOS (Tang et al., 2011), which may act as the pull forces affecting how a firm responds to OELS.

1.2. Significance of the Research

In spite of the perceived business potential of open standards, the number of companies that have implemented OELS for inter-organizational communication has been less than expected. Many industrial open standards initiatives have encountered

great difficulties in the establishment of standards and spreading process (Wareham et al., 2005). Additionally, as OELS can sufficiently reduce the costs of partner searching and connection, it is expected that companies will electronically connect with more supply chain members (Christiaanse et al., 2004). However, it is surprising to find that even in the financial industry where open standards have been widely accepted, open standards are primarily used for internal application integration instead of external communication with other organizations (Knox, 2003). Furthermore, a large number of companies have chosen to utilize IOS for tightly coupling with only a few long-term business partners rather than with many partners (Tang et al., 2011). These facts raise questions about the importance of improving the openness of IOS. While the technologies are open, the inter-organizational relationships are in various forms that some companies may prefer to trade in a small network with closely collaborated partners. Therefore, the characteristics of inter-organizational relationships will greatly affect the adoption decisions by firms (Chan et al., 2012; Chong and Bai, 2014; Chong et al., 2009a).

Over the past decades, researchers have proposed various OELS adoption models which aim to guide firms towards successful OELS development and implementation. However, the key limitation of the traditional models is the focus on explaining OELS adoption from a single adopter's behaviour, or multiple single adopters' behaviour in game theory models (Lyytinen and Damsgaard, 2011). The key missing link in OELS adoption studies is the failure to recognize that adoption and development are influenced by clusters of adopters participating in a supply chain network. Furthermore, the value of OELS to the firm is highly dependent on other firms using it as well, and therefore network effects and inter-organizational relationships play

important roles in understanding OELS adoptions. Because the adoption of OELS requires the collaboration and mutual information sharing among different participants, the hybrid and complex forms of inter-organizational interactions will influence the complexity of OELS adoption. Therefore, it is important to develop an integrated framework incorporating network structures and inter-organizational relationships for the analysis of OELS adoption.

Despite OELS' promise, it still suffers from low adoption and slow development progress. Academics are concerned that there are inadequate theoretical models and frameworks to understand and manage OELS adoptions (Robey et al., 2008). Without a good understanding of successful OELS adoption conditions, it will result in missed business opportunities caused by poor supply chain integration, and lead to inefficient government economic policies.

1.3. Research Questions and Objectives

OELS are currently at a crucial stage of survival. OELS' development and implementation growth are very slow despite investments and efforts by government and industries. OELS failure will prevent the achievement of a global supply chain network envisioned by governments and the manufacturing industry. This research aims to revive OELS' development and implementations, a technology that has shown great promise, only to be hindered by the lack of participation and adoptions by firms. To facilitate the digitalization process of manufacturing industry, this study aims to provide a scientific study to understand the conditions which improve the development and adoption of OELS. To achieve this objective, this study sets up to develop and test a research model that can perform the following tasks:

- Understand the factors facilitating/prohibiting the diffusion of OELS.
- Compare the differences between potential adopters and current adopters in terms of the factors affecting OELS diffusion.
- Develop and define factors pertinent to the context of OELS diffusion.
- Understand the impacts of OELS diffusion on adopters.

A research model that is able to explain these conditions will revive interest in OELS by the manufacturing industry.

This research is motivated by the following questions: What determines the diffusion of OELS, and how can OELS be successfully implemented in the manufacturing industry? Specifically, the following research questions will be answered:

- To what extent do external network properties affect the adoption of OELS?
- What are value creation mechanisms of OELS? How are they different from traditional EDI?
- What are the differences in the factors affecting the adoption and diffusion of OELS among the potential and current OELS adopters?

Despite OELS' promise, it still suffers from low adoption and slow development progress. Academics are concerned that there are inadequate theoretical models and frameworks to understand and manage OELS adoptions. Without a good understanding of successful OELS adoption conditions, it will result in missed

business opportunities caused by poor supply chain integration, leading to inefficient government economic policies.

1.4. Research Methodology

This study has collected data from manufacturing companies operating in Mainland China using a self-report survey instrument which was carefully developed following existing guidelines and exemplars (Straub, 1989; Sethi and King, 1994). China is considered as an ideal environment to study IOS and supply chain management because of the growing efforts devoted by Chinese companies in deploying IOS to integrate partners within their global supply chains (Huo et al., 2014; Liu et al., 2016). To collect data from both the potential adopters and adopters of OELS, this study prepared two versions of questionnaire. The respondents were asked to identify the type of IOS their companies are implementing before they were provided with the appropriate version of questionnaire to fill in. The group of potential adopters was identified to be those companies in the pre-adoption period who were employing traditional EDI systems for inter-firm integrations; the adopters were those companies in the post-adoption adoption period who had adopted OELS to integrate business processes and share information across organizational boundaries.

1.5. Definitions of Terms

Internal assimilation: the extent to which OELS have been used to support internal supply chain operation practices.

External diffusion: the extent to which OELS has been used to facilitate inter-organizational activities with supply chain partners.

Product complexity: the amount of information that is required to describe the attributes and specifications of a product.

Product specificity: the extent to which a product is designed or tailored for a specific company that cannot be readily utilized by other companies.

Environmental turbulence: the endogenous uncertainty or risk occurring within the supply chain networks that may impact the relationships between a firm and its partners.

Market turbulence: the heterogeneity and the rapid variations in the composition of customers and the preferences of such customers.

Technology turbulence: the speed of changes in technology over time in the principal industry a firm operates in and the consequences these changes may have for the industry.

Tie strength: the extent to which a firm and its partners are structurally and relationally tied in their supply chain relationships.

Structural strength: the intensity and frequency of interactions among supply chain partners and the diversity of their interactions.

Relational strength: the level of mutual trust, support and reciprocation among supply chain partners.

Bonding mechanism: the extent to which OELS can increase the depth and efficiency of inter-organizational collaboration.

Bridging mechanism: the capabilities of OELS to enrich a firm's perspectives and knowledge base by enabling it to gain access and insights into broader environments.

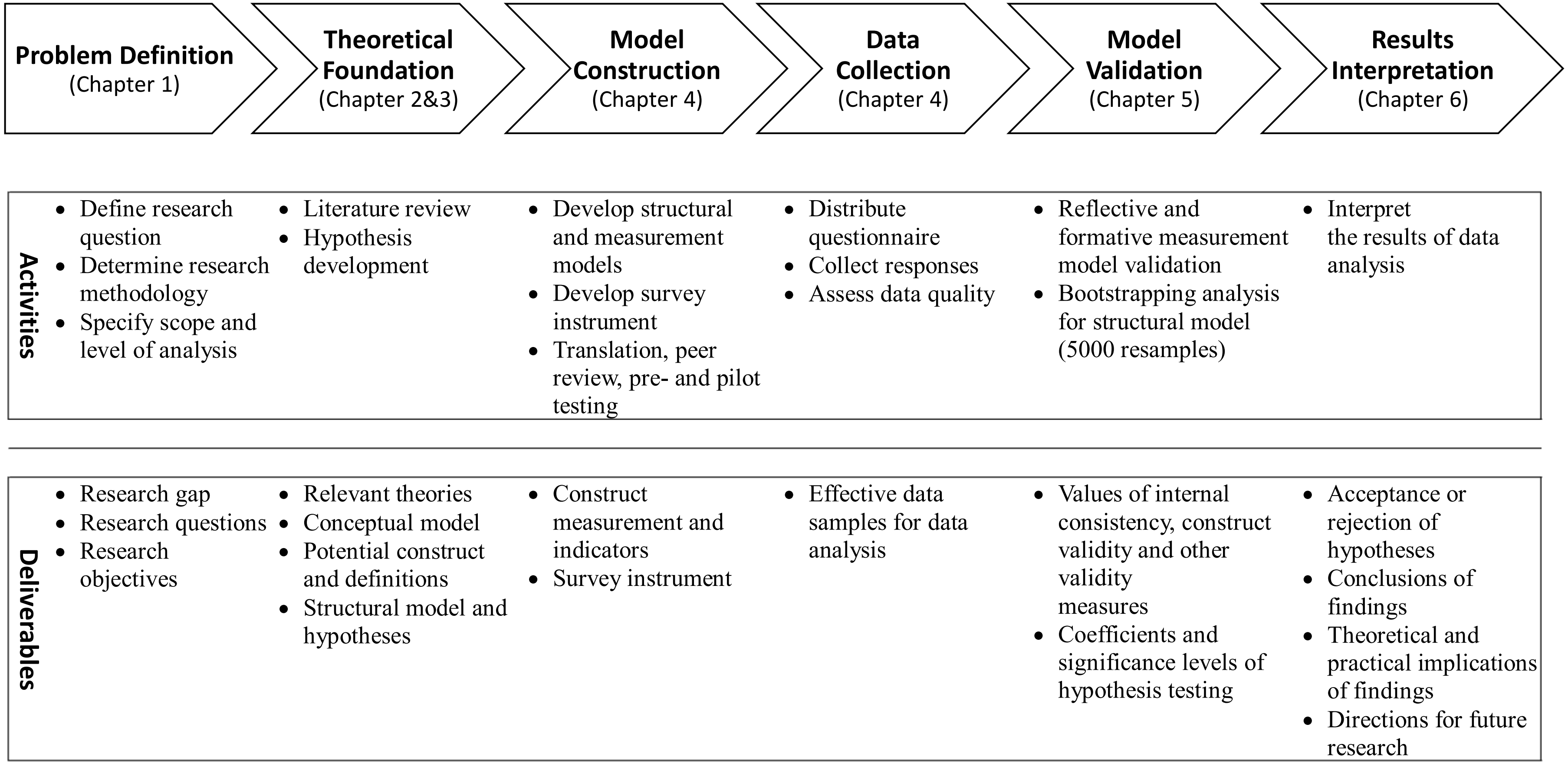
Process coupling: the extent to which OELS can facilitate the coordination and joint optimization of activities between a firm and its supply chain partners.

Process adaptability: the capability of OELS to promote organizational responsiveness to the changes in the external environment through reconfiguring and adjusting supply chain relationships and activities.

Relationship flexibility: the extent to which OELS can enhance a firm's ability to change or adjust its supply chain network through adding more partners.

1.6. Thesis Structure

This thesis is organized as follows. Chapter 2 reviews the literature investigating the antecedents to and outcomes of IOS adoption and assimilation, and derives directions for future studies. Chapter 3 establishes the theoretical backgrounds and conceptual framework of this study, based on which the hypotheses and research model were developed for further analysis. An empirical study was conducted to validate the research model, the methodology of which is detailed in Chapter 4. The procedures of data analysis and the results of hypothesis testing are discussed in Chapter 5. Chapter 6 summarizes the research findings and discusses the theoretical and practical implications of this research. The limitations of this study and the implications of future study are also addressed in Chapter 6. Figure 1-1 displays the structure of this thesis and summarizes the activities and deliverables of each chapter.



Source: Adapted from Urbach and Ahlemann (2010)

Figure 1-1. Thesis Structure

1.7. Summary

The most respected manufacturing firms are those that have a tightly integrated, collaborative supply network. OELS facilitate electronic integration and information sharing in the supply chain. OELS' importance has been recognized by both manufacturing industries and the government. Despites OELS' importance, there remain concerns about OELS' slow development progress and low adoption rates. The potential failure of OELS represents a significant stumbling block for governments and supply chain practitioners who have envisioned a globalized supply chain network electronically enabled by OELS. This chapter highlights the importance of investigating the factors affecting adoption of OELS, and identifies the research objectives of this research to develop a comprehensive model examining OELS adoption.

CHAPTER 2. LITERATURE REVIEW

The second chapter presents a comprehensive review of IOS adoption literature to identify the research issues. IOS adoption literature is the interaction of the inter-organizational systems stream and innovation diffusion literature stream. This chapter will first describe the methodology and selection criteria for conducting literature survey. Next the studies investigating the antecedents to IOS adoption will be reviewed, which will synthesize and integrate prior IOS adoption models and identify the most frequently studied antecedents and adoption variables, and the most popular theoretical frameworks. This chapter will further review the studies examining the organizational consequences of IOS adoption and summarize the influences of IOS diffusion from past studies. Finally, based on the results from the literature review, the last section will analyse the findings and identify research issues and gaps from future study.

2.1. Literature Review Methodology

The research on IOS is a cross-discipline topic. Therefore, literature review should not be conducted limited to only a handful of selected journals. Studies of IOS can be identified in journals under the fields of information systems, business and management, operations and supply chain management, and engineering (Tsiga and Chong, 2016). Following Ngai and Gunasekaran (2007), this study searched IOS literature from a list of selected online databases (see Table 2–1). The search efforts also extended to include the proceedings of the prestigious information systems conferences, e.g., International Conference on Information Systems (ICIS), Pacific Asia Conference on Information System (PACIS), Americas Conference on

Information Systems (AMIS), and European Conference on Information Systems (ECIS).

Table 2–1. Selected Databases for IOS Literature Review

No.	Databases	Related Subjects
1	ABI/INFORM	Business and management
2	Academic Search Premier	Business, science, medicine, and various subjects
3	ACM Digital Library	Computer science
4	Business Source Premier	Accounting, business, economics, management
5	Emerald Fulltext	Marketing, human resources, quality management, information management, library and information services, training and education, general management, property, operations, production and economics, engineering
6	IEEE Xplore	Physics, engineering, computer science
7	Inderscience Publishers	Environmental, healthcare, management, technical
8	Ingenta Journals	Business, computing, engineering, education, science, social sciences
9	Kluwer Online	Accounting, biotechnology, business and management, chemistry, computing, economics, education, engineering, environmental science and technology, life sciences, mathematics, medicine and nursing, humanities, physics, and astronomy
10	Science Direct	Chemistry and chemical engineering, clinical medicine, computer science, earth and planetary sciences, economics, business and management science, environmental science and technology, life sciences, materials science, mathematics, physics and astronomy, social sciences
11	Springer Link Online Libraries	Business, science, engineering, medical and social sciences
12	Wiley InterScience	Business, science, engineering, medical and social sciences

Source: Ngai and Gunasekaran (2007)

In a similar vein to Robey et al. (2008), keyword searching was combined with visual inspection of abstracts to search the relevant literature. The descriptors and keywords used to search the databases were *inter-organizational, information systems, e-business, e-marketplace, open standards, consortium, b2b, supply chain management, logistics, RosettaNet, XML, ERP*. Studies with titles suggesting a research focus on IOS were inspected by reading their abstracts to determine whether they were relevant even though they were not identified during the keyword search. The citation index

and references of the literature identified from the database search and abstract inspection were reviewed for the purpose of finding more relevant literature (Tsiga and Chong, 2016).

Because of the focus of the study on OELS, the literature search did not include studies on EDI. Although both OELS and EDI are IOS solutions for enterprises, the considerations and impacts related to EDI are very distinct from those of OELS because of EDI's proprietary nature (Zhu et al., 2006a). The literature on EDI, therefore, may provide little relevance for the study of OELS. This study primarily focused on the literature post the EDI era, i.e., when the internet and open standards had begun to play a major role in IOS. An extensive review of the literature on conventional IOS published between 1990 and 2003 is provided in Robey et al. (2008). The scope of this literature review only included studies published between 2003 and 2017, and those with a focus on **IOS based on open standards or the internet**, e.g., RossetaNet, eSCM, and XML.

The literature review was restricted to empirical studies by excluding theory development papers (e.g., Zhao et al., 2005; West, 2006; Kreuzer et al., 2014), literature reviews (e.g., Tsiga and Chong, 2016), mathematical models (e.g., Weitzel et al., 2006; Zhao et al., 2007), and design science research (e.g., Markus et al., 2006). Empirical research is more relevant to demonstrate how the choice of theoretical frameworks may guide the research findings. In addition, it is explained that in non-empirical studies, the influence of the theories is not validated by rigorous research practice (Robey et al., 2008).

The IOS literature can be classified into three main streams that investigate: 1) the antecedents affecting the adoption and assimilation of IOS; 2) the impacts of IOS on the market and organizational governance mechanisms; and 3) the organizational outcomes of IOS (Robey et al., 2008). Considering the focus of this study is on the antecedents and outcomes of OELS, studies focusing on the impacts on market and organizational governance structures were not included (e.g., Choi et al., 2017).

The search and selection yielded 26 studies on IOS based on open standards and/or the internet, among which, 13 of them investigated the antecedents to adoption and assimilation of IOS, 12 of them focused on the organizational outcomes of IOS adoption, and only one study (i.e., Venkatesh and Bala, 2012) took a longitudinal approach that examined both the antecedents to and outcomes of OELS.

2.2. Review of IOS Adoption Studies

Studies investigating the antecedents to open standards adoption mainly draw theoretical foundations from *institutional theory* (Son and Benbasat, 2007; Bala and Venkatesh, 2007; Liu et al., 2010; Venkatesh and Bala, 2012; Sodero et al., 2013), the *technology-organization-environment (TOE)* framework (Chong and Ooi, 2008; Venkatesh and Bala, 2012), *transaction cost theory* (Son and Benbasat, 2007; Chong et al., 2009a), and Roger's *diffusion of innovation theory* (Chong and Ooi, 2008; Lin et al., 2012). A summary of the antecedents and findings for literature studying the adoption of open standards based IOS is presented in Table 2– . In addition, Figure 2–1 concludes the antecedents that have been examined in past literature.

Table 2–2. Literature Review: Antecedents to IOS

Paper	Sampling Frame	Sample Size	Theories	Dependent Variables	Independent Variables	Findings
Venkatesh and Bala (2012)	Longitudinal dyadic data from firms in high-tech industries considering adopting RosettaNet	127	• TOE • Inter-organizational theory – Embeddedness Theory – Learning mechanism – Influence mechanisms	• IBPS adoption (no. of PIPs * the extent of use of PIPs)	**Firm-specific/Partner-specific/Synergistic Factors:** • Technological (Expected benefits, process compatibility, standards uncertainty, technological readiness) • Organizational (organizational innovativeness) • Environmental (Relational Trust)	• Process compatibility, standards uncertainty and technology readiness have significant synergistic effects on IBPS adoption. • Expected benefits, relational trust and organizational innovativeness do not have significant synergistic effects affecting IBPS adoption. • Expected benefits and relational trust have significant positive effects on IBPS adoption.
Zhu et al. (2006a)	Executives who were the best qualified to provide information for the firm's overall activities in 10 economies	1394	• Network Effect • Path Dependency Theory	OSIOS Adoption (Breadth, Volume, Depth)	• Network Effects: – Trading community influence – Peer Adoption • Expected Benefits • Adoption Costs: – Financial Costs – Managerial complexity – Transactional Risk – Legal Barriers • Moderator: Prior Use of EDI	• Network Effects and expected benefits are significant facilitators of OSIOS migration. • Adoption costs are significant inhibitors of OSIOS adoption. • EDI users are sensitive to switching costs while EDI non-users are non-sensitive to adoption costs.

Table 2–2. Literature Review: Antecedents to IOS (Continued)

Paper	Sampling Frame	Sample Size	Theories	Dependent Variables	Independent Variables	Findings
Son and Benbasat (2007)	Two versions of questionnaires for members of PMAC who are current adopter or potential adopter of B2B e-marketplaces	• 92 potential adopter • 80 current adopter	• Transaction Cost Theory • Institutional Theory	• Participation Level • Adoption Intention	**Efficiency-oriented factors:** • Product characteristics: – Asset specificity – Complexity of products • Demand uncertainty: – Frequency uncertainty, – Volume uncertainty • Market volatility **Legitimacy-oriented factors:** • Mimetic pressures • Coercive pressure • Normative pressures	• Demand uncertainty has a significant negative effect on participation level and adoption intention. • Asset specificity and product complexity have significant negative effects on e-marketplace participation levels but not on adoption intention. • Market volatility has significant and positive effects on participation level but not on adoption intent. • Mimetic and normative pressures have significant positive influence on adoption intention but not on the participation levels. • Coercive pressures do not influence neither participation level nor adoption intention.
Sodero et al. (2013)	• Firm-level data from RosettaNet consortium, and Compustat • Industry-level data from the Bureau of Labour Statistics	• 81 users • 740 non-users	Institutional theory	• Firm OSIOS assimilation: – Breadth – Diversity – Depth • Outcomes: – Firm supply chain dominance (relative market share)	• Competition asymmetry across supply chain echelons (Herfindahl-Hirschman index) • OSIOS assimilation within echelon-exponential: – Breadth – Diversity – Depth • Firm supply chain dominance (relative market share)	• Competition asymmetry, OSIOS assimilation within supply chain, and firm supply chain dominance have significant positive effects on OSIOS assimilation. • Firm-level OSIOS assimilation has significant positive effects on a firm's supply chain dominance. • Competition asymmetry has negative moderating effects on the relationship between OSIOS assimilation and supply chain dominance.

Table 2–2. Literature Review: Antecedents to IOS (Continued)

Paper	Sampling Frame	Sample Size	Theories	Dependent Variables	Independent Variables	Findings
Liu et al. (2010)	Senior executives of firms in manufacturing and service industries in China	131	Institutional Theory	Adoption Intention of eSCM	• Institutional Pressures: – Coercive – Normative – Mimetic • Organizational culture: – Flexibility orientation – Control orientation	• Normative and coercive pressures have significant positive influence on adoption intention while mimetic pressures have no significant influence on adoption intention. • Flexibility orientation negatively moderates the relationship between coercive pressures and adoption intention but does not moderate the relationship between normative pressures and adoption intention. • Control orientation positively moderates the relationships that normative and coercive pressures have with adoption intention. • Flexibility orientation positively moderates the relationship between mimetic pressures and adoption intention while control orientation negatively moderates the relationship between mimetic pressures and adoption intention.
Chong and Ooi (2008)	The managers and executives from the E&E manufacturing companies listed in FMM 2007	109 (50 adopters and 59 non-adopters)	• Diffusion of innovation (DOI) model • Technology-organization-environment (TOE) model	Adoption of RosettaNet: unaware, aware, interest, evaluation, commitment, limited deployment, and general deployment	• Trust • Partners' Power • Product Characteristics – Product complexity – Product volume – Transaction frequency • Government Influence	• Trust, partner power and product characteristics have significant positive impacts on the adoption of RosettaNet. • The effect of government influence is not significant.

Table 2–2. Literature Review: Antecedents to IOS (Continued)

Paper	Sampling Frame	Sample Size	Theories	Dependent Variables	Independent Variables	Findings
Nurmilaakso (2008)	IT managers in large companies and general managers in smaller companies conducted by e-Business W@tch	4570 companies from 25 European countries in 2003 5218 companies from seven EU countries in 2005	NA	• Adoption • Migration	• Size: number of employees • Scope: number of sites in one country • Skills: the percentage of employees with an university degree • EIS: indication of procession of ERP, SCM or CRM systems • Usage of EDI • Usage of EDI over VANs • Usage of EDI over the internet • Usage of XML e-business framework • Usage of other data exchange standards	• Scope, the number of enterprise information systems, use of standardized data, are positively associated with the number of e-business functions. • Firm size, company skills and number of e-business functions are positively associated with migration from EDI to XML-based e-business.
Chong and Bai (2014)	The IT or logistics heads of the SMEs listed in the Small and Medium Industries Development Corporation (SMIDEC)	136	NA	Adoption of RosettaNet	• Inter-organizational relationships: – Trust – Communication – Collaboration – Information sharing – Trading partners' power • Knowledge management: – Knowledge acquisition – Knowledge dissemination – Knowledge application	• Collaboration and information sharing are important determinants of the adoption of RosettaNet. • Communication has a significant negative effect on adoption. • Trust and partners' power are not significant in deciding on adoption. • Knowledge acquisition and knowledge application are positively associated with adoption. • Knowledge dissemination is negatively associated with adoption.

Table 2–2. Literature Review: Antecedents to IOS (Continued)

Paper	Sampling Frame	Sample Size	Theories	Dependent Variables	Independent Variables	Findings
Venkatesh and Bala (2007)	RosettaNet adopters	56 (41 potential adopters and 15 current adopters)	NA	IBPS adoption	• External – Institutional pressures – Standards uncertainty – Quality of inter-organizational relationships • Internal – Internal pressures – Job change – Technological readiness – ICT competence – Organizational culture • Instrumental – Perceived benefits – Process compatibility – Complexity	The various external, internal, and instrumental factors are identified to be the catalyst and inhibitors of IBPS adoption.
Lin et al. (2012)	National accredited hospitals in Taiwan	119	Innovation diffusion theory	HL7 adoption	• Push of environment – Environment pressure (mimetic pressures) • Pull of Environment – Top Management Attitude – Staff technology capability – System integrity (technology compatibility and complexity) – Information security – Organization (hospital) size	• Environmental pressure, system integrity, top management attitudes towards HL7, staff's technological capability, and hospital scale positively affect HL7 adoption. • System integrity is the most important facilitator.

Table 2–2. Literature Review: Antecedents to IOS (Continued)

Paper	Sampling Frame	Sample Size	Theories	Dependent Variables	Independent Variables	Findings
Bala and Venkatesh (2007)	Semi-structured interviews, documents provided by the IT departments and key informants, and other publicly available information about the adoption of RosettaNet	21 individuals from 11 firms	• Relational view of firm • Institutional theory • Organizational inertia theory	• Assimilation of IBPS: – Non-adoption – Adoption – Limited deployment – General deployment	• Relational Mechanisms: – Relational specificity – Relational depth – Relationship extendability • Influence Mechanisms – Coercive pressure – Mimetic pressure – Normative pressure • Inertial Mechanisms – Resource rigidity – Routine rigidity • Moderator: – Firm dominance	• For non-adopters (either dominant or non-dominant), there is a lack of relational mechanisms, institutional pressures, and resource rigidity as well as high routine rigidity. • Relational specificity and all three institutional pressures drive the non-dominant firms to adopt. • Relational depth and extendability as well as normative pressures drive the dominant firms to adopt IBPS. • Relational specificity and all three types of institutional pressures drive general deployment by non-dominant firms. • Relational depth, relationship extendability, and the willingness to overcome resource and routine rigidities lead to general deployment by dominant firms. • Lack of relational mechanisms, institutional pressures and high organizational inertia lead to only limited deployment by both non-dominant and dominant firms.
Ke et al. (2009)	Executives attending training programmes at a Chinese institute	134	• Institutional theory • Inter-organizational trust	• Adoption intention of eSCM	• Mediated power • Non-mediated power • Coercive pressures • Normative Pressures • Trust	• Coercive pressures have significant positive effects on exercised non-mediated power. • Normative pressures a have significant positive effects on non-mediated power. • Trust is negatively associated with exercised mediated power, and positively associated with non-mediated power. • Coercive pressures, normative pressures and trust are positively associated with eSCM adoption.

Table 2–2. Literature Review: Antecedents to IOS (Continued)

Paper	Sampling Frame	Sample Size	Theories	Dependent Variables	Independent Variables	Findings
Chong et al. (2009b)	Senior executive responsible for SCM in Malaysian E&E companies from FMM 2007 listed members	109 companies (53 local companies ; 53 MNCs; 18 joint venture)	Transaction cost Theory	E-Collaboration tools adoption level	• Supply chain factors: – Product complexity – Product volume • Transaction frequency	• Trust, product complexity, product volume, and transaction frequency are positively related to the adoption of e-collaboration tools.
Adebanjo and Laosirihongthong (2014)	ELM Guide Automotive Supplier Database ISO 14001 North American World Preferred Registry database	3152	Liability of foreignness theory	Dichotomous variable with value 1 if the automotive supplier facility had ISO 14001 that particular year	• Asset Specificity (degree of customization): – Sub-assembly supplier Production Generalization (number of suppliers producing the same part for each part that facility produces) • Age(logarithm number of years since the supplier company that owns the facility was founded): – Young supplier (taking the value of 1 for those facilities owned by companies that were six years old or younger by 2003)	• Asset specificity is positively related to ISO 14001 adoption. • Younger suppliers are more likely to adopt ISO 14001 than others older suppliers • Facilities reporting to the Toxic Releases Inventory (TRI) are more likely to adopt ISO 14001 • Experience with CMS and QS 9000 is positively related to ISO 14001 adoption. • Supplier facilities located in Canada are more likely to adopt than facilities located in the US. • Supplier facilities located in Mexico are less likely to adopt than facilities located in the US.

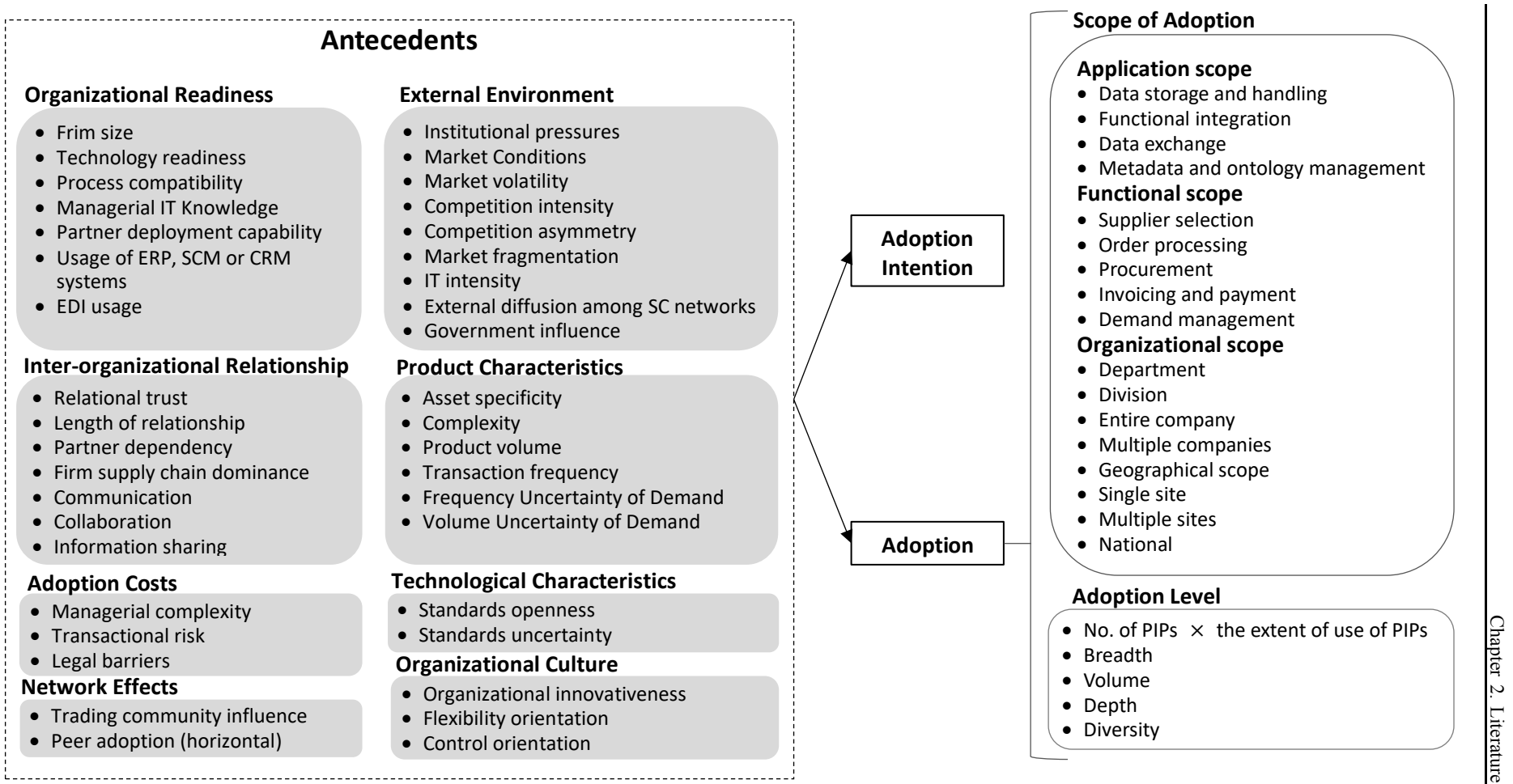


Figure 2-1. Factors Investigated in IOS Adoption Literature

Regarding the studies investigating the influence of **institutional forces**, the results are mixed. Bala and Venkatesh (2007) examine the power of institutional forces at different stages of the assimilation of RosettaNet in the high-tech industry. It is identified that normative pressures are important factors that lead to the adoption and general deployment in the dominant firms. In regard to non-dominant firms, all three types of pressures are equally important for the adoption and greater deployment of RosettaNet. The study of Son and Benbasat (2007) also supports the positive effects of mimetic and normative pressures on the adoption intention of B2B e-marketplaces. However, the influence of these two forces are not found to be significant on the participation level of B2B e-marketplaces. Coercive pressures have no influence on either the adoption intention of B2B e-marketplaces or on the participation level. The study of Liu et al. (2010) is consistent with the findings of Son and Benbasat (2007). Normative and coercive pressures have significant positive effects on adoption intention while mimetic pressures are not related to adoption intention. However, the positive effects of mimetic pressures are supported by Lin et al. (2012) where environmental pressure (i.e., mimetic pressures) are positively related to the adoption of HL7 among hospitals. The study of Sodero et al. (2013) also confirms the positive effect of open standard-based IOS (OSIOS) assimilation within the supply chain echelon (i.e., mimetic pressures) on the assimilation of OSIOS. The effects of coercive pressures (government influence) are not supported in the research of Chong and Ooi (2008).

Organizational readiness is the pull force of technology adoption. It includes not only the internal resources for the deployment of inter-organizational information systems, but also the readiness of the supply chain counterparties. It was found by Venkatesh and Bala (2012) that the synergistic effects of technological readiness as well as process compatibility between trading partners have a significant positive influence on the adoption of inter-organizational business process standards (IBPS). Other variables for organizational readiness that have positive effects on adoption include employee skills (Nurmilaakso, 2008; Lin et al., 2012), procession of ERP, SCM or CRM systems (Nurmilaakso, 2008), prior usage of EDI and other e-business standards (Nurmilaakso, 2008), system integrity, top management attitude, and organizational scale (Lin et al., 2012).

Technological factors include expected benefits, adoption costs, process compatibility, standards uncertainty (Zhu et al., 2006a; Venkatesh and Bala, 2012). It is found that the expected benefits of IBPS not only have direct positive influence on adoption, but also have synergic significant positive influence (Venkatesh and Bala, 2012). In a similar vein, the positive association between the expected benefits of OELS and its adoption is supported by Zhu et al. (2006a). Adoption costs include financial costs, managerial complexity, transactional risk and legal barriers. It was identified that adoption costs are significant barriers to OSIOS adoption (Zhu et al., 2006a).

Network effects and **path dependency** are also investigated by researchers. Network effects refer to the influence exerted on a product user by the other users consuming the same product, which expand the analysis of OELS adoption beyond individual entities to the peer firms in the same networks. According to Zhu et al. (2006a), there are two types of network effects – *trading community influence* and *peer adoption*. While trading community influence measures network effects from vertical networks, peer adoption measures the influence on horizontal environment. Network effects are identified to be key drivers of the adoption of OELS. Based on path dependence theory, a company's prior experience with EDI might have an influence on their decision to adopt OELS. Prior experience with EDI could either facilitate the adoption because of the experience with e-collaboration or prohibit the implementation because EDI systems have limited flexibility and will prevent companies from making further adjustments (Swanson, 1994). It is found that EDI users are highly sensitive to switching costs associated with adopting new IOS while EDI non-users are not sensitive to adoption costs. Therefore, because of path dependency, prior experience with EDI inhibits companies from migrating towards OSIOS from proprietary EDI (Zhu et al., 2006a).

Supply chain relationship factors including trust, collaboration, communication partner's power, product characteristics, and information sharing are also investigated (Chong and Ooi, 2008; Chong et al., 2009b; Chong and Bai, 2014). According to Chong and Bai (2014), collaboration and information sharing are important

determinants of the adoption of RosettaNet. However, communication has a significant negative effect on adoption. Trust and partner power are not significant in deciding the adoption of RosettaNet. Chong and Ooi (2008) found that trust, partner power and product characteristics are positively associated with adoption.

The review reveals that past studies on the adoption of OELS supports the relationships concerning the antecedents of IOS adoption that have been investigated in the classical innovation diffusion model. Therefore, it appears that OELS can be treated as the same as many other technologies and innovations. However, studies examining network effects and inter-organizational relationship factors show that there is a complex relationship between network characteristics and adoption as the realization of the benefits of OELS requires co-adoption by all supply chain participants.

2.3. Organizational Outcomes of IOS Assimilation

The literature review reveals that the studies on the organizational outcomes of IOS assimilation mainly focus on the operational performance, financial performance, strategic performance, and relationship value of IOS. The main constructs and relationships examined in the literature are summarized in Figure 2-2, and Table 2– summarizes the research models and findings of the selected studies.

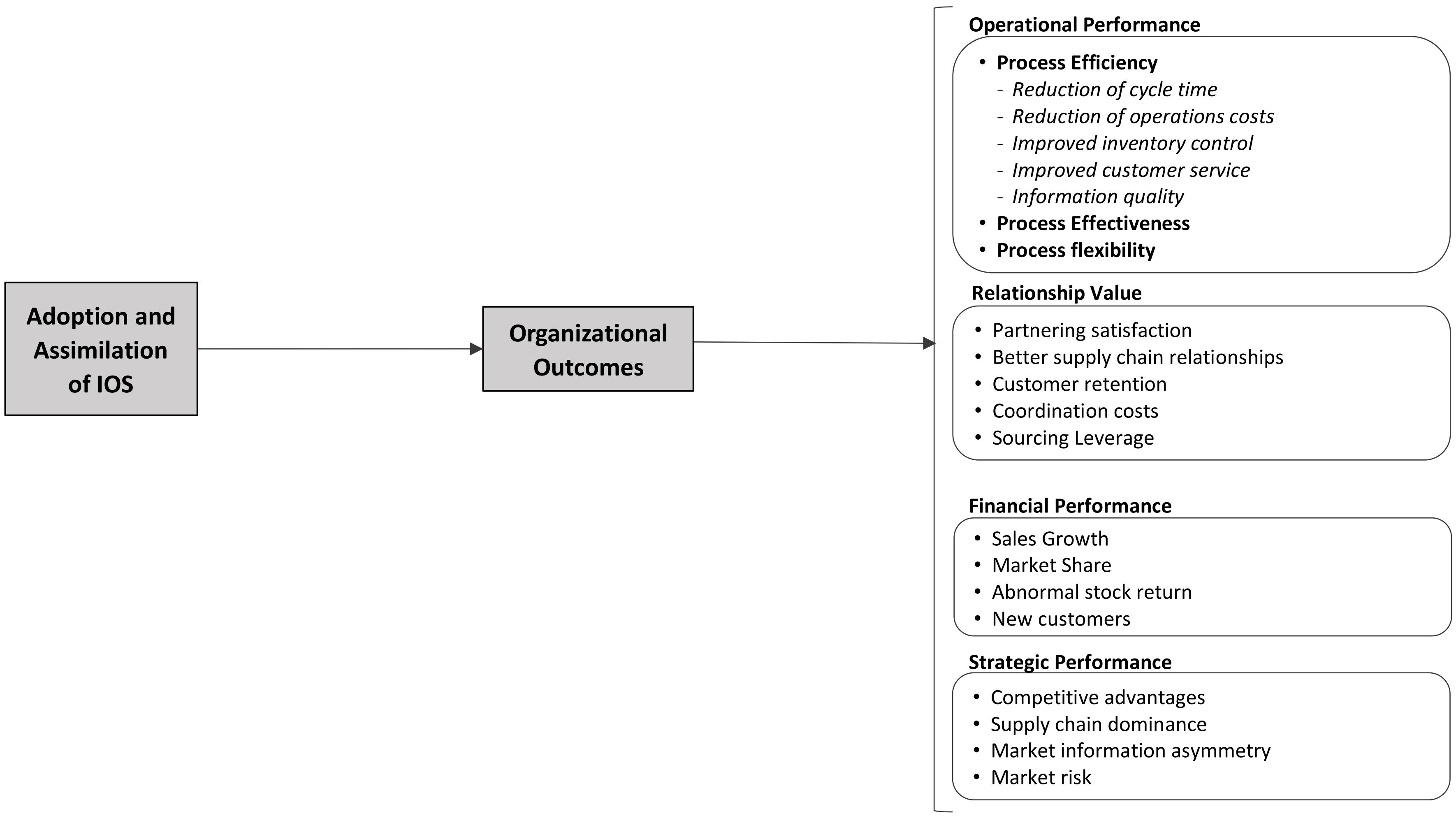


Figure 2-2. Organizational Outcomes of IOS Assimilation

Table 2–3 Literature Review: Organizational Outcomes of IOS Assimilation (

Paper	Sampling Frame	Sample Size	Theories	Dependent Variables	Independent Variables	Findings
Chang (2003)	Managers in charge of RosettaNet development in member companies of the RosettaNet consortium, and also top information systems executives at US semiconductor companies which expressed interest in joining RosettaNet consortium	• 27 RosettaNet member • 16 potential members	Balance scorecard framework	**Value components:** • Direct technology value – Connection benefits – Platform Benefits – IT personnel benefits – Indirect technology value – Learning benefits – Network benefits • Direct process value – Cycle time reduction – Information quality – Interest benefits(early invoicing) • Indirect process value: – Inventory costs – Capacity utilization – Product performance **Relationship improvement** • Customer satisfaction • Customer retention • Coordination costs • Quality of offering • Better price **Market Performance** • Improved market share • Increase sales • Attract new customers	• IT environment: – Technology readiness (IT integration level; level of EDI use) • Process characteristics: – Trading volume and frequency – Product complexity • Trust • Market conditions: – Market power – Market fragmentation **Moderators:** • Stages of SC collaboration: – Penetration level – Scope of sharing	• Non-adopters require a greater level of corporate technology readiness to have a positive outcome • Trading volume and frequency is more favourable to the performance of supply chain collaboration as companies implement a larger scope of process sharing • Product complexity is more favourable for the performance of supply chain collaboration as companies implement smaller scope of process sharing • The positive influence of trust on the performance of supply chain collaboration is enhanced by the scope of process sharing • The negative influence of market fragmentation on collaboration performance increases with the penetration of process sharing

Table 2–3 Literature Review: Organizational Outcomes of IOS Assimilation (Continued)

Paper	Sampling Frame	Sample Size	Theories	Dependent Variables	Independent Variables	Findings
Chang and Shaw (2009)	RosettaNet members and users in 2003	127	The process-oriented view	**Second-order Business Value:** • Firm Level Performance: – Sales Growth – Market Share	**First-order Business Value:** • Business Value of Process Sharing – Supplier/Customer Relationship Value – Direct & Indirect Process Value – Direct & Indirect Technological Value **Moderating Variables:** – Supply chain Collaboration Level (deployment levels of RosettaNet PIPs)	• Direct technological value, direct/indirect process value and relationship value are positively related to firm performance. • Process value was found to be more important than technological value. • Indirect technological value was found to have an insignificant relationship with firm performance. • Collaboration level moderate the effects of direct technological value and direct/indirect process value, but does not moderate the effects of indirect technological value and relationship value.
Benlian and Hess (2009)	Firms in German Publishers and Booksellers Association	201	Process theory	Perceived cost effectiveness	• Process standardization • Process automation • XML usage intensity	• XML usage intensity, process standardization, process automation have a positive effect on perceived cost-effectiveness. • No moderating effects of process standardization and process automation on the relationship between XML usage intensity are found. • The effects of XML usage intensity on perceived cost-effectiveness are mediated through process standardization and process automation.

Table 2–3 Literature Review: Organizational Outcomes of IOS Assimilation (Continued)

Paper	Sampling Frame	Sample Size	Theories	Dependent Variables	Independent Variables	Findings
Zhang and Dhaliwal (2009)	Companies listed on the China Stock Exchange Directory	101	• Institutional Theory • Resource-based View	• Internal assimilation • External Diffusion • Impact of e-business on firm performance: – Operational improvement; – Strategic Improvement	• Managerial IT Knowledge • IT deployment capability • Partner deployment capability • Partner dependence • Competition intensity • IT usage intensity (the extent of IT usage by industry participants)	• Managerial IT knowledge and partner dependence are positively associated with internal assimilation. • IT intensity and partner dependence are positively associated with external diffusion. • External diffusion has positive effects on internal assimilation • Both internal assimilation and external diffusion have significant positive effects on operational improvement, which in turn positively affects strategic improvement of performance.
Aggarwal et al. (2006)	• Announcement of XML schema initiatives by Lexis-Nexis • CRSP • Compustat	148 firms announced XML schema initiatives between 1999 and 2003	NA	• Cumulative standard abnormal stock return	• Dummy indicating openness of XML schema • Control Variables: – Firm size (Annual sales); – Industry (dummy indicating whether a firm is in the software industry • Dummy indicating whether company adopt a schema only or adopt an IT product with a schema	• Firms obtain positive abnormal returns on stock price from the announcement of XML schema initiatives. • However, no abnormal returns were gained from open XML schema standardization. Markets prefer proprietary XML schema than open schema. • The abnormal returns to the announcement of XML schema did not change over time.

Table 2–3 Literature Review: Organizational Outcomes of IOS Assimilation (Continued)

Paper	Sampling Frame	Sample Size	Theories	Dependent Variables	Independent Variables	Findings
Aggarwal et al. (2011)	• Public announcements of standard-setting initiatives by Lexis-Nexis (1996 - 2005) • Market return data from CRSP • Total sales data from Compustat	196 unique firms	• NA	• Risk adjusted return • Market risk • Idiosyncratic risk	• Number of firms participating in a standard-setting initiative • Moderating variable: firm size	• The more firms involved in a standard-setting initiative, the less risk-adjusted abnormal return a participating firm's shareholders receive, but the absolute effect is smaller for larger firms. • The more firms involved in a standard-setting initiative, the less market risk a participating firm's shareholders must bear, but the absolute effect is smaller for larger firms. • The more firms involved in a standard-setting initiative, the more idiosyncratic risk a participating firm's shareholders must bear, but the absolute effect is less for larger firms.
Zhang et al. (2016)	Firms listed in China Stock Exchange's Listed Company Directory	101	The asset orchestration perspective	• Operational improvement • Competitive performance	• Depth of IOS deployment • Breadth of IOS deployment • Balanced alignment between IOS depth and breadth • Reinforcing alignment between IOS depth and breath	• IOS depth and breadth directly lead to operational improvement, which in turn improves competitive performance • Balanced alignment between IOS depth and breadth directly improves competitive performance while reinforcing alignment between depth and breadth has no effect on competitive performance

Table 2–3 Literature Review: Organizational Outcomes of IOS Assimilation (Continued)

Paper	Sampling Frame	Sample Size	Theories	Dependent Variables	Independent Variables	Findings
Wu and Chang (2012)	Manufacturing and service firms listed on the Taiwan Stock Exchange Corporation	127	• Innovation diffusion theory • Balanced scorecard framework	• Learning and growth • Business process performance • Customer performance • Financial performance	• eSCM diffusion – Adoption – Internal Diffusion – Enteral Diffusion	• Adoption has a significant positive impact on learning and growth performance and business process performance • Internal diffusion has a significant positive impact on learning and growth, business process, and customer performance • External diffusion is positively related to all four performance aspects
Benlian and Hess (2010)	Firms in the publication industry; senior - most IS executive of firms from the database of Association of German Publishers and Booksellers	188	Innovation Diffusion Theory	**Business process outcomes:** weighted average of process efficiency; process effectiveness; process flexibility	• Extent of XML implementation – Application scope – Functional scope – Organizational scope – Geographical scope **Moderators**: • XML-related knowledge • Business process radicalness (second order): – Business process complexity – Business information intensity	• Extent of XML implementation has a significant positive impact on business process outcomes. • Business process radicalness and XML-related knowledge positively moderate the relationship between the extent of XML implementation and business process outcomes.

Table 2–3 Literature Review: Organizational Outcomes of IOS Assimilation (Continued)

Paper	Sampling Frame	Sample Size	Theories	Dependent Variables	Independent Variables	Findings
Saeed et al. (2005)	Survey of vice presidents of manufacturing or operations of companies in the rubber, plastics, and metal fabrication industries	38 companies established electronic links with suppliers	Transaction cost economics	• Process Efficiency • Sourcing Leverage	• External Integration – IOS Breadth – IOS Initiation • Competitive Intensity • Product Characteristics • Control variables: – Internal Integration	• The extent of external integration and the extent of IOS initiation are have positive impacts on process efficiency. • IOS breadth and IOS initiation are positively related to sourcing leverage. • External integration is not associated with sourcing leverage. • Companies in highly competitive environments and which produce standardized products have greater external integration and process efficiency than firms in low competitive environments and producing customized products.
Venkatesh and Bala (2012)	Longitudinal dyadic data from firms in high-tech industries	127	• TOE • Inter-organizational theory – Embeddedness Theory – Learning mechanisms – Influence mechanisms	• Operational efficiency (reduction of cycle time) • Relationship quality (partnering satisfaction - collected six months after RosettaNet adoption)	• IBPS adoption (no. of PIPs * the extent of use of PIPs)	• IBPS adoption was found to have a significant negative effect on cycle time and a significant positive effect on partnering satisfaction. • IBPS adoptions mediate the relationships between the TOE factors and the IBPS outcomes.

Table 2–3 Literature Review: Organizational Outcomes of IOS Assimilation (Continued)

Paper	Sampling Frame	Sample Size	Theories	Dependent Variables	Independent Variables	Findings
Yoon et al. (2011)	• Public companies in Korea from Dec. 2007 to Aug. 2007, and from Dec. 2007 to Aug. 2008	550	NA	• Information asymmetry in capital market (relative spread)	• Adoption of XBRL • Firm size • Turnover rate • Volatility • Stock price	• XBRL adoption is negatively associated with information asymmetry. • Firm size positively moderate the effect of XBRL adoption.
Malhotra et al. (2007)	Adopters of RosettaNet	41	Inter-organizational relationship perspective	• Mutual adaptation • Adaptive knowledge creation	• Use of SEBIs • Mediator: Collaborative information exchange	• The use of SEBIs directly improves mutual adaptation and collaborative information exchange • Collaborative information exchange mediates the effect of the use of SEBIs on mutual adaptation and adaptive knowledge creation

Various theoretical frameworks have been applied to investigate the impacts of IOS adoption, which include the *process-oriented view* (Chang and Shaw, 2009), *process theory* (Benlian and Hess, 2009), *the balanced scorecard framework* (Chang, 2003; Wu and Chang, 2012), *institutional theory* (Zhang and Dhaliwal, 2009), *resource-based view* (Zhang and Dhaliwal, 2009), the *asset orchestration perspective* (Zhang et al., 2016), the *innovation diffusion theory* (Benlian and Hess, 2010; Wu and Chang, 2012), the *transaction cost economics* (Saeed et al., 2005), and *inter-organizational theory* (Malhotra et al., 2007; Venkatesh and Bala, 2012).

According to Chang and Shaw (2009), the performance impacts of IOS adoption and assimilation can be categorized into *first-order* and *second-order* business values. The first-order performance impacts refer to the immediate influence of IOS technologies on business processes and supply chain relationships. The second-order performance impacts are concerned with broader organizational performance, e.g., market share and competitive advantage. It may take a long period of time for firms to obtain second-order benefits from IOS implementation. It is shown that second-order performance values can be derived from the immediate first-order performance impacts from IOS technologies (Chang and Shaw, 2009). Operational performance and relationship value can be classified as first-order impacts of IOS on business operations and supply chains, while strategic performance and financial performance represent the second-order values resulting from IOS adoption.

Operational performance refers to an improvement in supply chain processes and operations, such as reduction of cycle time, and enhanced information quality and inventory control. A number of studies have reported that IOS adoption can lead toimproved operational performance (Chang, 2003; Benlian and Hess, 2009; Zhang and Dhaliwal, 2009; Zhang et al., 2016; Benlian and Hess, 2010; Saeed et al., 2005; Venkatesh and Bala, 2012; Wu and Chang, 2012). Cycle time reduction, informationquality and interest benefits are identified to be the direct operational impacts of IOS adoption while inventory costs, capacity utilization and product performance are the indirect operational impacts. Compared with potential adopters, existing adopters of IOS tend to place more importance on operational performance (Chang, 2003). Several studies show that IOS assimilation can lead to improvements in operational and process performance (Zhang and Dhaliwal, 2009; Wu and Chang, 2012; Zhang et al., 2016). Saeed et al. (2005) found that external integration through IOS is positively related to process efficiency. In addition, the implementation of XML is revealed to have positive impacts on process efficiency, process effectiveness and process flexibility. Furthermore, higher intensity of XML usage will enhance process standardization and process automation, which in turn will improve cost-effectiveness (Benlian and Hess, 2009). Venkatesh and Bala (2012) found that the adoption of OELS will improve operational efficiency by reducing the cycle time.

Relationship value refers to the influence of IOS adoption on the inter-organizational relationship structure and relationship quality (Robey et al., 2008). The integration and flexibility capabilities of IOS can facilitate inter-firm relationships by enhancing process coupling and knowledge sharing (Saraf et al., 2007). It is indicated that the potential adopters of IOS emphasize relationship value to a greater extent. The influence of inter-organizational trust on collaboration performance is positively moderated by process sharing via IOS (Chang, 2003). The breadth of IOS implementation can help a firm gain sourcing leverage over its supply chain partners through reducing search costs and enhancing market transparency (Saeed et al., 2005). The internal and external diffusion of IOS are positively associated with customer performance (Wu and Chang, 2012). In addition, OELS adoption can enhance relationship quality by improving partnering satisfaction (Venkatesh and Bala, 2012). Malhotra et al. (2007) draw on an inter-organizational relationship perspective and show that the assimilation of OELS can directly improve mutual adaptation and collaborative information exchange between supply chain partners, the impacts of which are mediated by collaborative information exchange. The results suggest that in the context of OELS, bridging and bonding effects interact together to affect adaptiveness in inter-organizational relationships. Although supply chain partners can develop high levels of bonding by sharing broad and private information, without implementing OELS, they will be faced with inadequate bridging to connect and explore each other's knowledge bases.

Strategic performance refers to the effects of IOS on an organization's market position as well as competitive position relative to major competitors. It is recognized that internal assimilation and external diffusion of IOS have significant positive effects on operational improvement, which in turn lead to strategic improvement (Zhang and Dhaliwal, 2009). To obtain competitive performance from IOS adoption, organizations need to deploy a balanced alignment between IOS depth and breadth (Zhang et al., 2016). Open standards can effectively reduce the level of information asymmetry in the market, especially for large companies (Yoon et al., 2011). It is highlighted that the number of participants is critical for the success of an open standard initiative. A greater number of firms involved in a standard-setting initiative will result in less market risk for a participating firm to bear. However, a firm must bear greater idiosyncratic risk when there are more firms involved in a standard-setting initiative (Aggarwal et al., 2011).

A more explicit question that most companies are concerned with is whether IOS adoption can lead to direct **financial performance**, e.g., market share, sales, and stock prices. Several studies provide evidence supporting a direct relationship between IOS adoption and financial returns (Chang and Shaw, 2009; Aggarwal et al., 2006; Wu and Chang, 2012). It is suggested that by providing technological, process, and relationship value, open standards can lead to sales growth and an increase in market share. The effects of technological and process value on financial performance will be greater when a firm deploys open standards to a greater extent (Chang and Shaw, 2009). By studying equity market data, Aggarwal et al. (2006) showed that firms can obtain

positive abnormal returns on stock prices from the announcement of an open standard initiative, and abnormal returns will be sustained over time. (Wu and Chang, 2012) highlight that to capture financial improvement from IOS technologies, a company must not be restricted to the adoption and internal diffusion of IOS. Only external diffusion can lead to financial improvement.

2.4. Conclusions and Directions for Future Research

IOS based on open standards and the internet have attracted the attention of both practitioners and academics. We believe that OELS are becoming increasingly pervasive. The literature review identified 26 articles on IOS technologies based on open standards and the internet published between 2003 and 2017. The results presented in this section have several important implications:

- There have been a thrust of work investigating the antecedents to IOS adoption. Among them, a large part of the studies focus on the adoption intention of potential adopters. The investigation of the factors affecting IOS adoption has been limited because of DOI's relatively generic typology of technology properties. Prior studies treat IOS in a way that there are no distinctive characteristics of IOS that are different from other technologies (Robey et al., 2008). It is important to focus on the properties of the IOS artefact to generate a more complete understanding of IOS adoption.

- There lacks an awareness that IOS are network systems and the network structures in which IOS are embedded play significant roles in shaping the capabilities and

influence of IOS (Tang et al., 2011; Kreuzer et al., 2014). Although recent studies focusing on network externalities have expanded beyond the classical theoretical models and revealed more complex associations between network properties and IOS adoption (Robey et al., 2008; Zhu et al., 2006a; Weitzel et al., 2006), the perspective that network structures can have significant influence on IOS and related organizational behaviours is still not very evident in the literature (Tang et al., 2011).

- The analysis of the consequences of IOS indicates that generally IOS adoption is positively associate with the first-order and second-order organizational performance. Most studies focus on the operational and relational value that companies can garner from IOS adoption.

In addition to the above implications, the following suggestions are offered for further research in OELS:

- The review of the literature has revealed several cross-disciplinary research addressing IOS adoption (e.g., Bala and Venkatesh, 2007; Son and Benbasat, 2007). Future study should continue to focus on the potential of employing various theories to explain the phenomenon of IOS adoption and other unexplored theories. When more diverse theories are used to study IOS adoption, IOS will be adaptable in more diverse contexts (Robey et al., 2008). Especially, future research can explore the network perspectives and the effects of inter-organizational

relationships to enhance existing understanding of IOS adoption. It is indicated by Barringer and Harrison (2000, p. 395) that it is imperative to take account into multiple perspectives and develop new theories because no inter-organizational relationship theories is complete by itself. Therefore, it is important to draw on different theoretical perspectives to develop a more completed understanding of OELS adoption and assimilation.

- It is important for future studies to examine the explanatory power of the technological properties of IOS. Zhu et al. (2006b) and Venkatesh and Bala (2012) provide the starting point of this research direction by investigating the network externalities and standard uncertainty that directly reflect the characteristics of OELS. Future study should continue to enrich the understanding of more contemporary IOS technologies by drawing on theoretical perspectives that can better reflect the evolution of information technologies and adapting these theories to different contexts.

- Although the impacts of IOS adoption has been well understood, future research should explore the outcomes of IOS systems with different characteristics. Compared with EDI-based systems, OELS can help firms exploit the electronic integration without being exposed to the risks of rigidity (Bharadwaj, 2000), which may lead to different organizational consequences compared with conventional IOS systems. Future study can examine whether, and how, the impacts of different

IOS technologies differ in order to guide better decision-making for the practitioners.

Table 2–4 summarizes the findings and implications generalized from literature review, concludes the research directions for OELS studies, and specifies the relationships of these findings to the subsequent chapters of this thesis.

Table 2–4. Summary of Literature Review

Implications from IOS literature	Directions and goals for OELS studies	Action items of this thesis
Most of the literature were focusing on potential adopters' adoption intention, studies investigating actual adoption has been limited understanding of IOS adoption	Identify the differences in the factors affecting adoption intention and actual adoption of OELS	Chapter 3: Develop separate hypotheses for potential adopters and current adopters Chapter 4: Collect different datasets for potential adopters and current adopters
Prior studies treated IOS like they have no distinctive characteristics from other technologies (Robey et al., 2008). It is important to focus on the specific properties of IOS	Examine the explanatory power of the specific technological properties of OELS	Chapter 3: review and discuss relevant theories to identify factors and mechanisms pertinent to the context of OELS
Past literature did not recognize IOS are network systems and the network structures in which IOS are embedded play significant roles in shaping the capabilities and influence of IOS (Tang et al., 2011; Kreuzer et al., 2014)	Exploit the potential of employing various theories to explain the phenomenon of OELS adoption, especially, to explore the network perspectives and the effects of inter-organizational relationships	Chapter 3: develop theoretical background based on the structural embeddedness theory, the relational view of firm and organizational ambidexterity theory
Most past studies only focused on the operational and relational performance (first-order value) of IOS adoption	Examine the performance impacts of OELS (first and second-order performance)	Chapter 3: based organizational ambidexterity theory, develop hypotheses regarding the effects of OELS adoption on both operational and financial performance

2.5. Summary

This literature review identified 26 studies on OSIOS published between 2003 and 2018. Although this literature review is not necessarily exhaustive, it can shed light on the state of the art of OSIOS. By reviewing past studies, this chapter provides a solid

basis and framework for conducting future IOS diffusion research. The various conceptualizations, antecedents, and consequences are summarized from past studies. A set of theoretical perspectives that past IOS studies have explored so far are highlighted. The literature review identified several research issues for future studies, which shed light on the objectives and research questions of this thesis. These findings also provides the foundation for constructing the conceptual model for OELS diffusion and the research framework which will be discussed in Chapter 3.

CHAPTER 3. THEORETICAL BACKGROUND AND HYPOTHESIS DEVELOPMENT

This chapter aims to build the *theoretical foundation* upon which this research is based. As has been evidenced by the literature review of Chapter 2, there is a need to extend theories beyond traditional theoretical paradigms, e.g., the innovation diffusion model, transaction costs economics and institutional theories, to those theoretical frameworks considering inter-organizational relationships for OELS diffusion research. This chapter will discuss the theories, i.e., *the structural embeddedness theory*, *the relational view of the firm*, and t*he organizational ambidexterity theory*, to build the theoretical foundation for this study. Based on these theories, the key factors affecting OELS adoption will be identified. The subsequent sections will focus on developing the hypotheses regarding the relationships between the key factors and OELS adoption, which will lead to the conceptual model of this thesis.

3.1. Theoretical Foundations

3.1.1. Structural Embeddedness Theory

Early research has extensively employed the classical Diffusion of Innovation theory (DOI) to investigate IOS adoption (Kreuzer et al., 2014; Robey et al., 2008). However, because of DOI's relatively generic typology of technology properties, in prior studies, IOS seems to have no distinctive characteristics that are different from other technologies (Robey et al., 2008). Especially, there is a lack of awareness that IOS are

network systems and network structures in which IOS are embedded play significant roles in shaping the capabilities and influence of IOS (Tang et al., 2011; Kreuzer et al., 2014). Although recent studies focusing on network externalities have expanded beyond classical model and revealed more complex associations between network properties and IOS adoption (Robey et al., 2008; Zhu et al., 2006a; Weitzel et al., 2006), the perspective that network structures can have significant influence on IOS and related organizational behaviours is still not very evident in the literature (Tang et al., 2011). Therefore, this study aims at addressing the knowledge gap and enhancing the understanding of the relationship between network properties and OELS adoption.

The focus on network structure drove this study to draw on *the embeddedness theory* which explains that organizational behaviour and the logic of exchange hinge on a firm's embeddedness in the transactional networks consisting of repetitive market and personal relations (Granovetter, 1985; Uzzi, 1997; Dacin et al., 1999). Unlike the traditional theoretical paradigms which commonly assume that firms are independent, self-sustaining economic entities whose business decisions are made solely based on a single firm's perspective, the embeddedness theory suggests that firms are embedded in exchange networks that have significant impacts on their organizational behaviours (Tang et al., 2011; Pu et al., 2016). There are majorly two dimensions of embeddedness (Rossignoli and Ricciardi, 2015): *relational embeddedness* which emphasizes the quality of the personal relationships developed by the people involved in the organization (Uzzi, 1997), and *structural embeddedness* which concerns the key

properties of the network itself, e.g., the number of relationships, the level of network closure and density, and the structure of ties.

This paper focuses on the dimension of structural embeddedness, which, through affecting the influence of inter-organizational relationships on network performance, may promote more networking behaviour (Rossignoli and Ricciardi, 2015). Prior studies have established the relationship between network configurations and firms' strategic positions (Gulati, 1999; McEvily and Zaheer, 1999). Embedded networks are suggested to have a positive influence on cooperative norms to foster mutually beneficial relationships (Granovetter, 1985; Coleman, 1988). Therefore, the structural embeddedness perspective can be employed as an appropriate theoretical lens to examine how network properties can influence the adoption of OELS as a facilitator of inter-organizational collaboration.

Past studies have identified a wide range of structural attributes to characterize the configurations of inter-organizational networks (Löhe and Legner, 2010). Some of the widely studied factors are concerned with firm-level network properties, e.g., network centrality and structural autonomy (Devi et al., 2006), or pair-level network properties, e.g., structural equivalence (Wasserman and Faust, 1994). With a focus on the supply chain networks in which firms are embedded, the present study investigates two dimensions of network-level properties: *exchange structure* and *tie structure* (Tang et al., 2011).

The exchange structure is concerned with the *content* and *context* of the transactions and exchange behaviour among the economic actors in a network. The content of exchange is most relevant to the characteristics or attributes of the products and services that are majorly exchanged in a transactional network (Tang et al., 2011), which will directly affect how much information companies will need to reduce the information asymmetry in transactions. Therefore, when a large amount of information is imperative to delineate the products or services in exchange, the content of exchange can shape network structures through affecting the levels of uncertainty and the search costs associated with the buyers as well as the marketing and communication costs for the sellers (Rai et al., 2008). As another dimension of network structure, the context of exchange refers to the attributes of the exchange environments, e.g., opportunism, complexity, and risks that are embedded in the processes of exchange (Tang et al., 2011). These factors can affect the efficiency of information diffusion in supply chain networks, which can restructure the exchange and collaboration patterns (Soh et al., 2006), such as the search and negotiation processes.

Tie structure, which is essentially shaped by the attributes of exchange structure, refers to the overall structure of the connections among the economic actors in a network (Tang et al., 2011). Tie structures can range from arm's length transactional relationships to highly integrated collaborative networks (Coleman, 1990; Kogut, 2000). It is at the core of a firm's supply chain strategies to decide which tie structures should be formed. While companies can obtain network externalities and reduce search

costs from transactional exchanges, coordination efficiency and common understandings can be achieved from tightly collaborated hubs (Konsynski and McFarlan, 1990; Rai et al., 2008).

3.1.2. The Relational View of the Firm

The relational view of the firm, extending beyond the resource-based view which asserts that competitive advantage originates from the resources housed within a single firm, contends that a firm's critical resources will span beyond organizational boundaries and be embedded in inter-organizational processes and routines (Dyer and Singh, 1998). There has been a growing momentum that IOS such as OELS are being used for creating, sustaining and developing inter-organizational relationships (Hagel and Brown, 2005), which provides the electronic enablers of *extended enterprise networks* consisting of a large variety of economic actors (Saraf et al., 2007). The value of IOS to support business integration and interfirm coordination in extended enterprises has been widely recognized in the literature. Increasingly, more attention has been given to the competency of IOS to create *relational value* through supporting knowledge-based process connections with network partners (Sambamurthy et al., 2003; Malhotra et al., 2005; Malhotra et al., 2007).

Saraf et al. (2007) conceptualizes *relational value* as the economic rents generated from inter-organizational linkages through uniquely configuring and combining the complementary relationship-specific resources emerging from partnerships.

According to the framework of Dyer and Singh (1998), there are four sources of *relational rents* (drivers of organizational performance) that can be generated from inter-organizational relationships: 1) relationship-specific assets; 2) knowledge exchange and joint learning; 3) complementary capabilities; and 4) effective governance mechanisms. It is suggested that IOS can provide a platform that can enable the combination of these resources to create relational value in inter-organizational relationships (Bensaou and Venkatraman, 1996; Bala and Venkatesh, 2007).

Past studies have examined the relational value of IOS and identified several capabilities that can promote relational benefits in supply chain networks, e.g., IOS integration (Rai et al., 2006), IOS flexibility (Ray et al., 2005), and IOS adaptability (Malhotra et al., 2007). It is suggested that, to effectively manage supply chain relationships and leverage external resources, these capabilities are highly correlated together (Bharadwaj, 2000; Langdon, 2006). While it has been shown that implementing IOS technologies in supply chains can lead to electronic integration (Hart and Estrin, 1991), some studies argue that IOS integration is at odds with acquiring IOS flexibility, and, therefore, is not always beneficial (Gosain et al., 2004). The trade-off between IOS integration and flexibility has been pertinent to the context of traditional EDI systems, where companies are faced with the risks of lock-in effects because they have to devote highly partner-specific investments to maintain high integration levels (Hart and Estrin, 1991). The recent development of IOS technologies

(e.g., web services, modular design and extensible markups) and the emergence of OELS are suggested to resolve the conflicts of integration and flexibility (Zhu et al., 2006a; Saraf et al., 2007; Malhotra et al., 2007). There is going to be a higher degree of IOS flexibility after the implementation of OELS, which in turn can enhance the level of integration in supply chains (Hagel and Brown, 2005). Saraf et al. (2007) reveal that IOS flexibility complements IOS integration to create relational value, e.g., knowledge sharing and process coupling, in inter-organizational relationships.

Bala and Venkatesh (2007) applied and extended the concepts of the relational view in the context of OELS, and suggested that the four types of relational rents proposed by Dyer and Singh (1998) can create *relational specificity*. A firm will be more willing to o develop a unique relationship with a specific supply chain partner when it values relational specificity (Madhok and Tallman, 1998). It is indicated that implementing OELS can either reduce or improve the level of relational specificity. When the major partners of a firm do not adopt OELS, or when many other firms in a network adopt the same OELS, implementing OELS can threaten the relational septicity that a firm has with existing partners. In some occasions, OELS can enhance current relational specificity when the dominant partners of a firm employ the same OELS to standardize supply chain processes and activities, which could, at least in the short term, enhance asset interconnectedness among network participants (Dyer and Singh, 1998).

Besides relational specificity, Bala and Venkatesh (2007) also identify *relational depth* and *relationship extendability* as two additional relational mechanisms associated with

OELS adoption that can create relational rents. Relational depth is defined as the degree to which a firm can have new channels to collaborate with existing supply chain partners. By implementing OELS, a firm can enhance relational depth in supply chain relationships through streamlining interfirm processes to improve coordination efficiency (Gosain et al., 2003), developing knowledge sharing routines with partners to enrich knowledge base (Malhotra et al., 2005; Sambamurthy et al., 2003), and standardizing business processes to improve the depth of collaboration with greater flexibility and information visibility in the supply chain network (Damodaran, 2005).

Relationship extendability is conceptualized as the extent to which a company can adjust and redeploy its current relationship-specific assets, knowledge sharing routines, and capabilities for new inter-organizational relationships (Teece et al., 1997). Through extending beyond current collaborative networks, a company can greatly enhance its breath of collaboration (Rokkan et al., 2003). The "plug-and-play" competency of OELS can enable companies to achieve relationship extendibility by easily extending its current supply chain network to incorporate new partners who have also implemented similar types of OELS (Gosain et al., 2003).

Bala and Venkatesh (2007) propose that relationship specificity, relational depth and relationship extendability will affect the adoption of OELS in different ways and predict that their effects will vary with the dominant positions of firms accordingly. Although support has been provided by case studies regarding the influence of these three relational mechanisms on OELS adoption, there has been no empirical evidence

validated by large-scale firm samples. Therefore, it is imperative to examine how the relational mechanisms will affect the adoption of OELS using empirical data.

Extending the work of Saraf et al. (2007) and Bala and Venkatesh (2007), this study defines two major relational mechanisms – ***bonding mechanism*** and ***bridging mechanism*** – that can affect the adoption of OELS. On one hand, a bonding mechanism that increases the *depth and efficiency* of inter-organizational collaboration can be provided by IOS integration through enhancing information richness and streamlining operational processes among the supply chain partners (Ravichandran et al., 2007; Malhotra et al., 2007). On the other hand, IOS flexibility enables a bridging mechanism that facilitates the formation of *new collaborative relationships* through reconfiguring a firm's IOS resources and adapting operational processes to accommodate new requirements in inter-organizational relationships (Tiwana, 2008; Rai and Tang, 2010). Adopting OELS can bridge the information gaps, match markets, and facilitate interfirm transactions, which can substantially reduce search costs and help companies identify potential partners (Choudhury, 1997; Ravichandran et al., 2007).

By conciliating the tension between IOS integration and flexibility, OELS can provide a *dual-purpose relational mechanism* that enables a company to exploit bonding and bridging effects at the same time (Malhotra et al., 2007). The relational mechanisms work as the full forces facilitating the adoption of OELS (Rai and Tang, 2010). A company will be more inclined to adopt OELS, or implement OELS to a greater extent,

when the assimilation of OELS is perceived to enhance bonding or bridging effects (Bala and Venkatesh, 2007)

3.1.3. Organizational Ambidexterity Theory

It has been widely acknowledged that organizational ambidexterity is the key to long-term success (O'Reilly and Tushman, 2013). Organizational ambidexterity refers to the ability to balance the trade-off between alignment (exploitation) and adaptation (exploration) (Gibson and Birkinshaw, 2004), such that companies can compete in mature markets where efficiency, control, and certainty are important and also in new markets where flexibility, autonomy, and innovation are valued (March, 1991; O'Reilly and Tushman, 2013). There has been a proliferation of studies investigating ambidexterity in intra-organizational contexts. The positive influence of ambidexterity on organizational performance has been warranted at firm, business unit, and project levels by various studies (O'Reilly and Tushman, 2013).

Increasingly, the research interest in ambidexterity has begun to shift beyond intra-organizational settings (Lin et al., 2007). It is argued that, for research on ambidexterity, the unit of analysis should not only be confined to the firm or corporation level, but also incorporate "the firm's larger ecosystems" (O'Reilly and Tushman, 2013, p. 333). There has been a growing body of research investigating the influence of ambidexterity in inter-organizational contexts, such as alliance formation, inter-organizational learning, and supply chain management (e.g., Koza and Lewin, 1998; Lavie and

Rosenkopf, 2006; Im and Rai, 2008; Tiwana, 2008; Araceli et al., 2016). Inter-organizational relationships have been shown to be important sources to develop ambidexterity (Kauppila, 2010).

According to Lavie and Rosenkopf (2006), inter-organizational ambidexterity can be conceptualized into three different domains: the *function domain* which considers the content and nature of relationships with partners; the *structure domain* which relates to the prior positions of partners in broader networks; and the *attribute domain* which deals with the intertemporal variance in partners' organizational attributes. Because of the major role of OELS as a boundary-spanning mechanism to enable inter-organizational networks consisting of various partners (Malhotra et al., 2007; Saraf et al., 2007), this study focuses on the ***structure domain*** of ambidexterity which is directly concerned with network structure (Beckman et al., 2004; Lavie and Rosenkopf, 2006). Inter-organizational relationships are considered as the source of learning that can not only facilitate cross-boundary transfer of knowledge but also promote the discoveries of new knowledge (Powell et al., 1996), which presents opportunities for both exploitation and exploration (Lin et al., 2007).

With a focus on network structure, it is proposed that reinforcing relationships with existing partners is a form of exploitation while expanding networks with new partners is considered as exportation (Beckman et al., 2004). When a firm forms recurrent relationships with existing partners, it can utilize existing collaboration channels to effectively transfer knowledge that has been developed in proximate networks.

Therefore, consolidating partnerships that are already in place can facilitate information sharing and promote the efficiency of collaboration (Verspagen and Duysters, 2004), thereby extending a firm's existing knowledge base with existing partners (Beckman et al., 2004), which corresponds to the notion of exploitation proposed by March (1991). On the other hand, by adding new partners to a network, a firm can broaden its access to remote knowledge and new resources which are not readily available from existing partners. Therefore, new opportunities and competencies can be created by expanding beyond a firm's immediate network, which is in line with the concept of exploration (March, 1991).

The structural domain of exploitation versus exploration reflects the two seemingly conflicting perspectives of network stability and change (Beckman et al., 2004; Lin et al., 2007). The literature emphasizing stability in network structure has documented that organizations are prone to network consolidation by repeating relationships with partners with which they have prior ties (Podolny, 1994; Gulati, 1995). The preference for stability can be explained by the *structural embeddedness theory* which explains that organizations resist change because of the institutional and technical structures of the external environment they are embedded in (Granovetter, 1985). In addition, the *structural inertia theory* suggests that organizations tend to institutionalize and routinize organizational goals and activities to attain reliability and accountability, which results in their propensity for repeating and developing existing skills (Hannan and Freeman, 1984; Amburgey et al., 1993). Furthermore, close and recurrent

relationships with partners are viewed as important sources of social capital, which facilitates the efficiency of coordination and cooperation (Coleman, 1988; Putnam, 1993), creating favourable conditions for further cooperation (Gulati, 1999). Evidence from the organizational learning literature also suggests that companies tend to engage in repeated activities because they can develop and refine organizational capabilities from past experience (Levinthal and March, 1993).

In contrast to the above theoretical perspectives which depict relatively inflexible organizational and network structures, many other influential theories, such as contingency theory (Lawrence and Lorsch, 1986; Thompson, 1967), evolutionary theory (Nelson and Winter, 1982; Aldrich, 1999), resource dependence theory (Pfeffer and Salancik, 1978) and institutional theory (DiMaggio and Powell, 1983; Scott, 1995), hold that organizations are malleable, and can adapt their practices to changes in the external environment. These theoretical perspectives emphasize the importance of establishing new partnerships to reduce dependence on a given source, alleviate uncertainty, and cultivate new sources of knowledge (Pfeffer and Salancik, 1978; Powell et al., 1996). Because companies are bounded by limited resources, the practices of broadening and consolidation are conflicting as they have to compete for resource allocation. Although the conflict cannot be entirely eliminated, an ambidextrous approach that balances the simultaneous presence of both existing and new partners in interfirm networks can to a large degree reconcile the tension (Lin et al., 2007).

Not much is known, however, about how companies can address the challenge of balancing the contradictory requirements of boundary reinforcement and creation (Raisch et al., 2009). It has been challenging for companies to leverage both IOS integration and flexibility capabilities to achieve electronic integration and brokerage at the same time (Hart and Estrin, 1991; Kambil et al., 1999), which reflects the conflict between close alignment and rapid adaptation in supply chains (Gosain et al., 2004; Lavie and Rosenkopf, 2006). To integrate with selected partners, the conventional EDI systems require excessive relationship-specific IOS investments, which creates a lock-in effect that prevents companies from reconfiguring their IOS assets to connect with diverse partners (Clemons and Kleindorfer, 1992). In addition, the rigidity of data formats and complexity of implementation have also greatly restricted the flexibility of EDI systems to adapt business processes and activities to emergent collaboration requirements (Gosain et al., 2004).

This study draws on a supply chain competency perspective and suggests that an ambidextrous network can be enabled via the simultaneous attainment of bonding and bridging effects through the implementation of OELS. The bonding mechanism of OELS can facilitate the development of routine activities and procedures to effectively coordinate interdependent processes with existing network partners (Gulati et al., 2000; Rai and Tang, 2010), though which a company can establish close collaborative relationships (Subramani, 2004), promote effective utilization of inter-organizational resources, and enhance the ability to leverage and reinforce existing ties (exploitation).

The bridging mechanism of OELS can help companies adjust existing partnerships and reconfigure interfirm activities to quickly respond to the changes in internal and external business environments (Gosain et al., 2004). A firm can rapidly adapt its processes and activities to incorporate new partners into an existing network (exploration), which provides access to new knowledge and resources, creates new opportunities, and promotes supply chain responsiveness (Rai and Tang, 2010). Therefore, an ambidextrous network structure which permits both existing and new partners can be attained by developing bonding and bridging capabilities at the same time.

3.1.4. The Conceptual Framework

Drawing on the three theoretical perspectives discussed above, the conceptual framework that guides this study is depicted in Figure 3-1. On one hand, different exchange and tie structures of supply chain networks will form the push forces influencing the adoption of OELS. On the other hand, the bonding and bridging mechanisms present the pull forces that drive companies to adopt OELS. The assimilation and diffusion of OELS will improve organizational performance because of enhanced organizational ambidexterity. Following Saraf et al. (2007), the relational mechanisms are conceptualized not at a single dyadic level, but are the aggregated effects across the major relationships with a firm's supply chain. The aggregation of multiple supply chain relationships is more appropriate with the context of OELS as in this study because of the major role of OELS in managing various inter-

organizational relationships. Therefore, although the relational view of firm is initially proposed in the context of dyadic-level analysis (Dyer and Singh, 1998), in theory development, this study draws from a network-level perspective to apply the theory in the context of the key supply chain partners of a focal firm.

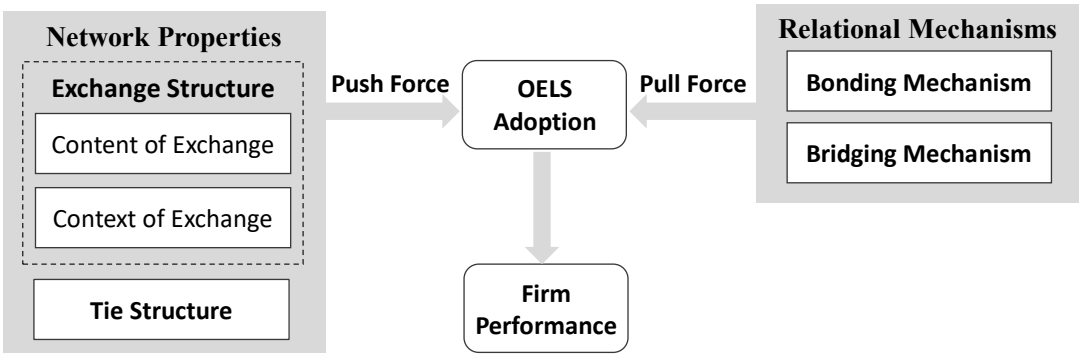


Figure 3-1. The Conceptual Framework

3.2. Hypothesis Development

This section will focus on developing the hypotheses to delineate the relationships proposed in the conceptual model. The specific factors rooted in network properties and relational mechanisms will be identified within the context of OELS adoption. The literature has suggested that there is a significant distinction between the pre- and post-adoption periods (Son and Benbasat, 2007). Therefore, the effects of network properties and relational mechanisms on the adoption intention of potential adopters and the actual adoption level should be investigated separately.

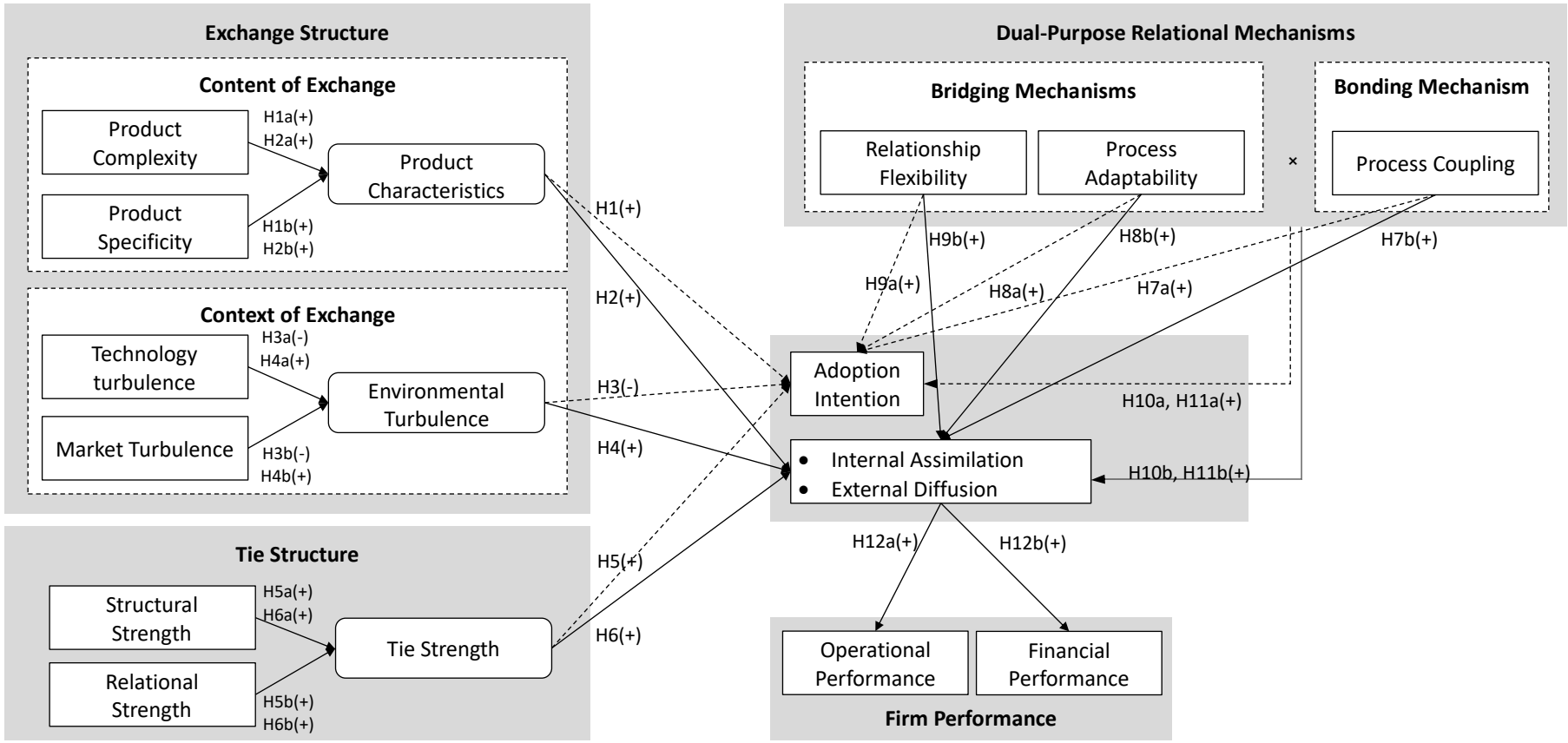
Consistent with Chwelos et al. (2001), Teo et al. (2003) and Son and Benbasat (2007), adoption intention is measured as the dependent variable for the potential adopter

model. For the existing adopters of OELS, internal assimilation and external diffusion, which are to be discussed later in Section 3.2.1, are chosen to measure the level of actual adoption.

The research model which summarizes all the hypothesized relationships is presented in Figure 3-2. The remainder of this section identifies two groups of factors pertaining to network properties and relational mechanisms that may influence the adoption intention, internal assimilation, and external diffusion of OELS. Hypotheses H1 to H6 correspond to the factors rooted in network structures. Hypotheses H7 to H9 assess the factors associated with relational mechanisms. Hypotheses H10 and H11 focus on the complementary effects between the two relational mechanisms. Hypotheses H12a and H12b examine the organizational outcomes of OELS adoption for existing adopters. In Figure 3-2, the solid paths represent the hypotheses developed for current adopters of OELS, and the dashed paths show the hypotheses for potential adopters.

3.2.1. Internal Assimilation and External Diffusion of IOS

The concept of *extended enterprise* emphasizes that supply chain partners, rather than being connected by discrete, independent, and isolated supply chain activities, should be tightly integrated and in close collaborative relationships (Dyer, 2000). In extended enterprises, all the partners in a value network work together towards a commonly recognized goal, which entails the importance of creating a new mode of value configurations through integrating the supply chain processes of diverse partners into



Note: the paths for potential adopter are presented in dashed lines while the paths for OELS current adopter are shown as solid lines.

Figure 3-2. The Research Model

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an organization's internal system of the value chain (Stabell and Fjeldstad, 1998). It has been widely recognized that the capabilities of IOS can facilitate the formation of extended enterprises through influencing, enhancing, and extending digitally-enabled partnerships. To develop extended enterprises via the implementation of IOS, companies must assimilate the IOS solutions *internally* across their supply chain activities and also, at the same time, diffuse them *externally* among the partners in the supply chain networks (Ranganathan et al., 2004).

Therefore, *internal assimilation* is defined as the extent to which IOS and related technological solutions have been deployed in the key supply chain activities to support inter-organizational relationships. *External diffusion* refers to the degree to which IOS and related technological solutions have been utilized to integrate supply chain partners and to conduct interfirm transactions (Ranganathan et al., 2004; Zhang and Dhaliwal, 2009). After being adopted, a technology will be employed to support organizational routines and activities as well as the exchange of knowledge and technology across organizational boundaries. Internal assimilation and external diffusion, therefore, work together to contribute to the infusion stage of the overall diffusion process for a typical IOS technology (Premkumar et al., 1994; Ramamurthy and Premkumar, 1995).

Despite internal assimilation and external diffusion inextricably interweave to affect the degree to which an IOS technology is adopted by an organization, a sparsity of studies has recognized the difference between them. Most studies, based on the classic

innovation diffusion theory (Rogers, 1995), adopt a three-stage technology diffusion model comprising initiation, adoption and diffusion stages. In a similar vein, the three stages through which IOS-related technologies pervade an organization are classified as the exploration, trial, and commitment stages (Son and Benbasat, 2007), or as the adoption, limited deployment, and general deployment stages (Bala and Venkatesh, 2007). These conceptualizations, however, may not be appropriate in the context of the adoption of OELS which focus on managing a wide range of internal supply chain activities and processes that extend across organizational boundaries (Ranganathan et al., 2004).

Therefore, to investigate the actual adoption of OELS, this study measures both internal assimilation and external diffusion and examines the antecedents to these two constructs. Although the antecedents to internal assimilation and external diffusion may differ, this study does not make an explicit distinction between the two concepts in the hypothesis development. The hypotheses for internal assimilation and external diffusion are integrated together to examine the factors affecting the actual adoption of OELS. Differences in the antecedents, if any, that are identified during hypothesis testing, will be discussed and explained in Chapter 6.

3.2.2. Effects of Network Properties

3.2.2.1. Content of Exchange: Product Characteristics

The content of exchange, which concerns the properties of products that are exchanged in a supply chain network, are prominent factors to consider in exchange structure (Tang et al., 2011). Product characteristics can influence the transactional relationships among supply chain partners, the procurement and supply processes, and SCM practices (Saeed et al., 2005). Therefore, the characteristics of the products should be taken into consideration to understand the factors affecting OELS adoption. However, there has been little progress made in the literature to validate the role that product characteristics play in a firm's decision to adopt and use OELS (Saeed et al., 2005; Son and Benbasat, 2007), which entails the importance of examining the impacts of product characteristics through empirical studies.

According to Malone et al. (1987), two products characteristics, which are *product complexity* and *product specificity*, present important determinants of an organization's strategic decision OELS adoption. Product complexity refers to the degree to which a product involves a large number of components, the difficulty of parts coupling, and the level of product novelty (Novak and Eppinger, 2001), which is positively correlated with the amount of information that is needed to delineate the attributes and specifications of that product. Product specificity refers to the degree to which a product is tailored or customized for a specific firm such that it cannot be

readily utilized by other firms in the market (Son and Benbasat, 2007; Safizadeh et al., 2000). Although a product can be highly complex and specific at the same time, product complexity and specificity are two independent product attributes that are not necessarily concomitant (Malone et al., 1987). It is, therefore, reasonable to investigate the two concepts separately (Son and Benbasat, 2007).

When a product involves complex production processes or sophisticated components, generally a large amount of information should be provided to detail product specifications, which exerts great pressure on a firm's ability to process and exchange information. It is found that due to the inadequate capability of electronic marketplaces to display detailed product descriptions, companies tend to participate less in electronic markets to trade products that are characterized by a high level of product complexity (Son and Benbasat, 2007). OELS, with enhanced ability to process complex and rich-content information, however, can resolve the problem of inadequate information sharing that characterizes electronic marketplaces. In addition, the production of complex products also requires close collaboration between supply chain partners in the areas of product design, inventory planning, product manufacturing and logistics (Chong and Ooi, 2008). Through implementing OELS, companies can facilitate the integration of processes in these supply chain areas, which can greatly improve the efficiency of companies whose major product lines are highly complex.

To manufacture highly specific products, supply chain partners need to closely coordinate and align their production processes to satisfy the requirements of

customization (Son and Benbasat, 2007). By deploying OELS, firms will be better equipped to integrate and coordinate their supply chain processes. The costs of coordination can also be dramatically reduced through the automation of supply chain activities (Liu et al., 2010). In addition, the relationship-specific assets involved in producing highly specific products can induce a high level of interdependency in collaborative relationships, which may foster a favourable environment for partners to work together to implement OELS for supply chain integration. Therefore, it is expected that companies that intend to deal in products that are characterized by both high product complexity and specificity will be more willing to adopt OELS. Based on the above discussion, this study posits the following hypothesis regarding the relationship between product characteristics and the adoption intention of OELS, and its corollaries regarding the effects of product complexity and product specificity:

*H1: The characteristics of products as a whole that are traded within a firm's supply chain network **positively** affect the adoption intention of OELS.*

*H1a: The complexity of products as a whole that are traded within a firm's supply chain network **positively** affects the adoption intention of OELS.*

*H1b: The specificity of products as a whole that are exchanged within a firm's supply chain network **positively** affects the adoption intention of OELS.*

It is expected that product characteristics will affect the actual adoption of OELS in a similar way as it affects firms' adoption intention. The multifariousness of products

may deteriorate the performance of the supply chain, which calls for strategies to mitigate product complexity (Hu et al., 2008). Companies, therefore, will utilize OELS more intensively in multiple internal supply chain activities to enhance the agility of product design, delivery, and customer services. In addition, when product specificity is high, OELS will be employed to a greater extent to coordinate with external partners to facilitate interfirm process integration. Therefore, with respect to the effects of product characteristics on internal assimilation and external diffusion, the following hypothesis and its corollaries are proposed:

*H2: The characteristics of products as a whole that are traded within a firm's supply chain network **positively** affect the level of internal assimilation and external diffusion of OELS.*

*H2a: The complexity of products as a whole that are traded within a firm's supply chain network **positively** affects the level of internal assimilation and external diffusion of OELS.*

*H2b: The specificity of products as a whole that are traded within a firm's supply chain network **positively** affects the level of internal assimilation and external diffusion of OELS.*

3.2.2.2. Context of Exchange: Environmental Turbulence

The *context of exchange* presents another important dimension of exchange structure (Tang et al., 2011). It has been highlighted that the context in which a firm operates should be considered as one of the determinants of OELS adoption (Saeed et al., 2005). This study primarily focuses on the level of *environmental turbulence* in the exchange context because of the prominent role of environmental turbulence affecting a firm's capability and tactics to manage its supply chain relationships (Rai and Tang, 2010). It is suggested that the uncertainties embedded in external environments can restrain the effectiveness of SCM practices (Hsu, 2005), which, therefore, will affect the performance of OELS as a tool to manage supply chain activities, and influence a firm's decision to adopt OELS.

Turbulent environments are characterized by frequent and unpredictable variations in markets or/and volatile changes in technologies, which makes it difficult to accurately forecast market trends and ratchets up the risks associated with supply chains (Calantone et al., 2003). *Market turbulence* and *technology turbulence*, therefore, are suggested to be the two most notable dimensions of environmental turbulence that can impact the relationships among supply chain partners (Trkman and McCormack, 2009). Market turbulence refers to the heterogeneities and volatilities in a firm's portfolio of customers and the preferences of such customers (Kandemir et al., 2006). In highly turbulent markets, the demands and preferences of customers are continuously changing, which leads to unstable price and cost structures and intensifies competition

(Calantone et al., 2003). Companies in such environments thus have to adapt and modify their product offerings or production processes more frequently to follow market trends (Kandemir et al., 2006).

Technology turbulence is associated with the frequency and extent of the changes in the major technologies of an industry, and the influence that these changes may exert on the overall industry environment (Chatterjee, 2004). Dynamisms in underlying technologies may involve the speed of technological changes, and revolutions in manufacturing and mass production processes (Hsu and Chen, 2004), which may pose challenges for firms to adopt effective SCM practices to promote fast information sharing (Fynes et al., 2005).

It is indicated that to reduce or manage uncertainty, firms will implement strategies, e.g., supply chain integration, network consolidation, and network broadening, to influence and alter their supply chain networks (Beckman et al., 2004). However, There has been no conclusive theory about how environmental turbulence will affect a firm's choice of the tools and solutions for SCM (Trkman and McCormack, 2009). Although Stonebraker and Liao (2004) contend that environmental turbulence and supply chain integration are positively associated with each other, no evidence is provided to support this statement. Drawing from contingency theory, Trkman and McCormack (2009) suggest that the influence of environmental turbulence on a firm's strategic decisions may be contingent on the specific context as well as the particular strategies employed to manage supply chain uncertainties. Therefore, the influence of

environmental turbulence on a firm's decision to adopt or use OELS may be contingent on the particular strategic position of the firm. The potential adopters and current adopters of OELS thus will respond differently to the use of OELS when faced with turbulent environments.

For companies that are still using EDI for supply chain coordination, migrating to OELS may present a disruption of current partnerships and production processes which will further increase their exposure to external risks. In turbulent markets, companies will seek stability and trust in supply chain networks, which are more likely to flourish in existing relationships rather than new partnerships that are uncertain (Hansen, 1999). In addition, reinforcing existing ties can increase the efficiency of interfirm collaboration, which can not only reduce market uncertainty by enhancing responsiveness to changes in demand (Trkman and McCormack, 2009), but can also alleviate technological uncertainty by accelerating time to market and securing the access to complementary products (Chatterjee, 2004). Therefore, when the level of external uncertainty is high, companies will be more inclined to enhance current supply chain relationships with EDI that is already in place, and they are likely to migrate from EDI to OELS to explore and extend new supply chain relationships (Beckman et al., 2004). Therefore, the following hypothesis and its corollaries are proposed regarding the influence of turbulence on a firm's intention to adopt OELS:

*H3: Environmental turbulence **negatively** affects the adoption intention of OELS.*

*H3a: Market turbulence **negatively** affects the adoption intention of OELS.*

*H3b: Technology turbulence **negatively** affects adoption intention of OELS.*

For companies that have already implemented OELS as a tool to manage inter-organizational relationships and supply chain activities, uncertainty and turbulence in external markets will catalyze greater assimilation and diffusion of OELS to cope with supply chain risks. The aforementioned logic of relationship reinforcement, which predicts a negative relationship between environmental turbulence and potential adopters' adoption intention of OELS, also applies to OELS adopters, but implies a positive association between turbulence and the degree of OELS usage. The adopters will be motivated to utilize OELS to coordinate more supply chain activities to strengthen and exploit existing ties to tackle uncertainties. In addition, OELS can facilitate the adaptability and flexibility of a supply chain, which can enhance a firm's ability to respond quickly to market and technological changes in external environments (Gosain et al., 2004; Rai and Tang, 2010). Therefore, contradictory to its relationship with adoption intention, environmental turbulence is proposed to be positively associated with internal assimilation and external diffusion, which leads to the following hypothesis and its corollaries regarding the influence of market turbulence and technology turbulence respectively:

*H4: Environmental turbulence **positively** affects the level of internal assimilation, and external diffusion of OELS.*

*H4a: Market turbulence **positively** affects the level of internal assimilation, and external diffusion of OELS.*

*H4b: Technology turbulence **positively** affects the level of internal assimilation, and external diffusion of OELS.*

3.2.2.3. Tie Structure: Tie Strength

Tie structure describes the overall structure of the relationships among supply chain partners (Tang et al., 2011), which is indicated to have a profound influence on a firm's decision on IOS adoption (Shah et al., 2002; Choudhury, 1997). Although in some studies tie strength is examined as a dyadic property (Granovetter, 1973), this study focuses on the average strength of the relationships a firm has connected via OELS, or, for a potential adopter, the average strength of the ties it intends to integrate with OELS. Therefore, tie strength is conceptualized as a network-level property in this study. Network relationships can range from loosely connected transactional exchanges to closely integrated long-term collaborative hubs (Coleman, 1990; Burt, 2009; Kogut, 2000). A prominent factor to differentiate these tie structures is the *strength of ties* among the partners. Tie strength is mainly concerned with the nature of the relational bonds between business partners and how it will affect the information and resource flows between different firms (Friedkin, 1982). Strong ties are characterized by frequent and intense communications and contacts, and high levels of closeness and reciprocity (Levin and Cross, 2004). Therefore, the strength of ties is

closely associated with the strategies that companies will adopt to manage supply chain resources and the ways to generate value from interfirm relationships (Kim and Choi, 2018), which thus should be considered as an important factor that affects OELS adoption.

The literature has categorized tie strength as *structural strength* and *relational strength (Krackhardt, 1992)*. The structural domain of tie strength concerns the frequency and intensity of interfirm interactions, and the diversity of interactive activities (Hansen, 1999). The relational domain of tie strength mainly refers to the levels of trust, support and reciprocity that are shared by business partners (Ibarra, 1992). While structural strength is mostly correlated with the efficiency of interfirm collaboration, relation strength primarily affects the willingness of partners to offer help and transfer resources (Hansen, 1999; Krackhardt, 1992).

In relationships with high levels of structural strength, partners are inclined to mutually engage in activities to reallocate and combine their resources, e.g., knowledge, technology and skills, to enhance collaboration efficiency (Kim and Choi, 2018), which will motivate the co-adoption of OELS to facilitate the transfer of information and know-how among partners. Strong ties are also characterized by well-established routines, standards, and production processes, which can create a favourable environment to implement OELS more easily in supply chain networks (Eisenhardt and Schoonhoven, 1996).

Partners with strong relational bonds generally share common understandings and expect moral support and acceptance from others (Coleman, 1990; Kim and Choi, 2018). The high level of comfort and mutual ease in strong ties will promote repeated contacts among supply chain partners, which will motivate companies to adopt OELS to utilize the mutually available resources for the greater utility of all parties (McEvily and Marcus, 2005). Close relational bonds will also generate a highly supportive atmosphere, wherein companies will feel less vulnerable to value-exploitation tactics by trading partners, and, therefore, will be more inclined to engage in OELS adoption to promote collaborative relationships (Kumar et al., 1995). Furthermore, mutual trust can mitigate the fear of leaking vital business secrets, which can encourage more information sharing, and enhance the willingness to deploy OELS to facilitate cross-boundary information sharing. Based on the above discussion, tie strength is considered to have a positive impact on a firm's intention to adopt OELS, which leads to the following hypothesis regarding the relationship between tie strength and adoption intention, and the corollaries with respect to the effects of structural and relational strength:

H5: Strength of ties as a whole between a firm and its major suppliers ***positively*** *affects the adoption intention of OELS.*

H5a: Structural strength of ties as a whole between a firm and its major suppliers ***positively*** *affects the adoption intention of OELS.*

H5b: Relational strength of ties as a whole between a firm and its major suppliers ***positively*** *affects the adoption intention of OELS.*

It is expected that tie strength will affect the level of internal assimilation and external diffusion of OELS in the same way as it affects the adoption intention of OELS. A company will use OELS more frequently and intensely to coordinate the frequent flows of information and resources among structurally tied partners (Levin and Cross, 2004). More transactions will be conducted through OELS when supply chain partners have closer and more diverse interactions. In addition, the Mutual support and trust in relational ties will catalyse more exchange of resources and know-how through OELS. Therefore, stronger ties are associated with greater internal assimilation and external diffusion of OELS. The following hypothesis and its corollaries are proposed:

H6: Strength of ties as a whole between a firm and its major suppliers ***positively*** *affects the level of internal assimilation, and external diffusion of OELS.*

H6a: The structural strength of ties as a whole between a firm and its major suppliers ***positively*** *affects the level of internal assimilation and external diffusion of OELS.*

H6b: The relational strength of ties as a whole between a firm and its major suppliers ***positively*** *affects the level of internal assimilation and external diffusion of OELS.*

3.2.3. Bonding and Bridging Mechanisms

3.2.3.1. Bonding Mechanism: Process Coupling

IOS have been increasingly used by firms as the digital enablers of cross-boundary collaboration (Saraf et al., 2007; Malhotra et al., 2007). Past literature has identified ***process coupling*** as a relational mechanism to obtain bonding effects (Saraf et al., 2007). Through process coupling, a focal firm can coordinate and interweave the interdependent supply chain activities with its business partners, which can ensure that the business processes spanning across the supply chain network are operationally integrated (Rai and Tang, 2010).

A major source of process coupling is suggested to be asset interconnectedness which is generated when supply chain partners closely link their business processes thereby leading to increased relationship specificity (Dyer and Singh, 1998). OELS can enhance a firm's integration capability through ensuring that its IT assets work as a "functional whole" with that of its partners (Saraf et al., 2007, p. 324), thus leading to tight coupling across a firm's supply chain (Rai and Tang, 2010). Through implementing OELS, companies can achieve integration such that business partners can resolve their differences at both *syntactic* and *semantic* boundaries (Yang and Papazoglou, 2000; Malhotra et al., 2007). Syntactic integration ensures that data are based on common language and presentation format, which is a necessary condition for the access and exchange of information between partners (Rai et al., 2006).

Semantic integration reconciles and harmonizes the meaning of data across different sources and channels, which ensures that exchanged information is interpreted in the same manner by different partners (Mouzakitis et al., 2009). As a result, in tightly coupled systems, the suppliers can quickly respond to the idiosyncrasies in the interfirm processes of their customers (Saraf et al., 2007). OELS can permit the communication and interoperation of the IT platforms and functional applications across different supply chain partners (Rai et al., 2006), allowing companies to transmit rich-content data, align business processes, and coordinate supply chain activities (Rai and Tang, 2010).

Therefore, process coupling can facilitate a firm's ability to resolve the mismatch of information processing capabilities across its business partners, which will motivate the firm to adopt OELS to ensure that its trading partners have adequate information transmission ability such that the transactions can be conducted in an accurate and timely manner (Jap and Ganesan, 2000). It is suggested that this instrumental benefit of OELS to enable process coupling will provide the incentive for companies to invest resources to adopt OELS or to facilitate greater assimilation and diffusion of OELS within them (Magretta, 2002; Bala and Venkatesh, 2007). On other occasions, when a firm's major partners in the supply chain network have deployed OELS, the firm will be more inclined to adopt OELS or assimilate OELS to a greater extent to achieve and develop process coupling with its key partners, through which the bonding between the firm and its partners can be improved to sustain the trading relationships that are

critical sources of revenue and resources (Jap and Ganesan, 2000). To summarize the discussion above, this study proposes that:

H7: When OELS are perceived to enhance process coupling, a firm will be more likely to adopt OELS (H7a), or have greater internal assimilation and external diffusion of OELS (H7b).

3.2.3.2. Bridging Mechanisms: Relationship Flexibility and Process Adaptability

The literature has identified that the bridging mechanism is enabled by OELS through two aspects: 1) ***relationship flexibility*** which facilitates the formation of new collaborative relationships (Fjeldstad and Haanœs, 2001; Malhotra et al., 2007); and 2) ***process adaptability*** which enhances a firm's ability to reconfigure and adapt supply chain activities and operational processes in inter-organizational relationships (Tiwana, 2008; Rai and Tang, 2010; Gosain et al., 2004; Young-Ybarra and Wiersema, 1999). Relationship flexibility and process adaptability together reflect a firm's ability to exploit the opportunities in the markets by bridging the information gaps in markets and quickly responding to the changes in external environments using various strategies and actions (Gosain et al., 2004). Compared with traditional EDI systems, OELS can equip companies with greater flexibilities to reconfigure their IT resources, which creates the opportunities for relationship flexibility and process adaptability because the requirements for specific assets to coordinate partners are reduced (Bala and Venkatesh, 2007).

To achieve process adaptability, the focal firm and its business partners should mutually adjust their supply chain plans and activities together (Lee, 2004), which can be enhanced by OELS because a firm's IT platforms can be flexibly adjusted to accommodate the needs for changing existing supply chain processes to adapt to that of the partners. In addition, OELS can facilitate mutual adaptation of business processes also through developing IOS integration capabilities that improve the richness and timeliness of information exchange about production, logistics, sourcing and other mutual supply chain activities (Simchi-Levi et al., 2008). Therefore, this study posits that:

H8: When OELS are perceived to enhance process adaptability, a firm will be more likely to adopt OELS (H8a), or have greater internal assimilation and external diffusion of OELS (H8b).

Similar to process adaptability, relationship flexibility is affected by OELS by enhancing a firm's bridging capabilities to resolve the heterogeneity in the IT platforms across new and existing partners (Gosain et al., 2004). The modular design, structured data connectivity, and standardized interfaces of OELS can greatly reduce the costs of searching and switching business partners, leading to greater flexibility in inter-organizational relationships. It is suggested that the network externality of OELS can also affect a firm's ability to extend current networks because companies that have adopted the same type of OELS can find and connect with others more easily (Zhu et al., 2006a). In turbulent environments, companies will need to frequently adjust their

supply chain relationships to respond to the changes in the markets, and to access knowledge and resources beyond their immediate network (Varian and Shapiro, 1999). Therefore, when OELS are perceived to have the ability to enhance relationship flexibility, a company will be motivated to adopt, or promote greater assimilation of, OELS, which leads to the following hypothesis:

H9: When OELS are perceived to enhance relationship flexibility, a firm will be more likely to adopt OELS (H9a), or have greater internal assimilation and external diffusion of OELS (H9b).

3.2.3.3. The Interaction between Bonding and Bridging Mechanisms

Although both bonding and bridging mechanisms have a positive impact on firm performance, the traditional view considers them contradictory such that firms, with limited resources, have to choose to develop one mechanism while forgoing another. However, this either-or thinking ignores the interactions between these two mechanisms, which precludes firms from exploiting synergies from complementarity, resulting in suboptimal performance in the long run (Milgrom and Roberts, 1995). The development of OELS, through standardizing not only data exchange formats but also business process content and choreography (Bala and Venkatesh, 2007), can reconcile the trade-off between bonding and bridging (Gosain et al., 2004; Langdon, 2006; Malhotra et al., 2007; Rai and Tang, 2010). OELS can strengthen interfirm collaboration by improving the quality and breadth of information exchange,

streamlining interconnected processes, and enhancing mutual understanding and knowledge sharing (Bala and Venkatesh, 2007; Malhotra et al., 2007). On the other hand, the flexible interfaces equip OELS with the "plug-and-play capabilities" (Gosain et al., 2003, p. 190), which allow companies to reconfigure their processes to incorporate existing or new partners at low cost.

It is suggested that bonding and bridging are mutually enhancing. By complementing bonding with bridging mechanism, a firm can more effectively manage its supply chain network through aligning with existing partners, adapting processes and routines, and reconfiguring network profile (Saraf et al., 2007; Rai and Tang, 2010). The bonding mechanism that facilitates close interfirm collaboration will complement the bridging mechanisms that develop the capabilities to form new ties by integrating the diverse skills, resources and expertise that are provided by the bridging mechanisms (Tiwana, 2008). Process coupling will enhance the effectiveness of process adaptability to adjust businesses process or relationship flexibility to deploy the resources of new partners. The mutually enhancing relationships between process coupling, process adaptability and relationship flexibility are suggested to reflect the essential dynamisms to effectively manage a firm's supply chain network (Rai and Tang, 2010). Therefore, the motivation to garner the complementarities between bonding and bridging will lead to higher adoption intention of OELS, or promote greater assimilation and diffusion of OELS. Based on the discussion, this study proposes that:

H10: When OELS is perceived to enhance process coupling and process adaptability at the same time, a firm will be more likely to adopt OELS (H10a), or have greater internal assimilation and external diffusion of OELS (H10b).

H11: When OELS is perceived to enhance process coupling and relationship flexibility at the same time, a firm will be more likely to adopt OELS (H11a), or have greater internal assimilation and external diffusion of OELS (H11b).

3.2.4. Performance Outcomes of OELS Adoption

Through implementing OELS, companies can achieve two levels of business value (Chang and Shaw, 2009). The first-order business value is directly derived from the impact of OELS on critical business processes. It is shown that through process standardization and automation, companies can achieve cost-effectiveness from OELS' implementation (Benlian and Hess, 2009). In addition, Venkatesh and Bala (2012) found that OELS' implementation contributes to operational performance through reducing the cycle time and improving relationship quality with partners. The bonding and bridging capabilities of OELS can shift the trade-off between efficiency and flexibility (Adler et al., 1999), which can lead to cost reduction and improve operational efficiency.

H12a: Internal assimilation and external diffusion of OELS ***positively*** *affects operational performance.*

The second-order business value of OELS refers to broader firm performance including sales growth and market share (Chang and Shaw, 2009). Compared with first-order business value whose impacts on operational performance are direct and immediate, the performance impacts of second-order business value generally take a long time to achieve (Venkatesh and Bala, 2012). The benefits of process efficiency can be translated into financial gains over time. It is shown that the process and relationship values of OELS are positively related to a firm's financial performance (Chang and Shaw, 2009). Furthermore, stock market data shows that OELS initiatives are positively related to abnormal stock return ref. Aggarwal et al. (2006). The concomitant bonding and bridging capabilities can shift the trade-off between efficiency and flexibility (Adler et al., 1999), which promotes cost reductions and customer satisfaction which consequently translate into financial performance advantages (Cao and Zhang, 2011). Based on the discussion, we propose the following hypotheses:

H12b: Internal assimilation and external diffusion of OELS ***positively*** *affect operational performance.*

The hypotheses developed in this section are summarized in .

Table 3–1. Summary of Research Hypotheses

Potential Adopter		OELS Adopter	
Hypotheses	**Corollaries**	**Hypotheses**	**Corollaries**
Influence of Network Properties			
H1: The characteristics of products as a whole that are traded within a firm's supply chain network **positively** affect the adoption intention of OELS.	H1a: The complexity of products as a whole that that are transacted within a firm's supply chain network **positively** affects the adoption intention of OELS. H1b: The specificity of products as a whole that that are traded within a firm's supply chain network **positively** affects the adoption intention of OELS.	H2: The characteristics of products as a whole that are traded within a firm's supply chain network **positively** affect the level of internal assimilation and external diffusion of OELS.	H2a: The complexity of products as a whole that that are traded within a firm's supply chain network **positively** affects the level of internal assimilation and external diffusion of OELS. H2b: The specificity of products as a whole that that are traded within a firm's supply chain network **positively** affects the level of internal assimilation and external diffusion of OELS.
H3: Environmental turbulence **negatively** affects the adoption intention of OELS.	H3a: Technology turbulence **negatively** affects the adoption intention of OELS. H3b: Market turbulence **negatively** affects the adoption intention of OELS.	H4: Environmental turbulence **positively** affects the level of internal assimilation, and external diffusion of OELS.	H4a: Market turbulence **positively** affects the level of internal assimilation, and external diffusion of OELS. H4b: Technology turbulence **positively** affects the level of internal assimilation, and external diffusion of OELS.
H5: Strength of ties as a whole between a firm and its major suppliers **positively** affects the adoption intention of OELS.	H5a: The structural strength of ties as a whole between a firm and its major suppliers **positively** affects the adoption intention of OELS. H5b: The relational strength of ties as a whole between a firm and its major suppliers **positively** affects the adoption intention of OELS.	H6: Strength of ties as a whole between a firm and its major suppliers **positively** affects the level of internal assimilation, and external diffusion of OELS.	H6a: Structural strength of ties as a whole between a firm and its major suppliers **positively** affects the level of internal assimilation and external diffusion of OELS. H6b: The relational strength of ties as a whole between a firm and its major suppliers **positively** affects the level of internal assimilation and external diffusion of OELS.

Table 3–1. Summary of Research Hypotheses (Continued)

Potential Adopter	OELS Adopter
Influence of Bonding and Bridging Mechanisms	
H7a: When OELS are perceived to enhance processing coupling, a firm will be more likely to adopt OELS.	H7b: When OELS are perceived to enhance processing coupling, a firm will have greater internal assimilation and external diffusion of OELS.
H8a: When OELS are perceived to enhance processing adaptability, a firm will be more likely to adopt OELS.	H8b: When OELS are perceived to enhance processing adaptability, a firm will have greater internal assimilation and external diffusion of OELS.
H9a: When OELS are perceived to enhance relationship flexibility, a firm will be more likely to adopt OELS.	H9b: When OELS are perceived to enhance relationship flexibility, a firm will have greater internal assimilation and external diffusion of OELS.
H10a: When OELS is perceived to enhance process coupling and process adaptability at the same time, a firm will be more likely to adopt OELS.	H10b: When OELS is perceived to enhance process coupling and process adaptability at the same time, a firm will have greater internal assimilation and external diffusion of OELS.
H11a: When OELS is perceived to enhance process coupling and relationship flexibility at the same time, a firm will be more likely to adopt OELS.	H11b: When OELS is perceived to enhance process coupling and relationship flexibility at the same time, a firm will have greater internal assimilation and external diffusion of OELS.
	Performance Outcomes of OELS Adoption
	H12a: Internal assimilation and external diffusion of OELS **positively** affect operational performance
	H12b: Internal assimilation and external diffusion of OELS **positively** affect operational performance

3.3. Summary

In this chapter, the theoretical frameworks and conceptual framework have been presented, which provides the basis for deriving the hypotheses and the research model. The developed hypotheses investigate the impacts of network properties (product characteristics, environmental turbulence and tie strength) and relational mechanisms (process coupling, process adaptability and relationship flexibility) on the adoption intention, internal assimilation and external diffusion of OELS. This chapter results in the research model which was tested empirically using survey data as described in the next chapter.

CHAPTER 4. METHODOLOGY

This chapter provides detailed discussions of the research design to address the research issues of concern. The rationales behind the selection of survey method to test the hypotheses will first be discussed. The sections further describe the methodology used to design the survey, the process of collecting data, and the demographics of the collected sample. The methods are further validated for their convergent validity, discriminant validity and common method bias to ensure the reliability of the analysis results.

4.1. Research Methods

To test the hypotheses, this study collected data from manufacturing companies operating in Mainland China using a self-report survey instrument which was carefully developed following existing guidelines and exemplars (Straub, 1989; Sethi and King, 1994). China is considered as an ideal environment to study IOS and supply chain management because of the growing efforts devoted by Chinese companies in deploying IOS to integrate partners within their global supply chains (Huo et al., 2014; Liu et al., 2016). To collect data from both the potential adopters and adopters of OELS, this study prepared two versions of survey. A professional marketing company was hired to collect data. The employees of the company first contacted the potential respondents through phone to solicit their cooperation and to identify whether the companies the respondents were working for were potential adopters or current

adopters of OELS. During the first contact, the respondents who agreed to collaborate were asked to identify the type of IOS their companies are implementing. The template questions formatted for the investigators to use during the first contact are listed in the Appendix I. Based on the responses from this stage, the researchers were able to classify the respondents as potential adopters if their companies had only implemented EDI systems or as current OELS adopters if their companies had already implemented at least one OELS (e.g., RosettaNet, UBL, ebXML). The respondents thus were provided with the appropriate version of questionnaire to fill in during the second-round contact. The details of the items measured in the survey instrument are discussed in the section below.

4.2. Development of Measures

The survey instrument employed in this study was designed based on a comprehensive review of the literature on inter-organizational information systems, inter-organizational relationship management and supply chain process management. Whenever possible, existing measurements in the literature were adapted from past studies to safeguard the *content validity* of the constructs and their *fit* in the research context, and to ensure that the *overlap* among the constructs was minimal (Cronbach, 1971; Kerlinger, 1986).

The key variables in this study were operationalized as multi-item reflective and formative constructs. To decide whether a construct should be modelled as formative

or reflective, four major criteria should be examined: (1) the direction of causality between constructs and their indicators, (2) the interchangeability of indicators, (3) the covariation among indicators, and (4) the nomological net of constructs (Jarvis et al., 2003). A latent variable should be constructed as formative when the direction of causality is from the indicators to the constructs (i.e., the indicators create the constructs), the indicators are not inter-changeable and do not necessarily covary, and the nomological net of the indicators can differ (Chin, 1998, Petter, 2007 #615). In contrast, reflective constructs should be created when the opposite conditions hold: the direction of causality is from the constructs to the indicators (i.e., the indicators are caused by the constructs), and the indicators are interchangeable and necessarily covary. Suggested by the decision rules, the three second-order constructs in the research model were modelled as formative, and their sub-constructs were measured as reflective. In Table 4–1, the constructs and sub-constructs and the number of indicators associated with each construct are summarized.

Table 4–1. Summary of Construct Characteristics

Construct	Type	Sub-construct	Type	Items
Product characteristics	F	Product complexity	R	3
		Product specificity	R	3
Environmental turbulence	F	Market turbulence	R	3
		Technology turbulence	R	4
Tie strength	F	Structural strength	R	4
		Relational strength	R	4
Process coupling	F			4
Relationship flexibility	R			3
Process adaptability	R			3
Internal assimilation	F			4
External diffusion	R			3
Adoption intention	R			3
Financial performance	R			4
Operational performance	F			6

As shown in Table 4–1, process coupling, internal assimilation and operational performance were modelled as formative first-order constructs; process adaptability, relationship flexibility, adoption intention, external diffusion and financial performance were modelled as reflective first-order constructs.

4.2.1. Dependent Variables

The dependent variables involve five main constructs: (1) adoption intention, (2) internal assimilation, (3) external diffusion, (4) operational performance, and (5) financial performance. While adoption intention is the dependent variable measured in the potential adopter version of the questionnaire, the other four constructs are measured in the questionnaire to collect data from OELS adopters. This section is going to discuss the operationalization of these constructs and their sources. The details of the questionnaire items used to measure these constructs are summarized in Table 4– .

Table 4–2. Questionnaire Items: Dependent Variables

Adoption Intention *Please indicate the extent to which you agree with the following statements…*								
Options		Strongly disagree	Disagree	Somewhat disagree	Neutral	Somewhat agree	Agree	Strongly agree
AI1	Your firm is contemplating to adopt an OELS-based inter-organizational information systems in a year's time.							
AI2	Your firm is likely to adopt an OELS-based inter-organizational information systems in a year's time.							
AI3	Your firm is expecting to adopt an OELS-based inter-organizational information systems in a year's time.							

Table 4–2. Questionnaire Items: Dependent Variables (Continued)

Internal Assimilation
Please rate the extent to which your firm has been using OELS to conduct the following supply chain collaboration activities…

Options		Extremely small extent	Very small extent	Small extent	Moderate	Large extent	Very large extent	Extremely large extent
INA1	Supplier selection (getting quotes, bidding etc.)							
INA2	Purchase order processing							
INA3	Procurement from suppliers (distribution, warehouse, shipping, logistics etc.)							
INA4	Invoicing and payment processing							

External Diffusion
Please indicate the percentage of total transactions or inter-firm interactions that your firm has performed through OELS…

Options		0-10%	11-20%	21-30%	31-40%	41-50%	51-60%	61-70%	71-80%	81-90%	91-100%
EXD1	Percentage of total supply chain partners who interact with your organization through OELS										
EXD2	Percentage of total supply chain partner transactions performed through OELS										
EXD3	Percentage of overall interactions with supply chain partners carried out through OELS										

Operational Performance
Over the past three years, your firm has performed better than your key competitors in…

Options		Strongly disagree	Disagree	Somewhat disagree	Neutral	Somewhat agree	Agree	Strongly agree
OP1	Decreasing product/service delivery cycle time							
OP2	Rapidly responding to market demand changes							
OP3	Rapidly bringing new products/services to the market							
OP4	Rapidly entering new markets							
OP5	Rapidly confirming customer orders							
OP6	Rapidly handling customer complaints							

Financial Performance
Over the past three years, your firm has performed better than your key competitors in…

Options		Strongly disagree	Disagree	Somewhat disagree	Neutral	Somewhat agree	Agree	Strongly agree
FIN1	Return on investment							
FIN2	Profits as percentage of sales							
FIN3	Net income before tax							
FIN4	Cash flow from operations							

Adoption intention is measured with three reflective questionnaire items adapted from Teo et al. (2003), Khalifa and Davison (2006) and Liu et al. (2010), and the items have been modified to reflect the target of this study (OELS) and the expected time frame (1 year). For complex supply chain operational strategy like the adoption of OELS, 1 year would be an appropriate period of time for prediction (Liu et al., 2010). As suggested by Ajzen and Fishbein (1980), to make a proper prediction of actual behaviour and to be consistent with the measures of actual behaviour, the measures for behavioural intention should contain the four criteria of behaviour in terms of action, target, context and time-frame. The three items used in this study can reflect these four elements of behaviour and thus are consistent with the measures for actual behaviours (Ajzen, 2005).

Internal Assimilation measures the extent to which OELS have been used to support internal supply chain operation practices (Zhang et al., 2016). Following Zhu et al. (2006b), Zhang and Dhaliwal (2009) and Zhang et al. (2016), a four-item formatively measured construct was developed to assess the degree of OELS usage in four key supply chain activities: supplier selection, purchase-order processing, procurement from suppliers, and invoicing and payment processing.

External diffusion refers to the degree to which OELS have been used to facilitate inter-organizational activities with supply chain partners. Three reflective items were adapted from Premkumar et al. (1994); Premkumar and Ramamurthy (1995); Zhang

and Dhaliwal (2009); and Zhang et al. (2016) to measure the breadth and volume of the transactions that a firm has conducted through OELS (Zhu and Kraemer, 2002; Zhang and Dhaliwal, 2009; Zhang et al., 2016), which includes the number of partners a firm has been interacting with, the volume of transactions with partners, and the overall interactions with partners that have been handled via OELS.

Operational performance was adapted from Liu et al. (2016) as a six-item formative variable to collectively assess a firm's ability to perform customer service and respond to changes in the market environment compared with its key competitors over the last three years. Compared with previous studies which typically assess firms' conformance to cost, delivery speed, quality, and flexibility (Neely et al., 1995), the six-item construct employed in this study could capture the arising challenges posed by time-based competition that emphasizes the ability to quickly respond to external changes (Rai et al., 2006). Additionally, these measurements are specially tailored to reflect the process-related benefits enabled by supply chain integration and information technology (Liu et al., 2016), which is appropriate for the context of this study that investigates the organizational consequences of OELS.

Financial performance was assessed using four reflective items adapted from Chen et al. (2004) and Liu et al. (2016). The scales measure the extent to which a firm perceives its performance in terms of return on investment, profits as a percentage of sales, net income before tax, and cash flow from operations to be better than its key

competitors over the last three years. Compared with traditional performance metrics such as cost and cycle time reduction, these measures would be more appropriate for the context of IOS-enabled supply chain integration where customer satisfaction and revenue generation are indicated to be more important factors for performance (Chen et al., 2004).

4.2.2. Independent Variables

As suggested by the research model, there are two main dimensions of independent variables: network-level properties and relational mechanisms. The three main constructs measuring supply chain network properties, i.e., product characteristics, environmental turbulence and tie strength, were operationalized as formative second-order constructs consisting of several sub-constructs.

All of the independent variables were measured in both potential adopter and OELS adopter versions. Slight modifications of wording were made in the two versions of questionnaire to reflect the differences between potential adopter and current adopter. Table 4–3 summarizes the items developed to measure network properties. The constructs measuring the relational mechanisms, i.e., process coupling, process adaptability, and relationship flexibility, were assessed with multi-item scales, the questionnaire items of which are provided in Table 4–4.

Table 4–3. Questionnaire Items: Network Properties

Product Complexity *For the following questions, please consider "the products" as the products as a whole that your firm has been trading through OELS [may consider trading through OELS].*								
Options		Strongly disagree	Disagree	Somewhat disagree	Neutral	Somewhat agree	Agree	Strongly agree
PC1	A large amount of information is required to describe the products							
PC2	Many attributes are required to describe the products							
PC3	The specifications of the products are relatively longer than other products we buy							
Product Specificity *For the following questions, please consider "the products" as the products as a whole that your firm has been trading through OELS [may consider trading through OELS].*								
Options		Strongly disagree	Disagree	Somewhat disagree	Neutral	Somewhat agree	Agree	Strongly agree
PS1	The products need to be designed specifically to our needs							
PS2	The products need to be customized (or tailored) specifically to needs of our firm							
PS3	The products are of value to only a small number of buyers							
Market Turbulence *Please indicate the extent to which you agree with the following statements regarding the principal market your company is operating in…*								
Options		Strongly disagree	Disagree	Somewhat disagree	Neutral	Somewhat agree	Agree	Strongly agree
MT1	We continuously cater too many new customers							
MT2	Demand and customer tastes are very difficult to forecast							
MT3	Our customers tend to look for new products all the time							
Technology Turbulence *Please indicate the extent to which you agree with the following statements regarding the principal industry your company is operating in…*								
Options		Strongly disagree	Disagree	Somewhat disagree	Neutral	Somewhat agree	Agree	Strongly agree
TT1	It is very difficult to forecast where the technology in our industry will be in the next 2–3 years							
TT2	A large number of new product ideas have been made possible by technological breakthroughs in our industry							

Table 4–3. Questionnaire Items: Network Properties (Continued)

Options		Strongly disagree	Disagree	Somewhat disagree	Neutral	Somewhat agree	Agree	Strongly agree
TT3	In our principal industry the modes of production and service often change							
TT3	In our principal industry the modes of production and service often change							
TT4	The rate of product/service obsolescence in our industry is very high							
Structural Strength *Please answer the following questions regarding the relationships between your firm and the partners that your firm has been interacting with through OELS [may consider interacting through OELS].*								
Option		1 or less times per year	2-4 times per year	5-8 times per year	9-11 times per year	1-3 times per month	1-4 times per week	1 or more times per day
SS1	All in all, how often does your organization interact with these partners (on average over the past 3–5 years)?							
Option		Never	Rarely	Occasionally	Sometimes	Frequently	Usually	Every time
SS2	To what extent has your organization been interacting with these partners (on average over the past 3–5 years)?							
Option		Very distant	Distant	Somewhat disagree	Neutral	Somewhat close	Close	Very close
SS3	How close has the working relationship been between your organization and these partners (on average over the past 3 years)?							
Option		Strongly disagree	Disagree	Somewhat disagree	Neutral	Somewhat agree	Agree	Strongly agree
SS4	Your organization is extensively engaged in joint projects with these partners							
Relational Strength *Please answer the following questions regarding the relationships between your firm and the partners that your firm has been interacting with through OELS [may consider interacting through OELS].*								
Options		Strongly disagree	Disagree	Somewhat disagree	Neutral	Somewhat agree	Agree	Strongly agree
RS1	Your organization trusts these partners to keep their promises							
RS2	These partners have always been fair in their negotiations with your organization							
RS3	These partners always reciprocate the favours you do for them							

RS4	These partners are trustworthy organizations							

Table 4–4. Questionnaire Items: Proxies for Relational Mechanisms

Process Coupling *OELS-based inter-organizational information systems can …*								
Options		Strongly disagree	Disagree	Somewhat disagree	Neutral	Somewhat agree	Agree	Strongly agree
PCL1	Help us closely coordinate interdependent processes with partners							
PCL2	Enable interdependent operating procedures and routines to be highly visible among partners and us							
PCL3	Help us jointly optimize related operating processes with partners							
PCL4	Help us share exceptions and errors that occur during daily operations with specific partners in a timely manner							
Process Adaptability *OELS-based inter-organizational information systems can …*								
Options		Strongly disagree	Disagree	Somewhat disagree	Neutral	Somewhat agree	Agree	Strongly agree
ADP1	Help our firm adapt existing supply chain relationships to respond quickly to changes in our markets							
ADP2	Help our firm adapt existing business processes to rapidly respond to shifts in our business priorities							
ADP3	Help our firm facilitate reconfiguration of supply chain activities to respond to changes in the external environment							
Relationship Flexibility *OELS-based inter-organizational information systems can …*								
Options		Strongly disagree	Disagree	Somewhat disagree	Neutral	Somewhat agree	Agree	Strongly agree
FLX1	Help our firm identify alternative sources							
FLX2	Help our firm locate alternative products or services							
FLX3	Help our firm seek new partners							

Product characteristics measured the characteristics of the products as a whole that an adopter firm has traded through OELS or a potential adopter firm may trade through OELS, which was constructed as a second-order variable consisting of two sub-constructs: **product complexity** and **product specificity**. Product complexity measures how much information is required to delineate the attributes and specifications of a product, while product specificity examines the extent to which a product is designed or tailored for a specific company that cannot be readily utilized by other companies (Son and Benbasat, 2007). Both product complexity and product specificity were measured by three reflective items adapted from Malone et al. (1987) and Son and Benbasat (2007).

Environmental turbulence, which is classified as **market turbulence** and **technology turbulence**, refers to the endogenous uncertainty or risk occurring within supply chain networks that may impact the relationships between a firm and its major partners (Trkman and McCormack, 2009). Market turbulence describes the heterogeneity and the rapid variations in a firm's customer portfolio and the preferences of its customers (Kandemir et al., 2006), which was assessed by three reflective items adapted from Calantone et al. (2003), Kandemir et al. (2006), Koo et al. (2006), and Trkman and McCormack (2009). Technology turbulence refers to the speed of changes in technology over time in the principal industry that a firm operates in and the consequences these changes induce to the industry (Chatterjee, 2004). Four reflective items adapted from Calantone et al. (2003), Auh and Menguc (2005),

Kandemir et al. (2006), Koo et al. (2006), and Trkman and McCormack (2009) were employed in this study to measure technology turbulence.

Tie strength assesses the extent to which an adopter firm and the partners it has been interacting with through OELS (or a potential adopter firm and the partners it may interact with through OELS) are structurally and relationally tied in their supply chain relationships (Kim and Choi, 2018). This study measured tie strength with two dimensions (Krackhardt, 1992): **structural strength** that refers to the intensity and frequency of interactions among supply chain partners and the diversity of their interactions (Hansen, 1999), and **relational strength** that refers to the level of mutual trust, support and reciprocation among supply chain partners (Ibarra, 1992). Four reflective items were adapted from Kim and Choi (2018) to reflect structural strength in terms of interaction frequency, closeness (Hansen, 1999; Peter, 2005), and multiplexity (Marsden and Campbell, 1984) of the ties between two companies. Relational strength was assessed with four reflective items adapted from Ganesan (1994), Zaheer et al. (1998); Johnson et al. (1996), and Kim and Choi (2018) to measure the perceptions held by a firm in terms of the reliability, integrity, trustworthiness and reciprocity of its supply chain partners.

Bonding mechanism was proxied by **process coupling**, which measured the extent to which OELS can facilitate the coordination and joint optimization of activities between a firm and its supply chain partners, and was measured with four formative

items adapted from Malone and Crowston (1994), Subramani and Venkatraman (2003), Tang and Rai (2012) and Rai and Tang (2010). The four items assessed the capabilities of OELS to enhance bonding among supply chain partners through coordinating interdependency, improving process visibility, optimizing supply chain processes, and handling operational exceptions and errors efficiently.

Bridging mechanism, which refers to the capabilities of OELS to enrich a firm's perspectives by enabling it to gain access and insights into broader environments, was proxied by **process adaptability** and **relationship flexibility**. Three reflective items were adapted from Gibson and Birkinshaw (2004) and Im and Rai (2008) to measure process adaptability as the capability of OELS to promote organizational responsiveness to the variantions in the external environment through reconfiguring and adjusting supply chain relationships and activities. Relationship flexibility, which was measured with three reflective items adapted from Gosain et al. (2004), Saeed et al. (2005) and Young-Ybarra and Wiersema (1999), captured the extent to which OELS can enhance a firm's ability to change or adjust its supply chain network by adding more partners.

4.2.3. Control Variables

To control for unobserved heterogeneity caused by industry effects in performance analysis, following China's industrial classification guide (National Bureau of Statistics, 2017), eight **industry dummies** were created to represent the industries of

the following: (1) automobiles and components, (2) electrical and electronics, (3) materials and chemicals, (4) healthcare and healthcare machinery, (5) industrial and commercial machinery and equipment, and (6) others. **Ownership** was also controlled by creating dummy variables to indicate whether a firm was state-owned, privately owned, or foreign-controlled. In addition, performance was also controlled for the influence of **firm size** by measuring the overall number of employees of a firm. Larger firms tend to enjoy more abundant resources that may lead to different performance compared with smaller firms.

Two control variables – **relationship duration** and **supplier base size** – were also created for dependent variables measuring adoption, i.e., internal assimilation, external diffusion and adoption intention, to account for the possible effects of supplier portfolio characteristics (Tang and Rai, 2012). Relationship duration measured the average relationship length (in years) between a firm and its major suppliers, which is consistent with Im and Rai (2008). Supplier base size refers to the number of major suppliers a firm has been routinely interacting with.

4.3. Data Collection

4.3.1. Sampling Frame and Collection Procedure

To facilitate the data collection process, a professional research company specialized in large marketing investigation was hired to distribute the questionnaires. The list of

manufacturing firms with the Chinese Industrial Classification (CIC) codes 1311 – 4290 (National Bureau of Statistics, 2017) was decided to be the **sampling frame** to ensure that the sample could span the comprehensive spectrum of manufacturing industries. Following Cai et al. (2010), the target companies were randomly selected based on the stratify probability proportional to sizes (PPS) method, which could ensure the representativeness of the sample in terms of industry, firm size and ownership. A list of 3,400 firms was selected as the target samples.

The surveys were conducted through computer-aided phone interviews by the employees of the professional research company. Based on standard practice (Flynn et al., 2010; Zhou et al., 2014; Liu et al., 2016), the senior executives, such as the chief executive officer, chief technology officer, and senior operations managers, were identified to be the key informants because they have adequate knowledge about their companies' overall operational and IT capabilities. As explained in an earlier section, the data collection professionals first identified whether a firm was a potential adopter or current adopter of OELS before administrating the right version of the questionnaire to the respondents. After discarding the responses with excessive missing data and low confidence levels, the final sample consisted of 423 valid responses (12.44% effective response rate), among which 205 were responses from potential adopters and 218 were from OELS current adopters.

To test for non-response bias, the companies in the final samples were compared with the non-respondent firms in terms of industry, ownership, and firm size. No significant differences were identified between them, which suggests that the sample had adequate representativeness with a minimal level of non-response bias.

4.3.2. Sample size

This study is going used partial least squares structural equation modelling (PLS-SEM) to analyse the data and test the hypotheses. Although a major advantage of PLS-SEM is its ability to work with a relatively small sample size (which will be explained in more details in the next chapter), researchers have emphasized the importance of considering the requirements for the sample size when using PLS-SEM (Goodhue et al., 2006; Marcoulides and Saunders, 2006; Marcoulides et al., 2009). The often cited rules of thumb, proposed by Barclay et al. (1995) and postulated by Chin (1998), suggest that the minimum sample size for PLS-SEM should be equal to the larger of:

(1) ten times the largest number of formative indicators used to measure one single construct, or

(2) ten times the largest number of structural paths directed at a particular latent construct in the full structural model.

For the potential adopter model, process coupling is the only formative construct formed with four indicators, which indicates that the minimum sample size should

equal to 40 if following the first rule. In addition, the construct with the most structural paths directed at it was adoption intention, with 19 paths in total (6 direct effects, 3 moderating effects, and 10 control variables). Therefore, the minimum sample size as indicated by the second rule is 190. Synthesizing the two rules, the minimum sample size for the potential model should be 190 (the larger of the two derived sample sizes). The sample size for the potential adopter model in this study was 205, thereby satisfying the requirements for sample size.

For the OELS adopter model, the formative construct with the most indicators was operational performance consisting of six indicators. Therefore, the minimum sample size indicated by the first rule should be 60. Regarding the number of structural paths, internal assimilation and external diffusion were the two constructs with the most paths, both of which had 17 paths (6 direct effects, 3 moderation effects, 8 control variables) directed at them. As a result, the minimum size indicated by the second rule should be 170, larger than the sample size suggested by the first rule. Therefore, the minimum sample size for the OELS adopter model should be 170 when considering both rules. The sample size in this study for the OELS adopter model (218) thus satisfied the requirements for minimum sample size.

4.3.3. Sample Characteristics

The firms in the potential adopter and OELS adopter samples represented a comprehensive spectrum of the major manufacturing industries, including automobiles

and components (12.68% of potential adopters and 5.5% of OELS adopters), electrical and electronics (17.07% of potential adopters and 23.39% of OELS adopters), materials and chemicals (26.83% of potential adopters and 29.82% of OELS adopters), healthcare and healthcare machinery (15.12% of potential adopters and 11.47% of OELS adopters), industrial and commercial machinery and equipment (14.15% of potential adopters and 15.14% of OELS adopters), and others (14.15% of potential adopters and 14.68% of OELS adopters). Among them, 7.32% of the potential adopters and 5.50% of the OELS adopters had a company history of less than 5 years; 27.32% of the potential adopters and 41.74% of the OELS adopters had operated between 6 and 10 years; 65.37% of the potential adopters and 52.75% of the OELS adopters had more than 11 years of company history. Regarding firm size in terms of annual turnover (last fiscal year), 12.68% of the potential adopters and 11.47% of the OELS adopters reported less than RMB25 millions of turnover; 6.83% of the potential adopters and 25.23% of the OELS adopters had turnovers between RMB25 million and RMB100 million; 10.73% of the potential adopters and 23.39% of the OELS adopters reported turnovers between RMB100 and 300 million; and 69.76% of the potential adopters and 39.91% of the OELS adopters reported more than RMB300 million of annual turnover. In addition, 10.73% of the potential adopters and 12.84% of the OELS adopters hired a workforce of below 160 employees; 28.29% of the potential adopters and 56.42% of the OELS adopters had 160 to 1,000 employees; and 60.98% of the potential adopters and 30.73% of the OELS adopters hired more than

1,000 employees. The respondent companies also represented an even distribution of company ownership, including companies that were state-owned (17.07% of the potential adopters and 9.17% of the OELS adopters), privately-owned (42.93% of the potential adopters and 50.0% of the OELS adopters) and foreign controlled (40.0% of the potential adopters and 40.83% of the OELS adopters). Among the potential adopters, 58.05% of them were operating in multiple nations and 41.95% of them were operating locally; 27% of the OELS adopters were multinational organizations, and 72.94 of them were local organizations. Regarding IT capability, only 14.63% of the potential adopters and 21.10% of the OELS adopters had an IT department of fewer than five IT staff; 21.46% of the potential adopters and 30.28% of the OELS adopters hired between six and 10 IT staff; 22.93% of the potential adopters and 30.73% of the OELS adopters hired between 11 and 15 IT staff; and 40.98% of the potential adopters and 17.89% of the OELS adopters ran an IT department of more than 16 IT staff. The demographics of the respondent firms are summarized in Table 4–5.

Regarding the respondent profile, only a very small portion of the respondents were the CEOs or presidents of their companies (2.44% of the potential adopter sample and 0.92% of the OELS adopter sample); 38.05% of the respondents in the potential adopter sample and 39.91% of respondents in the OELS adopter sample were senior executives or vice presidents; 25.37% of the respondents from the potential adopter companies and 22.48% of the respondents from the OELS adopter companies were IT managers, CIOs or CTOs; and more than 34% of the respondents of the potential

Table 4–5. Sample Demographics

	Potential Adopter (N=205)		OELS Adopter (N = 218)	
	Frequency	Percentage	Frequency	Percentage
Industry				
Automobiles & Components	26	12.68%	12	5.50%
Electronical & electronics	35	17.07%	51	23.39%
Materials/Metals/Chemicals	55	26.83%	65	29.82%
Energy	8	3.90%	8	3.67%
Food & Tobacco	11	5.37%	10	4.59%
Health Care	31	15.12%	25	11.47%
Equipment & machinery	29	14.15%	33	15.14%
Consumer Durables & Apparel	29	14.15%	32	14.68%
Years of Operation				
≦ 5 Years	15	7.32%	12	5.50%
6-10 Years	56	27.32%	91	41.74%
≧ 11 Years	134	65.37%	115	52.75%
Turnover				
< 25 million	26	12.68%	25	11.47%
25–100 million	14	6.83%	55	25.23%
100-300 million	22	10.73%	51	23.39%
> 300 million	143	69.76%	87	39.91%
Employee				
<160	22	10.73%	28	12.84%
160-1000	58	28.29%	123	56.42%
> 1000	125	60.98%	67	30.73%
Size of IT Department				
≦ 5	30	14.63%	46	21.10%
6 – 10	44	21.46%	66	30.28%
11– 15	47	22.93%	67	30.73%
≧ 16	84	40.98%	39	17.89%
Organization Type (Ownership)				
State-owned (fully/partly owned)	35	17.07%	20	9.17%
Privately-owned	88	42.93%	109	50.00%
Foreign Controlled	82	40.00%	89	40.83%
Operation Scope				
Multinational Organization	119	58.05%	59	27.06%
Non-Multinational Organization	86	41.95%	159	72.94%

Table 4–6. Respondent Profile

	Potential Adopter		OELS Adopter	
	Frequency	Percentage	Frequency	Percentage
Position				
CEO/President	5	2.44%	Am2	0.92%
Senior executive/Vice President	78	38.05%	87	39.91%
IT Manager/CIO/CTO	52	25.37%	49	22.48%
Supply Chain/Operations Manager/ COO	70	34.15%	80	36.70%
Years of Working				
< 5 Years	40	19.51%	69	31.65%
6-10 Years	151	73.66%	145	66.51%
> 11 Years	14	6.83%	4	1.83%

sample and more than 36% of the respondents of the OELS adopter sample were supply chain managers, operations managers or COOs. Among respondents from the potential adopter companies, 19.51% of them worked for less than 5 years; 73.66% of them had stayed in their companies for between 6 and 10 years; and 6.83% of them had experience of more than 11 years; 31.65% of the respondents from the OELS adopter companies had worked for less than 5 years; 66.51% of them had 6 to 10 years of experience; and only 1.83% of them had experience of more than 11 years. The summary of the respondent profiles is presented in Table 4–6.

4.4. Summary

This study has developed a survey instrument to collect data to examine the hypotheses proposed in Chapter 3. This chapter describes in details the rationales for the survey methodology, and the procedures of this study follows to design the research methodology. How the questionnaire measured the variables adopted in this study is presented. The minimum sample sizes to analyse the research models prp[osed in Chapter 3 are derived. A sample of 205 potential adopters and another sample of 218 current adopters of OELS data were collected in mainland China, which were utilized to test the hypotheses as described in the next chapter.

CHAPTER 5. DATA ANALYSIS AND RESULTS

This chapter discusses the detailed results and findings of hypothesis testing to determine the critical factors affecting OELS adoption. The Partial Least Squares Structural Equation Modelling (PLS-SEM) was employed to analyse the *measurement* and *structural* models. The discussion begins by describing each variable and its items, which is followed by validating the internal consistency, convergent validity, and discriminant validity. The assessments of the measurement models were conducted separately for *reflective* and *formative* indicators. The analysis of the structural models was performed after the validation of measurement models to examine the hypotheses proposed in Chapter 3. A bootstrapping procedure was employed to test the significance levels of the results. It is indicated that the number of bootstrap samples must be greater than or at least equal to the number of valid observations of the data. This study used 5,000 bootstrap samples as recommended by Hair et al. (2014).

5.1. Overview of the PLS-SEM Algorithm

There has been an increasing momentum of employing PLS-SEM to model and analyse data involving latent variables in various disciplines such as the fields of information systems, marketing and strategic management (Urbach and Ahlemann, 2010). As a causal modelling approach, PLS-SEM aims at maximizing the explained variance of the dependent variables (Hair et al., 2011), which is very different from conventional covariance-based structural equation modelling (CB-SEM) approach

where the focus is to reproduce the theoretical variance matrix but not the explained variance. In addition, because PLS-SEM calculates the latent variables' scores as the exact linear combinations of the observed latent variables' scores, indeterminacy problem, which refers to the difficulty in generating stable factor scores, can be avoided (Fornell and Larcker, 1981). Therefore, PLS-SEM would be especially useful when these scores will be used subsequently for data analysis.

It is suggested that the choice between PLS-SEM and CB-SEM hinges on the objectives of the underlying research. CB-SEM is more appropriate when the primary goals are testing, confirmation, or comparison between different theories because the foundation of prior theory is strong (Joreskog and Wold, 1982). However, the results of CB-SEM are not optimal for the purpose of prediction. PLS-SEM is more theory-oriented, which is suitable when the primary goal is prediction or theory development (Henseler et al., 2009). Table 5–1 displays the rules of thumb that can be applied when deciding whether to use CB-SEM or PLS-SEM.

Table 5–1. Rules of Thumb for Selecting between PLS-SEM and CB-SEM

Criteria	Select PLS-SEM when…	Select CB-SEM when…
Research Objective	• Prediction and identification of the key dependent constructs or the key independent constructs • Explanatory research or theory development	Theory testing, confirmation, and comparison between different theories
Model Specification	• There are formative constructs in the model • High complexity	Error terms require additional specification
Data Characteristics	Data are to some extent non-normal	Non-convergence and normal data distribution conditions are met
Model Evaluation	Latent variable scores are used for analysis	• Global goodness of fit indexes are needed • Measurement model invariance needs to be tested

To summarize, PLS-SEM is a more favourable approach when the underlying research problem demonstrates the following characteristics (Chin, 1998; Hair et al., 2011)：

- The research phenomenon or question to be investigated is relatively new which requires the development of new measurement models
- The structural model is complex involving a large number of latent variables and measurement indicators
- Formative and reflective measurements are both employed to model the relationships between the indicators and their respective latent variables
- The requirements for sample size, independence, or normal distribution are not satisfied, and/or
- Prediction and theory development are more important than parameter estimation and theory confirmation

Therefore, this study employs PLS-SEM to perform data analysis and hypothesis testing because 1) OELS is still a relatively new phenomenon and the theoretical foundations employed in this study haven't been applied and tested to study OELS; 2) the research model involves both reflective and formative constructs; and 3) the structural model is complex involving 14 latent variables as well as interaction effects.

5.2. Descriptive Statistics

Before beginning with model estimations, the characteristics of the data samples are explored. Table 5– summarizes the mean, standard deviation, minimum value, and

maximum value of each indicator to present an overview of the items collected for data analysis.

Table 5–2. Descriptive Statistics

Construct	Item	Potential Adopter (N = 205)				OELS Adopter (N = 218)			
		Mean	Standard Deviation	Min	Max	Mean	Standard Deviation	Min	Max
Product Complexity	PC1	5.102	0.893	3	7	5.128	0.653	3	7
	PC2	5.020	0.816	3	7	5.211	0.881	3	7
	PC3	4.966	0.807	3	7	5.106	0.609	3	6
Product Specificity	PS1	4.946	0.961	3	7	5.101	0.842	3	7
	PS2	5.083	0.609	3	6	5.096	0.626	3	6
	PS3	4.785	0.621	2	6	4.817	0.653	3	6
Market Turbulence	MT1	4.990	0.891	3	7	4.977	0.817	3	7
	MT2	5.254	0.915	3	7	5.115	0.970	3	7
	MT3	5.298	1.036	3	7	5.394	0.901	3	7
Technology turbulence	TT1	5.585	1.224	3	7	5.500	1.196	3	7
	TT2	5.424	0.875	3	7	5.427	0.796	3	6
	TT3	5.590	0.959	3	7	5.569	0.772	3	7
	TT4	5.863	0.955	1	7	5.821	1.007	4	7
Structural Strength	SS1	4.073	1.154	1	7	3.688	0.995	1	7
	SS2	3.937	0.650	2	6	3.899	0.507	2	6
	SS3	4.195	0.642	3	6	4.128	0.510	3	6
	SS4	4.410	1.115	2	7	4.583	0.986	2	7
Relational Strength	RS1	4.663	0.975	3	7	4.661	0.839	3	6
	RS2	4.522	0.993	2	6	4.454	1.016	2	6
	RS3	4.293	0.996	2	6	4.394	0.843	3	6
	RS4	4.571	0.991	2	6	4.670	0.906	3	6
Process Coupling	PCL1	4.800	1.012	3	7	4.739	1.061	3	7
	PCL2	4.766	0.967	2	7	4.748	0.867	2	6
	PCL3	4.795	1.023	3	7	4.812	0.939	3	6
	PCL4	4.727	1.035	3	7	4.789	0.901	3	7
Process Adaptability	ADP1	5.020	1.057	2	7	5.078	0.925	1	7
	ADP2	4.780	1.022	3	7	4.894	0.855	1	7
	ADP3	5.054	0.887	3	7	4.936	0.934	1	7
Relationship Flexibility	FLX1	5.000	0.950	3	7	4.968	0.822	2	7
	FLX2	4.815	1.082	2	7	4.908	1.056	3	7
	FLX3	4.756	0.965	3	7	4.647	0.935	2	7
Adoption Intention	AI1	4.463	1.069	2	7				
	AI2	4.385	0.992	3	7				
	AI3	4.376	1.080	2	7				
Internal Assimilation	IAS1					3.963	1.068	1	7
	IAS2					3.968	0.897	1	7
	IAS3					3.963	0.940	1	7
	IAS4					5.101	0.863	3	7
External Diffusion	EDI1					4.766	1.868	2	8
	EDI2					4.193	1.856	2	8
	EDI3					4.482	1.776	1	8
Operational Performance	OP1					4.711	0.913	2	7
	OP2					4.812	0.904	3	7
	OP3					4.661	0.811	3	7
	OP4					4.862	0.900	3	6
	OP5					4.601	1.052	3	7
	OP6					4.977	0.587	3	6
Financial Performance	FIN1					4.092	1.184	1	6
	FIN2					3.963	1.068	1	6
	FIN3					4.133	0.867	2	6
	FIN4					3.789	1.132	1	6

5.3. Measurement Validation: Reflective Measures

The evaluation of the measurement model examines the relationships between the measurement items and the constructs. The estimation of the structural model will not be conducted until the reliability and validity of the latent constructs are established. Because reflectively measured constructs and formatively measured constructs are based on different concepts, they must be distinguished when evaluating the measurement models by using different assessment measures (Ringle et al., 2009). Reflective measurements were assessed regarding their **internal consistency reliability** and **construct validity**, and the rules of thumb for evaluating reflective measurement models are summarized in Table 5–3.

Table 5–3. Rules of Thumb for Reflective Measurement Evaluation

Category		Measure	Acceptance level
Internal Consistency Reliability		Composite Reliability	0.70 or higher
Construct Validity	Convergent Validity	Outer Loading	0.70 or higher
		AVE	0.50 or higher
	Discriminant Validity	AVE	Higher than the variable's largest squared correlation with any other latent variables
		Outer Loading	Greater than cross-loadings

Source: Hair et al. (2011)

Composite reliability is routinely used as the estimate of internal consistency reliability. The conventional mean to measure internal consistency – **Cronbach's alpha** – estimates reliability based on the inter-correlations of the indicators, and assumes that all of the indicators are equally reliable, which is suggested to be not appropriate in the context of PLS-SEM where individual reliability is used to prioritize indicators (Ringle et al., 2009). In addition, Cronbach's alpha is criticized as being too

sensitive to the number of items in a dimension, which may pose the threat of underestimating internal reliability (Hair et al., 2014). Therefore, composite reliability, which does not assume equal reliability among indicators, is a more appropriate estimate of internal reliability for PLS-SEM. Composite reliability evaluates internal consistency reliability using the standardized outer loading (λ_i) of the indicator i of a specific construct, which is calculated with the following formula (Chin, 1998):

$$Composite\ Reliability\ = \frac{(\sum \lambda_i)^2}{(\sum \lambda_i)^2 + \sum(1 - \lambda_i{}^2)}$$

Composite reliabilities of 0.70 or higher are considered to indicate adequate levels of internal consistency (Barclay et al., 1995; Compeau et al., 1999; Agarwal and Karahanna, 2000). As presented by Table 5–4, the composite reliabilities of all constructs were greater than the threshold, suggesting satisfactory internal consistency of the reflective measurement model.

Construct validity assesses whether the items can actually capture the concepts that the constructs intend to measure (Bagozzi, 1980), which is typically evaluated by convergent validity and discriminant validity respectively. **Convergent validity** indicates the degree to which an indicator is positively correlated with the remaining indicators in the same construct. For reflective measures, indicators measuring the same construct should converge or share a large portion of variance because they are

Table 5–4. Internal Consistency and Convergent Validity

Construct	Item	Potential Adopter			OELS Adopter		
		Outer loadings	Composite Reliability	AVE	Outer loadings	Composite Reliability	AVE
1. Product Complexity	PC1	0.857	0.832	0.624	0.781	0.810	0.589
	PC2	0.790			0.682		
	PC3	0.717			0.831		
2. Product Specificity	PS1	0.750	0.780	0.640	0.751	0.836	0.721
	PS2*	-			-		
	PS3	0.847			0.936		
3. Market Turbulence	MT1	0.768	0.832	0.622	0.825	0.832	0.624
	MT2	0.793			0.700		
	MT3	0.804			0.837		
4. Technological Turbulence	TT1	0.923	0.904	0.703	0.904	0.875	0.638
	TT2	0.816			0.738		
	TT3	0.824			0.805		
	TT4	0.784			0.738		
5. Structural Strength	SS1	0.835	0.862	0.609	0.765	0.837	0.563
	SS2	0.739			0.745		
	SS3	0.771			0.701		
	SS4	0.774			0.787		
6. Relational Strength	RS0	0.827	0.819	0.602	0.730	0.801	0.573
	RS2	0.778			0.804		
	RS3	0.719			0.735		
	RS4*	-			-		
7. Process Coupling	PCL1	0.852	-	-	0.858	-	-
	PCL2	0.823			0.833		
	PCL3	0.802			0.821		
	PCL4	0.813			0.721		
8. Process Adaptability	ADP1	0.826	0.888	0.726	0.872	0.872	0.695
	ADP2	0.900			0.759		
	ADP3	0.828			0.866		
9. Relationship Flexibility	FLX1	0.786	0.850	0.655	0.754	0.821	0.604
	FLX3	0.848			0.767		
	FLX4	0.792			0.809		
10. Adoption Intention	IAS1	0.897	0.924	0.802			
	IAS2	0.876					
	IAS3	0.913					
	IAS4				0.892		
11. Internal Assimilation	FA2				0.898	-	-
	FA3				0.913		
	FA4				0.680		
12. External Diffusion	EDI1				0.978	0.983	0.949
	EDI2				0.978		
	EDI3				0.967		
13. Operational Performance	OP1				0.710	-	-
	OP2				0.618		
	OP3				0.610		
	OP5				0.673		
	OP4				0.669		
	OP6				0.535		
14. Financial Performance	FIN1*				-	0.881	0.712
	FIN2				0.796		
	FIN3				0.879		
	FIN4				0.854		

* Item dropped because of loading lower than 0.70

treated as different approaches to measure the same variable (Hair et al., 2014). Therefore, the indicators' **standardized outer loadings** and the **average variance extracted (AVE)** should be considered to establish convergent validity.

The reflective measurement models exhibit desirable **indicator reliability** when the outer loadings of a construct are high because what are captured by the construct from the corresponding indicators have much in common. The general rule of thumb is that the standardized outer loadings (similar to the loadings in principal component analysis) should be greater than 0.70 (Compeau et al., 1999; Agarwal and Karahanna, 2000), because the square of an indicator's standardized outer loading, which measures how much of the variation in the indicator is explained by the associated construct (indicator communality), should be greater than 50% ($\approx 0.70^2$). For reflective with outer loadings between 0.40 and 0.70, it should be considered to remove them if the composite reliability of the associated construct can be improved after dropping them. Indicators with outer loadings below 0.40, however, should always be deleted from the construct measurements (Hair et al., 2011). As shown in Table 5–4, the outer loadings of the reflective indicators were all greater than 0.70 after dropping items PS2 and RS4, suggesting adequate indicator reliability for both potential adopter and adopter models.

To further establish convergent validity at the construct level, the **average variance extracted (AVE)** should be investigated. AVE is equivalent to the construct's **communality** by measuring the grand mean value of the standardized loadings of the

indicators in a construct (Hair et al., 2011), which is calculated with the following formula (Chin, 1998):

$$AVE = \frac{\sum \lambda_i^2}{\sum \lambda_i^2 + \sum(1 - \lambda_i^2)}$$

Similar to indicator-level communality, AVE should be greater than 0.50 to ensure that the construct explains, on average, more than 50% of the variance in the associated indicators. An AVE smaller than 0.50 would suggest that the errors in the indicators are more than the variance explained by the latent construct (Barclay et al., 1995; Chin, 1998; Hair et al., 2011). Table 5–4 shows the AVEs of all the reflective constructs, for both potential adopter and adopter samples, are greater than the critical value, which lends evidence to support the convergent validity of the reflective measurements.

Discriminant validity evaluates the extent to which a construct is distinct from other constructs in the same model, which ensures that a construct captures the unique concepts that are not measured by other constructs. To establish discriminant validity of the reflective measurements, the **Fornell-Larcker criterion** and **cross-loadings** were used as two measures. The Fornell-Larcker criterion (Fornell and Larcker, 1981) proposes that a construct should share more variance with its indicators than the variance shared with other constructs in the same model, which is statistically expressed as the rule suggesting that the square root of a construct's AVE should exceed the highest correlation it has with any other construct. As shown in Table 5-5, for both potential adopter and adopter samples, the square roots of the AVEs (figures

on the diagonal) are all greater than the correlations among the constructs (figures off the diagonal), providing evidence for discriminant validity.

Table 5–5. Discriminant Validity: Fornell-Larcker Criterion

Potential Adopter Sample													
	1	2	3	4	5	6	7	8	9	10			
1. Product Complexity	**0.79**												
2. Product Specificity	0.56	**0.80**											
3. Market Turbulence	0.52	0.60	**0.79**										
4. Technology Turbulence	0.45	0.71	0.66	**0.84**									
5. Structural Strength	0.60	0.50	0.48	0.44	**0.78**								
6. Relational Strength	0.57	0.42	0.31	0.21	0.56	**0.78**							
7. Process Coupling	0.65	0.55	0.57	0.49	0.73	0.65	-						
8. Process Adaptability	0.54	0.44	0.49	0.38	0.66	0.54	0.83	**0.85**					
9. Relationship Flexibility	0.59	0.54	0.64	0.51	0.78	0.51	0.79	0.76	**0.81**				
10. Adoption Intention	0.50	0.28	0.27	0.16	0.66	0.51	0.61	0.66	0.65	**0.90**			
OELS Adopter Sample													
	1	2	3	4	5	6	7	8	9	10	11	12	13
1. Product Complexity	**0.77**												
2. Product Specificity	0.28	**0.85**											
3. Market Turbulence	0.29	0.59	**0.79**										
4. Technology Turbulence	0.14	0.61	0.70	**0.80**									
5. Structural Strength	0.41	0.40	0.35	0.38	**0.75**								
6. Relational Strength	0.58	0.39	0.24	0.22	0.53	**0.76**							
7. Process Coupling	0.51	0.55	0.44	0.42	0.71	0.68	-						
8. Process Adaptability	0.41	0.27	0.25	0.25	0.60	0.50	0.66	**0.83**					
9. Relationship Flexibility	0.40	0.49	0.46	0.46	0.69	0.49	0.72	0.66	**0.78**				
10. Internal Assimilation	0.39	0.39	0.35	0.28	0.66	0.38	0.58	0.49	0.59	-			
11. External Diffusion	0.41	0.56	0.48	0.53	0.70	0.42	0.67	0.52	0.60	0.65	**0.97**		
12. Operational Performance	0.35	0.59	0.46	0.39	0.38	0.44	0.61	0.36	0.34	0.37	0.53	-	
13. Financial Performance	0.05	0.18	0.31	0.32	0.34	-0.08	0.20	0.13	0.30	0.34	0.54	0.30	**0.84**

The second method to assess discriminant validity requires that the outer loading of an indicator should be larger than its loadings on other constructs in the model (i.e., cross-loadings). Discriminant validity will be violated when the cross-loadings of an indicator exceed its outer loading (Diamantopoulos and Winklhofer, 2001; Petter et al., 2007). Compared with the Fornell-Larcker criterion, this method is a more liberal approach to assess discriminant validity (Hair et al., 2011). As displayed in Table 5–6, for the potential adopter sample, the loadings of indicators are greater than their cross-loadings on other constructs, which lends support for discriminant validity.

Table 5–6. Discriminant Validity and Cross Loadings: Potential Adopter Sample

Construct	Item	1	2	3	4	5	6	7	8	9	10
1. Product Complexity	PC1	**.857**	.494	.366	.248	.544	.592	.600	.476	.402	.435
	PC2	**.790**	.568	.463	.281	.448	.370	.467	.349	.397	.339
	PC3	**.717**	.389	.248	.347	.442	.354	.472	.427	.408	.408
2. Product Specificity	PS1	.554	**.750**	.459	.392	.571	.422	.609	.550	.579	.382
	PS3	.449	**.847**	.508	.492	.339	.255	.242	.167	.350	.251
3. Market Turbulence	MT1	.332	.486	**.768**	.409	.338	.406	.412	.235	.414	.159
	MT2	.272	.409	**.793**	.689	.185	.084	.290	.230	.388	-.043
	MT3	.481	.539	**.804**	.518	.458	.340	.533	.445	.543	.301
4. Technology Turbulence	TT1	.380	.526	.685	**.923**	.322	.219	.431	.255	.461	.069
	TT2	.310	.442	.605	**.816**	.274	.106	.304	.242	.366	.130
	TT3	.351	.535	.539	**.824**	.288	.179	.387	.293	.310	.195
	TT4	.159	.349	.461	**.784**	.125	.041	.167	.176	.279	-.054
5. Structural Strength	SS1	.545	.542	.469	.410	**.835**	.500	.585	.517	.660	.439
	SS2	.381	.300	.210	.083	**.739**	.458	.464	.402	.455	.528
	SS3	.540	.508	.315	.256	**.771**	.516	.569	.524	.534	.550
	SS4	.421	.357	.289	.193	**.774**	.662	.668	.605	.558	.606
6. Relational Strength	RS1	.429	.390	.331	.154	.582	**.827**	.575	.486	.449	.509
	RS2	.383	.120	.087	.054	.541	**.778**	.592	.636	.426	.595
	RS3	.529	.373	.290	.152	.431	**.719**	.525	.455	.379	.303
7. Process Couplinga	PCL1	.572	.447	.453	.356	.592	.574	**.852**	.771	.624	.559
	PCL2	.473	.359	.321	.217	.715	.695	**.823**	.686	.594	.564
	PCL3	.485	.381	.349	.240	.536	.503	**.802**	.622	.485	.425
	PCL4	.618	.480	.610	.490	.562	.596	**.813**	.649	.576	.464
8. Process Adaptability	ADP1	.493	.337	.354	.328	.526	.475	.720	**.826**	.536	.465
	ADP2	.469	.377	.346	.288	.596	.570	.734	**.900**	.617	.656
	ADP3	.394	.358	.298	.135	.563	.680	.685	**.828**	.601	.565
9. Relationship Flexibility	FLX1	.397	.405	.303	.284	.576	.298	.543	.576	**.786**	.481
	FLX2	.426	.419	.487	.355	.623	.534	.583	.573	**.848**	.488
	FLX3	.410	.556	.615	.408	.518	.485	.570	.520	**.792**	.415
10. Adoption Intention	AI1	.480	.363	.184	.098	.674	.559	.583	.628	.533	**.897**
	AI2	.413	.292	.057	.059	.528	.448	.488	.569	.452	**.876**
	AI3	.438	.372	.215	.118	.614	.599	.584	.599	.545	**.913**

[a] Formative Constructs

The discriminant validity for the OELS adopter sample is also supported by the results in Table 5–7 that no indicators load higher on other constructs than on their assigned constructs.

Table 5–7. Discriminant Validity and Cross Loadings: OELS Adopter Sample

Construct	Item	1	2	3	4	5	6	7	8	9	10	11	12	13
1. Product Complexity	PC1	**.781**	.165	.331	.052	.342	.456	.451	.388	.167	.307	.368	.405	.155
	PC2	**.682**	.104	.297	.044	.183	.449	.279	.204	.248	.227	.211	.239	-.039
	PC3	**.831**	.003	.129	.074	.436	.456	.496	.394	.357	.405	.404	.234	.021
2. Product Specificity	PS1	.084	**.751**	.225	.357	.108	.244	.131	.083	.262	.137	.158	.197	-.082
	PS3	.097	**.936**	.470	.536	.170	.170	.331	.034	.170	.081	.358	.480	.294
3. Market Turbulence	MT1	.394	.256	**.825**	.203	.433	.367	.557	.346	.307	.390	.504	.527	.333
	MT2	.040	.465	**.700**	.425	.121	.056	.213	.076	.170	.119	.287	.390	.149
	MT3	.189	.409	**.837**	.563	.337	.262	.468	.243	.334	.293	.460	.528	.277
4. Technology turbulence	TT1	.082	.542	.513	**.904**	.304	.087	.309	.158	.384	.178	.471	.381	.424
	TT2	.043	.237	.317	**.738**	.167	.045	.115	.131	.325	.096	.238	.107	.247
	TT3	.130	.491	.350	**.805**	.234	.208	.320	.192	.230	.034	.379	.364	.251
	TT4	-.093	.382	.234	**.738**	.078	.055	.215	.186	.252	-.026	.207	.164	.060
5. Structural Strength	SS1	.292	.253	.291	.382	**.765**	.290	.542	.445	.523	.518	.693	.326	.477
	SS2	.255	-.007	.177	-.026	**.745**	.346	.487	.463	.407	.522	.387	.250	.106
	SS3	.337	.049	.254	.087	**.701**	.397	.432	.440	.433	.489	.336	.184	.078
	SS4	.454	.163	.508	.302	**.787**	.603	.623	.499	.584	.480	.552	.402	.245
6. Relational Strength	RS1	.425	.116	.320	.147	.487	**.730**	.469	.316	.435	.405	.355	.336	.065
	RS2	.540	.233	.195	.084	.457	**.804**	.569	.433	.315	.339	.342	.335	-.114
	RS3	.244	.137	.233	.091	.320	**.735**	.492	.275	.202	.306	.230	.402	-.027
7. Process Coupling[a]	PCL1	.440	.308	.526	.320	.595	.493	**.858**	.608	.544	.487	.653	.548	.231
	PCL2	.458	.077	.293	.100	.577	.575	**.833**	.539	.427	.539	.430	.433	.106
	PCL3	.403	.243	.498	.209	.540	.549	**.821**	.472	.434	.480	.519	.584	.165
	PCL4	.509	.348	.510	.419	.553	.582	**.721**	.505	.511	.305	.511	.453	.167
8. Process Adaptability	ADP1	.390	.110	.314	.309	.551	.362	.556	**.872**	.532	.419	.512	.361	.195
	ADP2	.354	-.047	.182	.052	.451	.385	.485	**.759**	.402	.411	.320	.192	.070
	ADP3	.376	.048	.268	.099	.519	.485	.600	**.866**	.497	.420	.447	.346	.063
9. Relationship Flexibility	FLX1	.180	.275	.295	.228	.504	.214	.456	.395	**.754**	.494	.488	.323	.314
	FLX2	.367	.048	.248	.280	.548	.481	.469	.512	**.767**	.457	.359	.148	.066
	FLX3	.260	.199	.290	.400	.456	.309	.443	.447	**.809**	.299	.375	.289	.159
10. Internal Assimilation[a]	IAS1	.388	.138	.383	.210	.675	.373	.581	.449	.557	**.892**	.665	.393	.401
	IAS2	.425	.211	.383	.225	.607	.376	.494	.445	.541	**.898**	.592	.374	.334
	IAS3	.354	.133	.366	.110	.545	.348	.510	.450	.514	**.913**	.520	.397	.221
	IAS4	.250	-.170	.065	-.293	.399	.425	.289	.329	.205	**.680**	.209	.123	-.218
11. External Diffusion	EDI1	.375	.324	.531	.448	.641	.339	.596	.476	.503	.580	**.978**	.528	.607
	EDI2	.468	.347	.545	.425	.664	.443	.669	.533	.506	.606	**.978**	.567	.522
	EDI3	.488	.298	.540	.408	.688	.474	.680	.542	.565	.605	**.967**	.554	.503
12. Operational Performance[a]	OP1	.109	.311	.299	.113	.157	.126	.361	.136	.102	.187	.290	**.648**	.211
	OP2	.333	.358	.120	.156	.189	.281	.368	.273	.195	.106	.253	**.571**	.158
	OP3	.028	.184	.435	.079	.184	.224	.378	.256	.144	.172	.224	**.549**	.038
	OP5	.230	.408	.432	.500	.320	.403	.453	.386	.309	.287	.449	**.707**	.283
	OP4	.325	.283	.601	.381	.320	.239	.387	.169	.317	.313	.463	**.730**	.386
	OP6	.348	.109	.366	-.069	.267	.421	.448	.205	.107	.357	.347	**.577**	.073
13. Financial Performance	FIN2	.014	.085	.257	.094	.173	-.089	.149	.057	.092	.153	.380	.218	**.796**
	FIN3	.009	.193	.265	.283	.323	-.008	.197	.130	.186	.265	.522	.317	**.879**
	FIN4	.112	.276	.429	.511	.328	-.013	.211	.128	.312	.229	.547	.333	**.854**

[a] Formative Constructs

Cumulatively, the results suggest that the reflective measures in this study exhibited satisfactory internal consistency reliability and construct validity.

5.4. Measurement Validation: Formative Measures

For formative measures, different approaches should be employed to evaluate the measurement models because, unlike reflective indicators which have to covary and demonstrate high internal consistency, formative indicators do not necessarily covary (Jarvis et al., 2003). In PLS-SEM, it is assumed that the formative indicators should fully capture the concept domain of the underlying construct. Therefore, item purification practice based on the patterns of correlations may impair the content validity of the latent constructs (Hair et al., 2014). Formative indicators are considered to be the independent causes of the corresponding construct, and, therefore, do not necessarily correlate with each other. Formative measures are also assumed to be free of error (Edwards and Bagozzi, 2000; Diamantopoulos, 2006). As a result, the statistical assessment criteria for reflective measurements such as composite reliability and AVE are not applicable in the context of formative measurements. To evaluate formative measurement model, this study followed the guidelines in Rai and Tang (2010), the rules of thumb of which are summarized in Table 5–8.

Table 5–8. Rules of Thumb for Formative Measure Evaluation

Category		Measure	Acceptance Rules
Content Validity		Ensured pre-data-collection through peer review	
Parsimony	Indicator Contribution	Indicator Weight	Significant at $p < 0.01$
	Multicollinearity	VIF	4.0 or below
Content Validity	Discriminant validity	Indicator Loading	Greater than the cross-loadings

Source: Rai and Tang (2010)

Content validity, which ensures that all the formative indicators capture all, or at least a major part of, the facets of the construct domain (Nunnally, 1978), must be

established before data collection and estimation. Because all of the measures for formative constructs were adapted directly from previous literature in prestigious IS and OM journals, the theoretical grounding of the indicators could be safeguarded. In addition, as described in the data collection section, the questionnaire items were reviewed cautiously by a panel of eight academics and five practitioners to ensure the content validity of the formative indicators.

Parsimony determines whether a construct is effectively measured with the fewest measurement items (Rai and Tang, 2010). It is suggested that the contribution of all the formative items to a construct should be significant if each of them captures a portion of the underlying construct (Bollen and Lennox, 1991). Following Diamantopoulos and Winklhofer (2001), **item weights**, which are calculated by regressing the formative indicators against the latent variable scores, are used to measure the contribution of formative items. In most cases, the outer weights of formative indicators should be smaller than the outer loadings of reflective constructs. Bootstrapping must be used to determine whether the outer weights of formative indicators are significantly different from zero. Table 5–9 shows that for the non-adopter sample, the weights of the formative construct – process coupling – were significant at $p < 0.01$. For the OELS adopter sample, the item weights of process coupling, internal assimilation, and operational performance were all significant at $p < 0.01$, suggesting that all items contribute significantly to these three formative constructs.

Table 5–9. Parsimony Test: Significance of Item Weights and VIFs of Formative Constructs

		Potential Adopter			OELS Adopter		
Construct	Item	Weight	t-statistic	VIF	Weight	t-statistic	VIF
Process	PCL1	0.338	15.129	1.998	0.442	6.476	1.945
Coupling	PCL2	0.339	16.064	1.739	0.128	1.776	1.946
	PCL3	0.257	12.103	1.837	0.243	3.158	1.841
	PCL4	0.279	12.623	1.882	0.413	6.284	1.453
Internal	IAS1				0.408	28.798	2.827
Assimilation	IAS2				0.363	27.162	2.967
	IAS3				0.320	20.932	3.284
	IAS4				0.279	0.278	1.882
Operational	OP1				0.293	19.235	1.412
Performance	OP2				0.262	14.570	1.343
	OP3				0.246	11.202	1.282
	OP5				0.282	18.612	1.374
	OP4				0.262	12.162	1.310
	OP6				0.213	10.138	1.191

The parsimony of formative constructs also requires that the measurement items are not highly correlated. In contrast with reflective measurements which desire high correlations among the items to achieve internal consistency, the correlations among the formative items should be as low as possible because highly correlated indicators tend to measure the same facet of a construct rather than the different dimensions of the construct's scope (Diamantopoulos and Winklhofer, 2001). In addition, highly correlated items may also induce incorrect estimations of item weights, or even lead to the reversed signs of item weights (Hair et al., 2014). The **variance inflation factor (VIF)** is used as a measure of multicollinearity, which can indicate the amount of variance of a formative item not explained by the remaining items in the same construct (Hair et al., 2011). A VIF greater than 4.0 is suggested to imply a potential multicollinearity problem while a VIF greater than 10.0 indicates a serious multicollinearity issue (Rai and Tang, 2010). As suggested by Table 5–9, the VIFs of

all the formative items, for both adopter and non-adopter samples, were smaller than 4.0, suggesting that multicollinearity was not of concern in this study.

Because, as aforementioned, formative indicators do not necessarily covary, **discriminant validity** should be focused on to evaluate the construct validity of formatively measured constructs (Rai and Tang, 2010). Similar to reflective measurements, cross-loadings of formative indicators are employed to evaluate discriminant validity (Diamantopoulos and Winklhofer, 2001; Petter et al., 2007). As shown in Table 5–6 and Table 5–7, no formative indicators loaded greater on the constructs they are not intended to measure, which provides support for discriminant validity for both potential adopter and adopter samples.

Cumulatively, the formative measures in this study were safeguarded with content validity, and demonstrated adequate levels of parsimony and discriminant validity.

5.5. Common Method Bias

Because the data are self-reported perceptual information and were obtained from one single respondent at a single point of time, it is critical to check for the existence of common method bias which may inflate or deflate the relationships among the constructs (Siemsen et al., 2010). The method variance (MV) marker technique developed by Lindell and Whitney (2001) was employed in this study to observe the shared variance between a marker variable and the proposed variables (Malhotra et al.,

2006). To create a proper proxy for the amount of common method variance (CMV), the MV marker, included as an additional variable in the questionnaire, should be theoretically unrelated to at least one of the other variables in the research model (Lindell and Whitney, 2001). In an ideal setting, a perfect MV marker is expected to have zero correlations with substantive variables in the model (Williams et al., 2010). In this study, legal environment, a single-item variable measuring the extent to which "the legal system protects our interests" on a 1 to 7 Likert scale, was identified *a priori* as the MV marker that is theoretically not associated with the substantive constructs.

Following the procedures of Lindell and Whitney (2001), the smallest positive correlation between the MV marker and other constructs ($r_s = 0.015$ with market turbulence) was selected as the estimate of the MV adjustment for the potential adopter mode. For the OELS adopter model, the correlation between the MV marker and product specificity ($r_s = 0.003$) was selected as the MV adjustment. To generate the correlations $r_{ij \cdot M}$ that are accounted for by CMV, the original correlations among the constructs r_{ij} were then corrected using a partial correlation adjustment method with the following formula:

$$r_{ij \cdot M} = (r_{ij} - r_s)/(1 - r_s)$$

The confidence intervals for corrected correlations were calculated based on the following formula:

$$t_{\alpha/2,N-3} = \frac{r_{ij\cdot M}}{\sqrt{(1 - r_{ij\cdot M}{}^2)/(N-3)}}$$

where N is the sample size.

As shown in Table 5–10, the correlations that were statistically significant before the adjustment (figures below the diagonal) remained significant after adjustments (figures above the diagonal) for both the potential adopter and OELS adopter samples. Therefore, it is unlikely that the validity of the results was contaminated by common method bias.

5.6. Hypothesis Testing

This section reports the results of analysing the structural models, which include the standardized path coefficients, the t-statistics and the corresponding significance levels (two-tailed tests), and the amount of variance explained (R^2 and adjusted R^2). It is suggested that in multiple regressions, the coefficients of independent variables can only be interpretable as the main effects when they are *estimated without the interaction term(s)* (Aiken and West, 1991, pp. 38-39; Judd et al., 2009; Whisman and McClelland, 2005). In the presence of interaction term(s), the coefficient of an independent variable, rather than being the "main effect", is only the "simple effect"

Table 5–10. Common Method Bias

Potential Adopter Sample

	1	2	3	4	5	6	7	8	9	10	11
1. Product Complexity	1.00	0.55**	0.51**	0.44**	0.6**	0.57**	0.65**	0.53**	0.58**	0.49**	0.16*
2. Product Specificity	0.56**	1.00	0.59**	0.7**	0.49**	0.41**	0.54**	0.44**	0.54**	0.27**	0.14*
3. Market Turbulence	0.51**	0.60**	1.00	0.66**	0.47**	0.3**	0.57**	0.48**	0.63**	0.26**	0.00
4. Technology turbulence	0.45**	0.71**	0.66**	1.00	0.43**	0.2**	0.48**	0.37**	0.5**	0.14*	-0.08
5. Structural Strength	0.60**	0.50**	0.47**	0.44**	1.00	0.55**	0.73**	0.65**	0.78**	0.66**	0.14*
6. Relational Strength	0.57**	0.42**	0.31**	0.21**	0.56**	1.00	0.64**	0.53**	0.51**	0.5**	0.31**
7. Process Coupling	0.65**	0.55**	0.57**	0.49**	0.73**	0.65**	1.00	0.83**	0.78**	0.6**	0.16*
8. Process Adaptability	0.54**	0.44**	0.49**	0.38**	0.66**	0.54**	0.83**	1.00	0.76**	0.65**	0.2**
9. Relationship Flexibility	0.59**	0.54**	0.64**	0.51**	0.78**	0.51**	0.79**	0.76**	1.00	0.64**	0.12
10. Adoption Intention	0.50**	0.28**	0.27**	0.16*	0.66**	0.51**	0.61**	0.66**	0.65**	1.00	0.09
11. CMV Marker	0.18*	0.15*	0.015	-0.06	0.15*	0.33**	0.18*	0.21**	0.14	0.11	1.00

OELS Adopter Sample

	1	2	3	4	5	6	7	8	9	10	11	12	13	14
1. Product Complexity	1.00	0.27**	0.28**	0.14*	0.4**	0.58**	0.51**	0.4**	0.4**	0.39**	0.41**	0.35**	0.05	0.12
2. Product Specificity	0.28**	1.00	0.59**	0.6**	0.39**	0.39**	0.54**	0.27**	0.49**	0.39**	0.56**	0.58**	0.18**	0.00
3. Market Turbulence	0.29**	0.59**	1.00	0.7**	0.35**	0.24**	0.44**	0.25**	0.46**	0.35**	0.48**	0.46**	0.31**	0.13
4. Technology turbulence	0.14*	0.60**	0.70**	1.00	0.38**	0.22**	0.41**	0.25**	0.46**	0.28**	0.53**	0.39**	0.32**	-0.08
5. Structural Strength	0.40**	0.39**	0.35**	0.38**	1.00	0.53**	0.71**	0.6**	0.69**	0.66**	0.7**	0.38**	0.33**	0.4**
6. Relational Strength	0.58**	0.39**	0.24**	0.22**	0.53**	1.00	0.68**	0.5**	0.48**	0.38**	0.42**	0.44**	-0.08	-0.02
7. Process Coupling	0.51**	0.55**	0.44**	0.42**	0.71**	0.68**	1.00	0.66**	0.71**	0.57**	0.66**	0.61**	0.19**	0.22**
8. Process Adaptability	0.41**	0.27**	0.25**	0.25**	0.60**	0.50**	0.66**	1.00	0.66**	0.49**	0.52**	0.36**	0.13	0.09
9. Relationship Flexibility	0.40**	0.49**	0.46**	0.46**	0.69**	0.49**	0.71**	0.66**	1.00	0.59**	0.6**	0.33**	0.3**	0.23**
10. Internal Assimilation	0.39**	0.39**	0.35**	0.28**	0.66**	0.38**	0.58**	0.49**	0.59**	1.00	0.65**	0.37**	0.34**	0.29**
11. External Diffusion	0.41**	0.56**	0.48**	0.53**	0.70**	0.42**	0.67**	0.52**	0.60**	0.65**	1.00	0.53**	0.53**	0.33**
12. Operational Performance	0.35**	0.58**	0.46**	0.39**	0.38**	0.44**	0.61**	0.36**	0.34**	0.37**	0.53**	1.00	0.29**	0.08
13. Financial Performance	0.05	0.18**	0.31**	0.32**	0.34**	-0.08	0.20**	0.13	0.30**	0.34**	0.54**	0.30**	1.00	0.38**
14. CMV Marker	0.12	0.003	0.13	-0.08	0.40**	-0.02	0.22**	0.10	0.23**	0.30**	0.33**	0.08	0.38**	1.00

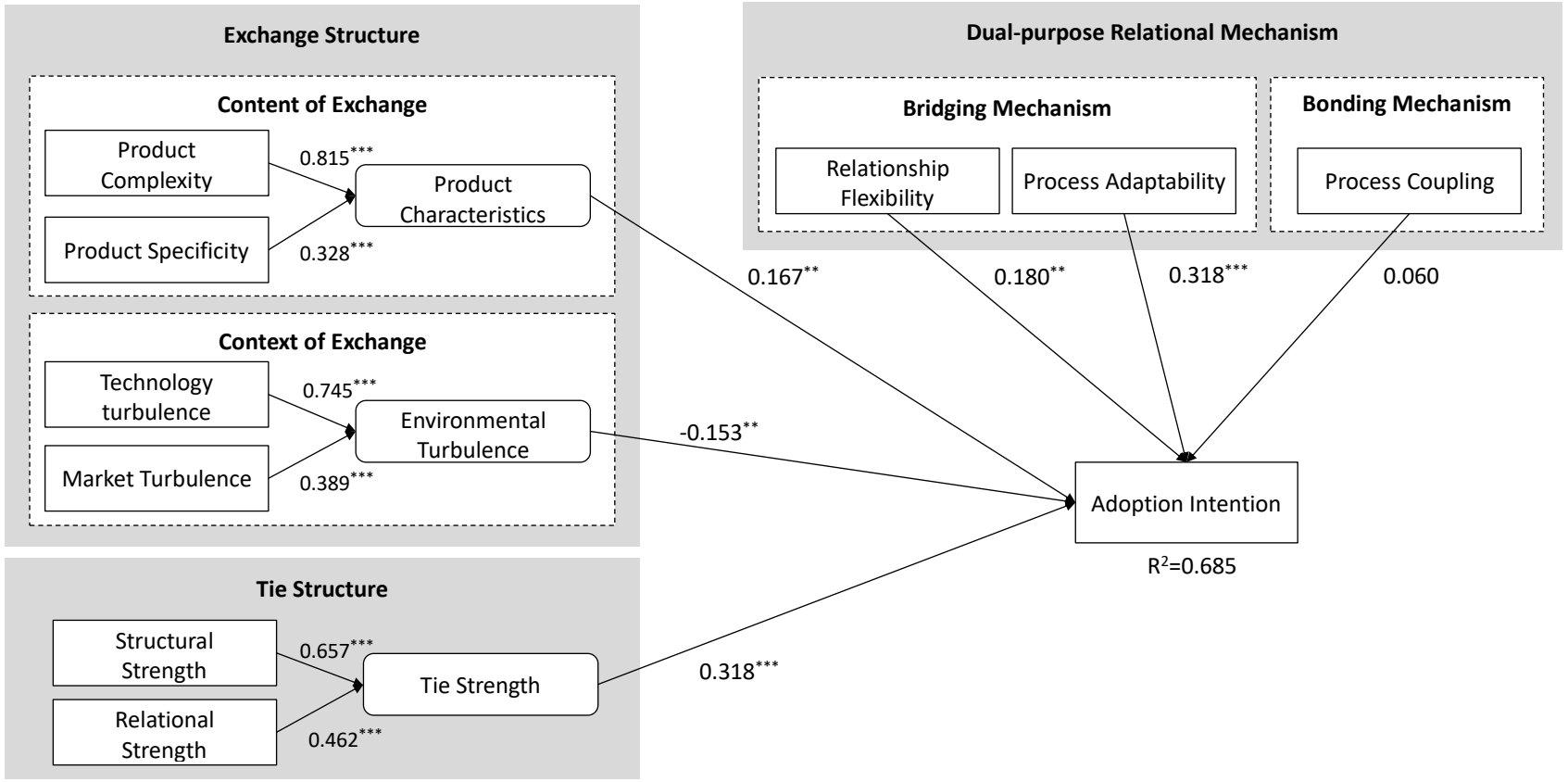
Note: The unadjusted correlations are shown below the diagonal; the correlations adjusted for CMV are shown above the diagonal

*$p < 0.05$; **$p < 0.01$

of that variable when other independent variables in the system are held at zero (Judd et al., 2009; Whisman and McClelland, 2005). As a result, a **two-step analysis** should be conducted where, in the first step, the models with only independent variables are assessed to obtain the main effects, and in the second step, the interaction terms are added to the models to analyze the interaction effects.

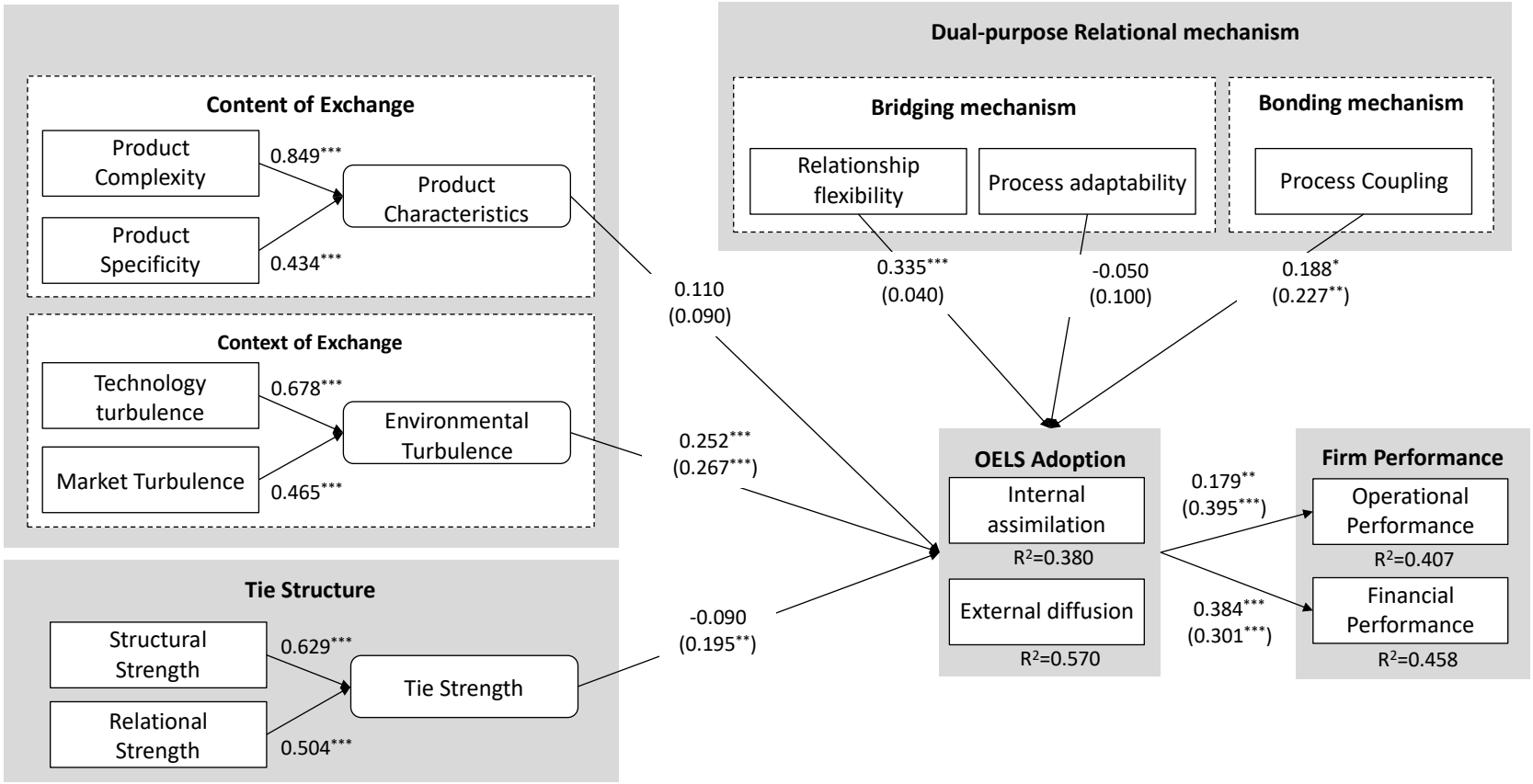
In Figure 5-1 and Figure 5-2, the path estimations without the presence of the interaction effects are presented for the potential adopter model and the OELS adopter model, respectively. The results are also summarized in Table 5–11 to show the coefficients of the main constructs for all the models, including the ones with (columns (2), (4) and (6)) and without the interaction terms (columns (1), (3) and (5)), as well as the coefficients of the control variables in these models. To test the hypotheses relating to the sub-constructs, both the weights of the formative sub-constructs and the coefficients of the underlying first-order constructs should be examined at the same time (Chin and Gopal, 1995; Chwelos et al., 2001; Teo et al., 2003; Son and Benbasat, 2007).

H1 postulates that product characteristics positively affect the adoption intention of OELS, which is supported by the result (β=0.167, $p < 0.05$). Therefore, the two respective corollaries of H1 are also supported (H1a: weight = 0.815, $p < 0.01$; H1b: weight = 0.328, $p < 0.01$), indicating that both product complexity and product specificity have significant and positive impacts on OELS adoption intention.



Note: * $p < 0.1$; ** $p < 0.05$; *** $p < 0.01$

Figure 5-1. Hypothesis Testing: Potential Adopter Model



Notes: Coeffients of the paths to (or from) internal assimilation are shown first and followed by the coffeffients of the paths to (or from) external diffusion exhibited in brakets;
$^{*}p < 0.1$; $^{**}p < 0.05$; $^{***}p < 0.01$

Figure 5-2. Hypothesis Testing: OELS Adopter Model

Table 5–11. Hypothesis Testing: Full Models

	Potential Adopter		OELS Adopter					
	Adoption Intention		Internal Assimilation		External Diffusion		Operational Performance	Financial Performance
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Product Characteristics (H1, H2)	0.167**	0.10	0.110	0.090	0.090	0.100		
	(2.27)	(1.41)	(1.18)	(0.89)	(1.35)	(1.38)		
Environmental Turbulence (H3, H4)	-0.153**	-0.132*	0.252***	0.215**	0.267***	0.218***		
	(2.15)	(1.81)	(3.02)	(2.41)	(5.34)	(3.47)		
Tie Strength (H5, H6)	**0.202****	**0.215****	-0.09	-0.06	**0.195****	**0.253*****		
	(1.99)	(2.12)	(4.40)	(0.34)	(2.23)	(2.72)		
Process Adaptability (ADP) (H8b)	**0.318*****	**0.173***	-0.05	-0.11	0.10	0.08		
	(3.76)	(1.87)	(0.58)	(0.87)	(1.33)	(0.89)		
Relationship Flexibility (FLX) (H9b)	**0.180****	**0.203*****	**0.335*****	**0.355*****	0.04	0.02		
	(2.50)	(2.69)	(4.40)	(4.39)	(0.55)	(0.32)		
Process Coupling (PCL) (H7b)	0.060	0.199*	**0.188***	**0.234****	**0.227****	**0.264****		
	(0.57)	(1.78)	(1.75)	(2.07)	(2.53)	(2.45)		
Internal Assimilation (H12a, H12b)							0.180**	0.360***
							(2.28)	(4.40)
External Diffusion (H12a, H12b)							0.400***	0.310***
							(2.80)	(3.88)
ADP * PCL (H10a, H10b)		-0.01		**0.178****		**0.153****		
		(0.08)		(2.33)		(2.11)		
FLX * PCL (H11a, H11b)		**0.344*****		-0.13		0.05		
		(3.54)		(1.15)		(0.52)		
ADP * FLX		0.301***		0.01		-0.08		
		(3.06)		(0.12)		(0.95)		
Control Variables								
Supplier Base Size	0.141**	0.146**	-0.05	-0.06	0.06	0.06		
	(2.50)	(2.50)	(0.79)	(0.98)	(1.33)	(1.09)		
Relationship Duration	0.23***	0.216***	0.03	0.03	0.06	0.06		
	(3.84)	(3.77)	(0.50)	(0.44)	(1.29)	(1.10)		
IND1	-0.18***	-0.184***					-0.03	-0.20***
	(2.58)	(2.58)					(0.33)	(2.64)
IND2	-0.06	-0.08					-0.09	-0.168*
	(0.88)	(1.08)					(0.64)	(1.78)
IND3	-0.11	-0.145*					0.02	-0.09
	(1.47)	(1.90)					(0.12)	(0.90)
IND4	-0.05	-0.08					-0.13	-0.10
	(0.70)	(1.12)					(1.04)	(1.22)
IND5	-0.08	-0.11					0.06	-0.07
	(1.16)	(1.59)					(0.51)	(0.79)
Ownership1 (state-owned)	0.165***	0.138**					0.00	0.00
	(2.94)	(2.46)					(1.28)	(0.99)
Ownership2 (privately-owned)	0.179***	0.162***					0.00	0.00
	(3.36)	(2.99)					(1.40)	(1.09)
Firm size	-0.02	-0.01					0.00	0.00
	(0.32)	(0.21)					(1.49)	(0.53)
R^2	0.685	0.713	0.380	0.395	0.570	0.586	0.409	0.440
R^2 adj.	0.653	0.678	0.357	0.363	0.570	0.564	0.372	0.405

Note: *t* statistics in parentheses

* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

[a] For industry dummies, other industries serve as the base group relative to the effects of other dummies.

[b] For ownership dummies, foreign-controlled firms serve as the base group relative to the effects other dummies.

IND1 = automobiles and components industry; IND2 = electrical and electronics; IND3 = materials and chemicals industry; IND4 = healthcare and healthcare machinery; IND5 = industrial and commercial machinery and equipment industry.

However, there was no evidence to support the positive impact of product characteristics on the actual adoption of OELS (H2) because the effects of product characteristics on neither internal assimilation (β=0.11) nor external diffusion (β=0.09) were statistically significant. H2a and H2b, the corollaries of H2, are therefore not supported either even though the weights of product complexity and product specificity were significant.

H3 assumes that environmental turbulence, including technology turbulence (H3a) and market turbulence (H3b), negatively affect the adoption intention of potential adopters. The significant and negative path from environmental turbulence to adoption intention (β=-0.153, $p < 0.05$) provides evidence supporting H3. The two corollaries of H3 are thus also supported with the weights of technology turbulence (H3a: weight = 0.745, $p < 0.01$) and market turbulence (H3b: weight = 0.389, $p < 0.01$) being statistically significant.

Contrary to the negative relationship between environmental turbulence and adoption intention, a positive influence of environmental turbulence on the actual adoption of OELS is hypothesized by H4. The results fully support H4 by suggesting that environmental turbulence has significant and positive impacts on both internal assimilation (β=0.252, $p < 0.01$) and external diffusion (β=0.267, $p < 0.01$). The significant weights of technology turbulence (H4a: weight = 0.678, $p < 0.01$) and market turbulence (H4b: weight = 0.465, $p < 0.01$) also provide evidence supporting

the two corollaries of H4, indicating that both technology turbulence and market turbulence have significant roles in affecting internal assimilation and external diffusion.

With respect to the effects of tie strength, it is posited that it is positively associated with both the adoption intention (H5) and the actual adoption of OELS (H6). The results fully support H5 and its corollaries with a significant and positive path from tie strength to adoption intention (β=0.318, $p < 0.01$) and the statistically significant weights of structural strength (H5a: weight = 0.657, $p < 0.01$) and relational strength (H5b: weight = 0.462, $p < 0.01$). Only partial support, however, was found for H6 with a significant and positive effect of tie strength on external diffusion (β=0.195, $p < 0.05$). A positive influence of tie strength on internal assimilation was not found (β=-0.09). The corollaries of H6 are therefore also only partially supported in that structural strength (H6a: weight = 0.629, $p < 0.01$) and relational strength (H5b: weight = 0.504, $p < 0.01$) only had positive associations with external diffusion but not with internal assimilation.

Regarding the impacts of relational mechanisms, it is posited that the three types of relational mechanisms – relationship flexibility, process adaptability (bridging mechanisms), and process coupling (bonding mechanism) – positively affect both the adoption intention and the actual adoption of OELS. The results show a positive and significant relationship between relationship flexibility and adoption intention

(β=0.180, $p < 0.05$), supporting H7a. However, relationship flexibility was only found to have a positive association with internal assimilation (β=0.335, $p < 0.01$), but not with external diffusion (β=0.040), which only renders partial support for H7b.

While a significant impact of process adaptability on adoption intention was identified to support H8a (β=0.318, $p < 0.05$), process adaptability does not significantly explain either internal assimilation (β=-0.05) or external diffusion (β=0.10). No evidence, therefore, can be provided to support H8b.

Interestingly, the impacts of process coupling were found to be insignificant with regard to adoption intention (H9a: β=0.06), but were shown to be significant and positive with regard to both internal assimilation (β=0.188, $p < 0.1$) and external diffusion (β=0.227, $p < 0.05$). Therefore, support can only be provided for H9b to indicate that process coupling plays a significant role in affecting the actual adoption of OELS.

This study also investigated the complementary effects between the bridging mechanisms and the bonding mechanism on the adoption intention and the actual adoption levels of OELS. Columns (2), (4) and (6) of Table 5–11 include the interaction terms of process coupling (the proxy of bonding mechanism) and each of the bridging mechanisms (i.e., process adaptability and relationship flexibility). It was interesting to find that while the interaction term between process coupling and process adaptability is not significant in affecting adoption intention (column 2: β=-0.01), it

has significant and positive effects on both internal assimilation (column 4: β=0.178, $p < 0.05$) and external diffusion (column 6: β=0.153, $p < 0.05$). Therefore, evidence was found to fully support H10b, but not H10a. The main effects of network properties and relational mechanisms together explained 68.5% of the variance in adoption intention (ΔR^2=0.685), 38% of the variance in internal assimilation (ΔR^2=0.380) and 57% of the variance of external diffusion (ΔR^2=0.570).

The interaction term between process coupling and relationship flexibility, on the contrary, was found to have a significant and positive effect on adoption intention (column 2: β=0.344, $p < 0.001$), but not on internal assimilation (column 4: β=0.13) and external diffusion (column 6: β=0.05). Therefore, H11a, which posits that process coupling and relationship flexibility have a positive complementary effect on adoption intention, is supported. Their complementary effects on the actual adoption of OELS assumed by H11b, however, are not supported. The interaction terms between the bonding mechanism and the bridging mechanisms explained an additional 2.8% variation in adoption intention (ΔR^2=0.028) compared with column 1 with no interaction effects. It was also noted that an additional 1.5% variance in internal assimilation compared with column (3) (ΔR^2=0.015) and an additional 1.6% variance in external diffusion compared with column (5) (ΔR^2=0.016) were explained by the interaction terms between the bonding mechanism and the bridging mechanisms.

Hypotheses 12a and 12b assume that internal assimilation and external diffusion of OELS can enhance the operational and financial performance of a firm. As shown in Figure 5-2, evidence could be found to support these two hypotheses by showing that internal assimilation has significant and positive effects on operational performance (β=0.179, $p < 0.05$) and financial performance (β=0.384, $p < 0.01$), and external diffusion has significant and positive effects on operational performance (β=0.395, $p < 0.01$) and financial performance (β=0.301, $p < 0.01$). Although columns 7 and 8 of Table 5–11 provide slightly different coefficients as compared with the figures in Figure 5-2 because of the involvement of interaction terms in the model, the results also support Hypotheses 12a and 12b.

With respect to the effects of control variables, it was identified that when a firm has a larger supplier base (β=0.141, $p < 0.05$) or maintains longer relationships with major suppliers (β=0.23, $p < 0.01$), it will have greater intention to adopt OELS. In addition, the companies in the automobiles and components industry will have a lower level of intention to adopt OELS (β=-0.18, $p < 0.01$). These companies generally have lower financial performance relative to companies in other industries (β=-0.20, $p < 0.01$). In addition, companies in the electrical and electronics industry also exhibited lower financial performance (β=-0.168, $p < 0.1$). The types of ownership also exhibited significant impacts on adoption intention such that state-owned (β=0.165, $p < 0.01$) and privately-owned (β=0.179, $p < 0.01$) companies tend to be more willing to adopt OELS compared with companies with other types of ownership.

5.7. Summary

This chapter aims to present the results and findings from the analysis to find support for the hypotheses proposed in Chapter 3. The methods and procedures of data analysis are explained in detail. PLS-SEM was employed to test the hypotheses to avoid endogeneity concerns. The findings in this chapter will be further discussed in the next chapter to shed light on the implications for theory and practice.

CHAPTER 6. CONCLUSIONS AND IMPLICATIONS

The findings for each research question or hypothesis are summarized from Chapter 5 and explained within the context of this and prior research examined in Chapter 2. The theoretical and practical implications, which are the most important contributions of this study, are presented in this chapter. The sections will further discuss the limitations pertaining to this research and suggest directions for future studies.

6.1. Conclusions about the Research Findings

In an effort to understand the theoretical antecedents to and the impacts of OELS adoption, a unified research model is developed to examine the research questions using empirical data collected from Chinese manufacturing companies. Grounded on structural embeddedness theory, the relational view of the firm, and the ambidexterity theory, this research investigates the influence of the network properties and relational mechanisms on OELS adoption and the resultant organizational outcomes. The examination of network properties and relational mechanisms shows the differences between the potential adopters and the current adopters regarding the antecedents to OELS. The findings also confirm the positive impacts of OELS adoption on both operational and financial performance. A summary of the research findings is presented in Table 6–1.

Table 6–1. Summary of Research Findings

Potential Adopter		OELS Adopter	
Hypothesis	**Finding**	**Hypothesis**	**Finding**
Influence of Network Properties			
H1 Product characteristics → adoption intention (+)	Support	H2 Product characteristics → internal assimilation and external diffusion (+)	No support
H1a Product complexity → adoption intention (+)	Support	H2a Product complexity → internal assimilation and external diffusion (+)	No support
H1b Product specificity → adoption intention (+)	Support	H2b Product specificity → internal assimilation and external diffusion (+)	No support
H3 Environmental turbulence → adoption intention (-)	Support	H4 Environmental turbulence → internal assimilation and external diffusion (+)	Support
H3a Technology turbulence → adoption intention (-)	Support	H4a Technology turbulence → internal assimilation and external diffusion (+)	Support
H3b Market turbulence → adoption intention (-)	Support	H4b Market turbulence → internal assimilation and external diffusion (+)	Support
H5 Tie strength → adoption intention (+)	Support	H6 Tie strength → internal assimilation and external diffusion (+)	Partial support
H5a Structural strength → adoption intention (+)	Support	H6a Structural strength → internal assimilation and external diffusion (+)	Partial support
H5b Relational strength → adoption intention (+)	Support	H6b Relational strength → internal assimilation and external diffusion (+)	Partial support
Influence of Bonding and Bridging Mechanisms			
H7a Relationship flexibility → adoption intention (+)	Support	H7b Relationship flexibility → internal assimilation and external diffusion (+)	Partial support
H8a Process adaptability → adoption intention (+)	Support	H8b Process adaptability → internal assimilation and external diffusion (+)	No support
H9a Process coupling → adoption intention (+)	No support	H9b Process coupling → internal assimilation and external diffusion (+)	Support
H10a Process coupling ×process adaptability → adoption intention (+)	No support	H10b Process coupling ×process adaptability → internal assimilation and external diffusion (+)	Support
H11a Process coupling × relationship flexibility → adoption intention (+)	Support	H11b Process coupling × relationship flexibility → internal assimilation and external diffusion (+)	No support
Performance Outcomes of OELS Adoption			
		H12a Internal assimilation and external diffusion → operational performance (+)	Support
		H12b Internal assimilation and external diffusion → financial performance (+)	Support

6.2. Discussions and Implications for Theory

This study draws on three different theoretical perspectives — *the structural embeddedness theory* (Granovetter, 1985; Uzzi, 1997; Dacin et al., 1999), *the relational view of the firm* (Dyer and Singh, 1998), and *organizational ambidexterity theory* (March, 1991; Gibson and Birkinshaw, 2004) — to understand OELS adoption. This study extends work on IOS adoption by adding new drivers of OELS adoption and assimilation. The findings highlight the distinct roles of the network properties and relational mechanisms play in determining adoption intention among potential adopters and actual adoption among current adopters.

To conclude, the contributions of this research can be summarized as follows:

- Theoretical development of two relational mechanisms pertinent to the context of OELS assimilation: bonding and bridging mechanisms.

- The development of proxies for bonding (i.e., process coupling) and bridging (i.e., process adaptability and relationship flexibility) established theoretical and methodological foundations for future studies investigating the specific characteristics of OELS.

- By surfacing the complementary effects between bonding mechanism and the two bridging mechanisms on OELS adoption, this study safeguards against the conventional belief that bonding and bridging are substitutes, and demonstrates

how these two mechanisms are mutually reinforcing to facilitate the adoption intention and the actual assimilation of OELS.

- This study compares different value preferences of potential adopters and existing adopters. Different diffusion models should be developed to study pre-adoption and post-adoption stages.

- This study empirically confirms that OELS enable companies to enjoy durable competitive advantages to pursue higher-order performance by developing bonding and bridging capabilities to continually restructure supply chain processes and respond to external changes.

6.2.1. Effects of Network Properties

No evidence was found to support the positive effect of product characteristics. Product complexity and product specificity have no effects on a firm's intention to adopt OELS, nor do them affect the internal assimilation and external diffusion of OELS for a current adopter. The result is inconsistent with the study of Son and Benbasat (2007), which reports that product complexity and product specificity negatively influence the assimilation of e-marketplace because of the inadequate information sharing capability of e-marketplace. When compared with literature with more similar context, the insignificant result is inconsistent with Chong and Ooi (2008) and Chong et al. (2009b), which shows that product complexity is a strong determinant

affecting the adoption of RosettaNet standards and e-collaboration tools. The inconsistencies could be due to that it has been years since Son and Benbasat (2007), Chong and Ooi (2008) and Chong et al. (2009b) were conducted, during which the information technologies have advanced to a great extent that the difficulty of presenting complex product information is not a concern for practitioners anymore. For potential adopters who are current EDI users, the advent of EDI over the internet can provide them with adequate capability to process and exchange product and transaction information with existing partners. In addition, EDI-based systems are characterized by high levels of relationship-specificity to support the transaction and production of highly customized products. It would make no difference for EDI users to adopt OELS as a mean to enhance inter-firm collaboration with a specific supply chain partner. Therefore, the potential adopters' intention to adopt OELS will not be affected by product characteristics. The logic also applies to current adopters of OELS. Because of the advent of web technologies and the associated enhanced information processing capability of OELS, the provision of a large amount of complex and specific product information is no longer a prominent technological feature that affects the extent to which OELS is used. This may explain why product characteristics, including product complexity and product specificity, are not significant predictors of the internal assimilation and external diffusion of OELS.

Consistent with the proposed hypotheses, market turbulence and technology turbulence are found to have significant negative impacts on adoption intention among

the potential adopters while positively affect internal assimilation and external diffusion among the current adopters. The results partially support the findings of Son and Benbasat (2007) which suggest that the positive influence of market volatility is significant for the participation level of e-marketplace among the current adopters, but not for the adoption intention among the potential adopters. The findings confirm the different roles that environmental turbulence may play in the pre-adoption and post-adoption periods. While environment turbulence presents an inhibitor of OELS adopter in the pre-adoption period, it acts as a catalyst of adoption in post-adoption period. For a potential adopter, migrating to OELS-based IOS would present a major turbulence to its extant supply chain environment. A firm would prefer to stick with existing partners using EDI systems than to seek for new partners through OELS when the external environment is highly unstable (Beckman et al., 2004). On the other hand, a current OELS adopter will be motivated to assimilate and diffusion OELS to a greater extent both internally and externally to facilitate inter-firm integration and collaboration with existing partners to cope with volatile external environment. Reinforcing existing partnerships can reduce uncertainties related to both market and technology by increasing information visibility in the supply chain, enhancing supply chain responsiveness (Trkman and McCormack, 2009), accelerating time to market, and securing access to complementary products and services (Chatterjee, 2004).

The relational and structural strength of ties between a firm and its major supply chain partners are found to be positively associated with the adoption intention of potential

adopters. The mutual engagement and resource sharing behaviours in strong relational bonds (Kim and Choi, 2018) will create motivation to adopt OELS to facilitate knowledge transfer. The well-established interfirm routines and processes in structurally strong partnerships will also nurture a favourable environment where OELS can be implemented more easily among supply chain partners (Eisenhardt and Schoonhoven, 1996). Therefore, a firm will be more inclined to adopt OELS when its relationships with major supply chain partners are relationally and/or structurally strong. For current adopters of OELS, relational and structural strength are only found to have a significant positive influence on external diffusion but not on internal assimilation of OELS. The positive association between tie strength and external diffusion of OELS confirms that OELS will be used more intensely and frequently to coordinate supply chain activities in strong relationships where supply chain partners share closer and more diverse interactions.

6.2.2. Impacts of Bonding and Bridging Mechanisms

This study contributes to the *relational view of the firm* (Dyer and Singh, 1998) by highlighting the importance of two relational mechanisms pertinent to the context of OELS assimilation: bonding and bridging mechanisms. OELS will improve and enhance supply chain relationships through bonding (i.e., process coupling) and bridging (i.e., process adaptability and relationship flexibility).

The bonding mechanism of OELS is found to have significant positive impacts on internal assimilation and external diffusion of OELS among current adopters, but not on the adoption intention of OELS among potential adopters. Contrastingly, for bridging mechanisms, process adaptability shows positive significant influence on adoption intention among potential adopters, but not on internal assimilation and external diffusion among current adopters. Relationship flexibility has significant positive effect on the adoption intention of potential adopters; for current adopters, however, the effect of relationship flexibility is only significant for internal assimilation but not for external diffusion. The results demonstrate the differences in the expected instrumental benefits between the potential adopters and current adopters.

For potential adopters, because existing EDI systems can provide adequate integration capability (Mukhopadhyay and Kekre, 2002), process coupling is not a significant driver of adopting OELS. However, in the context where a firm has implemented no IOS for supply chain integration, process coupling should be a significant catalyst for OELS adoption (Bala and Venkatesh, 2007). The insignificant impact of process coupling on the intention of EDI users to migrate to OELS can be explained by path dependency (Zhu et al., 2006a) which shows how a firm's motivation and ability to adopt a newer technology are affected by its related experience with existing technologies (Cohen and Levinthal, 1990). The finding of this study thus enhances the understanding of how EDI systems can reduce the incremental process coupling value of OELS.

Instead, the potential adopters value the bridging effects, i.e., relationship flexibility and process adaptability, that can be garnered from implementing OELS in supply chain networks. A potential adopter will favour the opportunity to explore new partnerships and to assess new knowledge that is not available in its immediate network (Chong and Bai, 2014). In addition, a firm can enhance its ability to respond to environmental turbulence by developing flexible and adaptable supply chain relationships through OELS, which can increase the variety of supply chain activities (Eisenhardt and Brown, 1999). The modular design, structured data connectivity, and standardized interfaces of OELS can reduce the relationship-specificity characterized by conventional EDI systems, reducing the threat of opportunism and the fear that supply chain partners will switch to alternative partners that will render the relationship-specific assets valueless (Bala and Venkatesh, 2007). Therefore, an EDI user will be favourably disposed to migrating to OELS-based IOS when it perceives that implementing OELS will reduce supply chain rigidity by bridging the information gap in the market, reducing searching costs, reconfiguring supply chain processes, and improve market responsiveness.

Process coupling is the major driver of the internal assimilation and external diffusion of OELS among existing adopters. A company can resolve the mismatch of information processing capabilities across its business partners through facilitating process coupling via OELS, which can ensure that interfirm transactions are conducted in an accurate and timely manner (Jap and Ganesan, 2000). In addition, interfirm

collaboration and knowledge sharing can be enhanced when business processes are closely integrated. Therefore, OELS will be used to a greater extent to facilitate the integration of supply chain activities and interfirm processes.

Surprisingly, process adaptability does not significantly affect neither the internal assimilation nor the external diffusion of OELS. A plausible explanation could be that process adaptability alone does not present a major relational value that can motivate greater assimilation or diffusion of OELS. Adaptation must be accompanied with close process alignment to increase responsiveness to competition, launch products swiftly, and offer quick customer services (El Sawy and Bowles, 1997). Inadequate cooperation from major partners can reduce the effectiveness of process adaptability because adjustments in relationship-specific assets should not only take place in the firm's internal business processes but also in the external processes controlled by the partners (Bala and Venkatesh, 2007).

Relationship flexibility is only significantly associated with internal assimilation, but not with external diffusion, which indicates that when a firm perceives that OELS can reduce searching and switching costs, it will use OELS more intensively for supplier selection and procurement analysis (internal assimilation) to expand exiting trading network. However, because relationship flexibility is mainly concerned with finding and establishing new partnerships, it does not significantly affect the number of overall interactions and transactions conducted through OELS (external diffusion).

6.2.3. Interaction effects of Bonding and Bridging Mechanisms

The significant positive interaction effects of process coupling and process adaptability/relationship flexibility on the adoption intention and actual adoption of OELS support the theoretical proposition that the individual effects of these relational mechanisms will be stronger when they are considered together. The findings suggest that isolating these two mechanisms may provide an incomplete delineation of OELS adoption. By exploring the bonding and bridging at the same time through OELS, firms can exploit the electronic integration without being exposed to the risks of rigidity (Bharadwaj, 2000). The complementary effects are different between potential adopters and current adopters of OELS. For a potential adopter, it will be willing to adopt OELS when it perceives that OELS can improve process coupling and relationship flexibility at the same time. However, process coupling does not complement process adaptability to mutually enhance adoption intention of OELS among potential adopters. With respect to existing adopters, the influence of process coupling on internal assimilation and external diffusion is only enhanced by the process adaptability, but not by relationship flexibility.

The findings reveal the different value preferences of potential adopters and existing adopters. Although the individual effect of process coupling on adoption intention is not significant, it will enhance a potential adopter's willingness to adopt OELS when the company perceives that OELS can facilitate relationship flexibility at the same

time. While process adaptability alone does not affect current adopters' internal assimilation and external diffusion, it will complement with process coupling to promote greater assimilation of OELS. Process adaptability will be more valuable when process coupling improves supply chain integration because the ability of adaptability to reduce switching costs will provide incremental benefits in highly integrated relationships characterized by high switching costs (Rai and Tang, 2010).

Although in IOS literature it has been widely argued that OELS adoption can balance the contradictory requirements of efficiency and flexibility (Adler et al., 1999), enabling companies to leverage bonding and bridging effects at the same time (Gosain et al., 2004; Malhotra et al., 2007; Rai and Tang, 2010), this statement has not yet, to the best of our knowledge, been empirically tested. By surfacing the complementary effects between bonding mechanism and the two bridging mechanisms on OELS adoption, this study safeguards against the conventional belief that bonding and bridging are substitutes, and demonstrates how these two mechanisms are mutually reinforcing to facilitate the adoption intention and the actual assimilation of OELS.

Our finding suggests that OELS adoption has a positive influence on supply chain process ambidexterity, which lends empirical evidence to the argument that IOS integration and IOS flexibility, being complementary rather than contradictory, can be developed simultaneously through OELS implementation (Rai and Tang, 2010). The finding also advances the understanding of how IOS capabilities affect supply chain

process capabilities by showing how OELS can help companies develop process ambidexterity to enable a dynamic supply chain network consisting of both existing and new ties.

6.2.4. Organizational Outcomes of OELS Adoption

As expected, a firm will obtain greater financial and operational performance when it assimilates OELS to a greater extent internally and externally. The finding is consistent with Chang and Shaw (2009) which finds that by providing first-order operational value, OELS such as RosettaNet will lead to the improvement of first-order organizational performance such as growth in sales and market share. The positive influence of IOS on performance is also confirmed by Zhang and Dhaliwal (2009) which shows that both internal assimilation and external diffusion are positively associated with operational and strategic improvement. Similar findings are also reported in Zhang et al. (2016) by showing that IOS assimilation will directly lead to operational improvement and improve competitive performance. Wu and Chang (2012) explicitly differentiate the impacts of internal and external diffusion of IOS, and demonstrate that internal assimilation is positively related to operational performance, and external diffusion is positively related with both operational and financial performance.

Robey et al. (2008) highlight the importance of investigating the organizational impacts of ISO adoption. This study answers this call and extends the IOS literature

by confirming the importance of OELS in enhancing supply chain relationships and operational efficiency has been widely recognized, previous studies have primarily focused on the antecedents of OELS adoption and assimilation, e.g., Zhu et al. (2006a); Bala and Venkatesh (2007); Chong and Ooi (2008). Only a few studies have been conducted to investigate the outcomes of OELS adoption, e.g., Malhotra et al. (2007); and Sodero et al. (2013). Therefore, our findings contribute to the IOS literature by showing that OELS adoption is positively associated with both operational and financial performance.

6.3. Implications for Practice

Even though OELS provide numerous opportunities for many countries to digitalize its manufacturing industry, contemporary applications of OELS still exist at an experimental stage. Given that organizations may have limited resources to facilitate OELS diffusion, this study offers implications on the strategies of **industrial practitioners, IT vendors and standard-making consortia** to facilitate greater diffusion of OELS.

The IT vendors providing OELS solutions and standard-making consortia should develop different strategies to promote OELS differently among potential adopters and existing adopters with limited deployment scale because the motivations driving them to adopt OELS or assimilate OELS to a greater extent are different. When convincing a potential firm to adopt OELS, the IT vendors should emphasize the capability of

OELS to provide relationship flexibility and process adaptability that traditional EDI systems cannot offer. The positive effects of bridging mechanisms for the potential adopters imply the importance of network externalities provided by OELS for the EDI users. Therefore, the standards-making consortia should focus on the relational values of OELS that are found to be significant in this study.

On the other hand, when promoting greater OELS assimilation and diffusion among those companies that have already adopted OELS, the IT vendors should highlight the ability of OELS to exchange complex, rich content information that can facilitate supply chain integration and collaboration because process coupling is the most significant factors valued by the current OELS adopters.

Most importantly, the ability of OELS to simultaneously provide process coupling, relationship flexibility, and process adaptability should be particularly emphasized when promoting OELS adoption and assimilation. The capability of OELS to resolve the paradox between bonding and bridging is the most significant driver of migration from EDI systems to OELS, which should be constantly promoted as the key advantage of OELS. The IT vendors and standard-making consortia should focus on the advantage of OELS to resolve the paradox between bonding and bridging in their promotional events such as seminars, workshops and trainings to educate the practitioners about what performance gains they can obtain from adopting OELS.

When the industry practitioners have gained more understandings about the advantage of OELS over the traditional EDI system, they will be more willing to adopt OELS.

The practitioners should also evaluate the characteristics of a firm's supply chain network when persuading it to adopt OELS. The results indicate that firms that have been maintaining strong ties with supply chain partners will react more positively to OELS adoption and assimilation. For these organizations, the ability of OELS to enhance process coupling will be more valued to further facilitate the collaboration with close. In addition, for potential adopters with high environmental turbulence, the success rate of persuading them to move from exiting IOS to OELS would be low. The IT vendors thus can avoid these companies when promoting OELS to save marketing costs. However, current adopters of OELS will be more inclined to assimilate and diffuse OELS to a greater extent. The IT vendors can provide more technical support for these organizations to help them alleviate external uncertainties with OELS. The findings of this study thus suggest that the practitioners should emphasize different aspects of OELS when dealing with firms with different supply chain networks.

By separating OELS adoption into internal assimilation and external diffusion, this study a richer understanding of how applying OELS within a firm's business process and its integration with its partners can help create values to a manufacturer. In this sense, our study informs practitioners who are planning or in the process of implementing OELS, to gain a comprehensive view of the value offer by OELS.

6.4. Limitations and Implications for Future Research

Despite the contributions of this study for both the theory and practice, there are several limitations. First, this study could not show the influence of OELS on supply chain performance over time. Future studies can consider the dynamism of time when evaluating the relationship between OELS and supply chain performance. This study used cross-sectional data, which might be subject to the risk that the influence of OELS on organizational outcomes is only temporal. It is important to ensure that organizations can sustain supply chain competitive advantage through OELS adoption.

Although the conceptual models are unified and can be generalized to be applied to various research contexts, the results of this study were obtained from analysing data collected in China only, which might restrict the explanatory power of the results to other countries, especially those developed economies where the business environments are greatly different from China. To test the generalizability of the research model, future studies can collect more various datasets from other economies to compare the differences in the findings regarding the factors affecting OELS adoption. In addition, because China is a collectivist cultural environment and therefore the respondents may have a tendency to agree regardless of the content of the questions (Liu et al., 2010). Thus there might be a slight chance of acquiescence bias in our data.

It is found that firm size has no significant effects in affecting OELS adoption, which is counter intuitive because larger firms are supposed to have more abundant resources and capabilities in deploying IT resources. It is possible that larger firms have already assimilated well-embedded legacy EDI systems, which will prevent them from adopting new OELS systems. Future research can look into this aspect and provide plausible reasons for why firm size will not affect OELS adoption, especially, why large organizations do not have greater willingness to adopt new innovations compared with small businesses.

In addition, we evaluated several network properties. Further research can incorporate other network properties, such as network density, firm centrality, and structural equivalence when investigating OELS assimilation. We also acknowledge that this research may be subject to limitations pertaining to cross-sectional data collected at a single point in time. In addition, although the research was conducted rigorously to ensure internal validity, the generalizability of the results may also be constrained by the research context.

6.5. Summary

This chapter summarizes the research work that has been carried out as described in prior chapters. The major findings and implications are presented in the context of this and previous research. This study identified the research issues and gaps in extant IOS studies through a comprehensive literature review. A conceptual model was developed

to examine the influence of various inter-organizational factors on OELS adoption. A survey instrument was designed to collect data to test the conceptual framework. PLS-SEM was employed to test the hypotheses. This thesis contributes to the IOS and innovation diffusion literature by showing the factors promoting/prohibiting OELS diffusion. It is expected that this thesis can yield valuable implications for academics, practitioners and policymakers.

APPENDIX I: PRE-SURVEY SCREENING QUESTIONS

The investigators provide the following information to the potential respondents to explain the purpose of research:

This research intends to investigate open e-logistic standards (OELS). OELS is a standard for information sharing within and between companies that specify business documents, business processes and messaging for exchange of standardized data. OELS are typically developed by standard-setting consortia of firms and are based on Extensible Markup Language (XML) to enable point-to-point connections through public internet.

Questions to ask if the respondent agree to cooperate and provide data:

1. Please describe your major business or functional responsibilities within your company.

2. Is your company implementing inter-organizational information systems to integrate and manage supply chains?

3. Which type of network are the inter-organizational information systems of your company based on (e.g., A. Proprietary Value Added Network (VANs), Intranet, Public Internet)?

4. Which types of standards or frameworks are the inter-organizational information systems of your company based on, e.g., EDI (e.g., ASC X12, EANCOM or EDIFACT), RosettaNet, ebXML, UBL?

   (The respondents can have multiple answers for this question)

APPENDIX II: SURVEY INSTRUMENT

Note:

This Appendix integrates the questionnaires for the potential adopters and current adopters together.

1. Questions in Part A are the same for both potential adopters and current adopters.
2. In Part B, Question 12 is for potential adopters only to measure their adoption intention; Questions 13 and 14 are for current adopters only to measure their levels of internal assimilation and external diffusion.
3. All the questions in the subsequent sections of Part B are collected for both the potential and current adopters. The descriptions for these questions in this Appendix are shown for the current OELS adopter version of questionnaire. Slight modifications of the wording were made in the potential adopter version of questionnaire, which are shown in the brackets.

Participant Information Sheet

Dear Participant,

Thank you for agreeing to participate in this survey in connection with my *PhD dissertation/research* at the Hong Kong Polytechnic University. The project is a study of *the adoption of open e-logistic standards in organizations*.

Your participation in the survey is voluntary. You are able to withdraw from the survey at any time and to request that the information you have provided is not used in the project. Any information provided will be confidential. Your identity will not be disclosed in any use of the information you have supplied during the survey.

The research project has been reviewed according to the ethical review processes in place in the Hong Kong Polytechnic University. Should you have any question now or in the future, please contact me or my supervisor.

Researcher: Xiaodie PU (jenny.pu@)

Supervisor: Prof. Felix Chan (f.chan@)

Participant Consent Form

Project title: Development of a Unified Open E-Logistics Standards Diffusion Model for Manufacturing Supply Chain Integrations

Researcher's name: Xiaodie Pu

Supervisor's name: Prof. Felix Chan

- I have read the Participant Information Sheet and the nature and purpose of the research project has been explained to me. I understand and agree to take part.
- I understand the purpose of the research project and my involvement in it.
- I understand that I may withdraw from the research project at any stage and that this will not affect my status now or in the future.
- I understand that while information gained during the study may be published, I will not be identified and my personal results will remain confidential.
- I understand that the interview will be recorded.
- I understand that data will be stored in accordance with data protection laws.
- I understand that I may contact the researcher or supervisor if I require more information about the research.

Signed _____ (participant)

Print name _____

Date _____

Part A: Firm and Respondent Information

Instructions: *Please answer the following questions about you and your organization.*

1. Operating industry:
   A. Automobile
   B. Power generating
   C. Electrical and electronic
   D. Chemical
   E. Steel
   F. Petroleum
   G. Pharmaceutical
   H. Others (please specify) _____

2. Years of operation:
   A. <1 Year
   B. 1-5 Years
   C. 6-10 Years
   D. 11-15 Years
   E. >15 Years

3. The approximate annual turnover in the last financial year (RMB):
   A. <25 million
   B. 25–100 million
   C. 100-300 million
   D. >300 million

4. Number of employees:
   A. <160
   B. 160-1,000
   C. > 1000

5. Number of IT employees
   A. <=5
   B. 6 – 10
   C. 11– 15
   D. >=16

6. Organizational ownership:
   A. State-owned (fully/partly owned)
   B. Privately-owned
   C. Local company with foreign ownership (Joint Venture)
   D. Foreign Controlled

7. Operational scope:
   A. Multinational Organization
   B. Non-Multinational Organization

8. Job title of respondent:
   A. CEO/President
   B: Senior executive/Vice President
   C: IT Manager/CIO/CTO
   D: Supply Chain/Operations Manager/COO

9. Number of years' the respondent has been with the organization:
   A. <1 Year
   B. 1-5 Years
   C. 6-10 Years
   D. 11-15 Years
   E. >15 Years

10. Please indicate the number of suppliers your company has been routinely interacting with _____.

11. Please indicate the average relationship length with your main suppliers (in years) _____.

Part B: OELS Adoption

Instructions: *Please read the following message and proceed to answer the following questions.*

Message for respondents

Open E-Logistic Standards (OELS) are typically developed by standard-setting consortia of firms and are based on Extensible Markup Language (XML) to enable point-to-point connections through public internet. OELS foster interoperability between supply chain partners and enable the integration of business processes across the supply chain.

12. Please indicate the extent to which you agree with the following statements… (only for potential adopters)

Options		Strongly disagree	Disagree	Somewhat disagree	Neutral	Somewhat agree	Agree	Strongly agree
AI1	Your firm is contemplating to adopt an OELS-based inter-organizational information systems in a year's time.							

AI2	Your firm is likely to adopt an OELS-based inter-organizational information systems in a year's time.							
AI3	Your firm is expecting to adopt an OELS-based inter-organizational information systems in a year's time.							

13. Please rate the extent to which your firm has been using OELS to conduct the following supply chain collaboration activities…(only for current OELS adopters)

Options		Extremely small extent	Very small extent	Small extent	Moderate	Large extent	Very large extent	Extremely large extent
INA1	Supplier selection (getting quotes, bidding etc.)							
INA2	Purchase order processing							
INA3	Procurement from suppliers (distribution, warehouse, shipping, logistics etc.)							
INA4	Invoicing and payment processing							

14. Please indicate the percentage of total transactions or inter-firm interactions that your firm has performed through OELS…(only for current OELS adopters)

Options		0-10%	11-20%	21-30%	31-40%	41-50%	51-60%	61-70%	71-80%	81-90%	91-100%
EXD1	Percent of total supply chain partners who interact with your organization through OELS										
EXD2	Percent of total supply chain partner transactions done through OELS										
EXD3	Percent of overall interactions with supply chain partners carried out through OELS										

Part C: Relational Mechanisms of OELS (for both potential and current adopters)

15. OELS-based inter-organizational information systems can …

		Strongly disagree	Disagree	Somewhat disagree	Neutral	Somewhat agree	Agree	Strongly agree
PCL1	Help us closely coordinate interdependent processes with partners							
PCL2	Enable interdependent operating procedures and routines to be highly visible among partners and us							
PCL3	Help us jointly optimize related operating processes with partners							
PCL4	Help us share exceptions and errors that occur during daily							

	operations with specific partners in a timely manner							

16. OELS-based inter-organizational information systems can …

		Strongly disagree	Disagree	Somewhat disagree	Neutral	Somewhat agree	Agree	Strongly agree
ADP1	Help our firm adapt existing supply chain relationships to respond quickly to changes in our markets							
ADP2	Help our firm adapt existing business processes to rapidly respond to shifts in our business priorities							
ADP3	Help our firm facilitate reconfiguration of supply chain activities to respond to changes in the external environments							

17. OELS-based inter-organizational information systems can …

		Strongly disagree	Disagree	Somewhat disagree	Neutral	Somewhat agree	Agree	Strongly agree
FLX1	Help our firm identify alternative sources							
FLX2	Help our firm locate alternative products or services							
FLX3	Help our firm seek new partners							

Part D: Network Properties

The descriptions below are shown for the current OELS adopter version of questionnaire. Slight modifications of the wording were made in the potential adopter version of questionnaire, and are shown in the brackets below.

18. For the following questions, please consider "the products" as the products as a whole that your firm has been trading through OELS [may consider to trade through OELS].

Options		Strongly disagree	Disagree	Somewhat disagree	Neutral	Somewhat agree	Agree	Strongly agree
PC1	A large amount of information is required to describe the products							
PC2	Many attributes are required to describe the products							
PC3	The specifications of the products are relatively longer than other products we buy							

19. For the following questions, please consider "the products" as the products as a whole that your firm has been trading through OELS [may consider to trade through OELS].

Options		Strongly disagree	Disagree	Somewhat disagree	Neutral	Somewhat agree	Agree	Strongly agree
PS1	The products need to be designed specifically to our needs							
PS2	The products need to be customized (or tailored) specifically to needs of our firm							
PS3	The products are of value to only a small number of buyers							

20. Please indicate the extent to which you agree with the following statements regarding the principal market your company is operating in…

Options		Strongly disagree	Disagree	Somewhat disagree	Neutral	Somewhat agree	Agree	Strongly agree
MT1	We continuously cater too many new customers							
MT2	Demand and customer tastes are very difficult to forecast							
MT3	Our customers tend to look for new products all the time							

21. Please indicate the extent to which you agree with the following statements regarding the principal industry your company is operating in…

Options		Strongly disagree	Disagree	Somewhat disagree	Neutral	Somewhat agree	Agree	Strongly agree
TT1	It is very difficult to forecast where the technology in our industry will be in the next 2–3 years							
TT2	A large number of new product ideas have been made possible by technological breakthroughs in our industry							
TT3	In our principal industry the modes of production and service often change							
TT3	In our principal industry the modes of production and service often change							
TT4	The rate of product/service obsolescence in our industry is very high							

22. Please answer the following questions regarding the relationships between your firm and the partners that your firm has been interacting with through OELS [may consider to interact with through OELS].

Options		1 or less times per year	2-4 times per year	5-8 times per year	9-11 times per year	1-3 times per month	1-4 times per week	1 or more times per day
SS1	All in all, how often does your organization interact with these partners (on average over the past 3–5 years)?							
Options		Never	Rarely	Occasionally	Sometimes	Frequently	Usually	Every time
SS2	To what extent has your organization been interacting with these partners (on average over the past 3–5 years)?							
Options		Very distant	Distant	Somewhat disagree	Neutral	Somewhat close	Close	Very close
SS3	How close has the working relationship been between your organization and these partners (on average over the past 3 years)?							
Options		Strongly disagree	Disagree	Somewhat disagree	Neutral	Somewhat agree	Agree	Strongly agree
SS4	Your organization is extensively engaged in joint projects with these partners							

23. Please answer the following questions regarding the relationships between your firm and the partners that your firm has been interacting with through OELS [may consider to interact with through OELS].

Options		Strongly disagree	Disagree	Somewhat disagree	Neutral	Somewhat agree	Agree	Strongly agree
RS1	Your organization trusts these partners to keep their promises							
RS2	These partners have always been fair in their negotiations with your organization							
RS3	These partners always reciprocate the favours you do for them							
RS4	These partners are trustworthy organizations							

Part E: Organizational Performance

24. Over the past three years, your firm has performed better than your key competitors in…

Options		Strongly disagree	Disagree	Somewhat disagree	Neutral	Somewhat agree	Agree	Strongly agree
OP1	Decreasing product/service delivery cycle time							

OP2	Rapidly responding to market demand changes							
OP3	Rapidly bringing new products/services to the market							
OP4	Rapidly entering new markets							
OP5	Rapidly confirming customer orders							
OP6	Rapidly handling customer complaints							

25. Over the past three years, your firm has performed better than your key competitors in…

Options		Strongly disagree	Disagree	Somewhat disagree	Neutral	Somewhat agree	Agree	Strongly agree
FIN1	Return on investment							
FIN2	Profits as percentage of sales							
FIN3	Net income before tax							
FIN4	Cash flow from operations							

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