The Effects of Network Properties on the Adoption of Open E-logistic Standards

Research-in-Progress

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Abstract

Based on structural embeddedness theory, this study investigates how network properties – product characteristics, environmental turbulence and tie structure– affect the adoption of open e-logistic standards (OELS). Network properties will influence OELS adoption, which will in turn affect a firm's operational performance. We collected data from manufacturing companies in mainland China using a survey instrument and 218 valid samples were received. The preliminary results show positive influence of product characteristics and tie structure on OELS adoption. Positive effect of OELS adoption on operational performance are also validated. However, the finding suggests an insignificant effect of environmental turbulence on OELS adoption. Future research aims to explore more interaction effects between different network properties on OELS adoption.

Keywords: open standards, network properties, structural embeddedness, IOS

Introduction

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. 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. 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 (Zhu et al. 2006). 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. 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).

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). 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. This study aims at addressing the knowledge gap in the extant literature to enhance the understanding of the relationship between network properties and OELS adoption.

Theoretical Background and Hypothesis Development

Structural Embeddedness Theory

The focus on network structure drove us 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). 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 (Pu et al. 2016; Tang et al. 2011). This paper focuses on the structural dimension of embeddedness, which, through affecting the influence of inter-organizational relationships on network performance, may promote more networking behaviour. Embedded networks are suggested to have a positive influence on cooperative norms to foster mutually beneficial relationships (Granovetter 1985). 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.

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. 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). *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). It is at the core of a firm's supply chain strategies to decide which tie structures should be formed.

Content of Exchange

this study, we mainly concern with the product characteristics to investigate the effects of the content of exchange. Product characteristics can influence the transactional relationships among supply chain partners, the procurement and supply processes, and supply chain management practices (Saeed et al. 2005), which thus should be investigated to understand the factors affecting OELS adoption. According to Malone et al. (1987), products characteristics can be investigated from two major aspects– *product complexity* and *product specificity*. 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, which generally requires a large amount of information to detail product specifications (Son and Benbasat 2007). 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 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 implement OELS in supply chain activities to enhance the agility of product design, delivery, and customer services.

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). 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 reduced through the automation of supply chain activities (Liu et al. 2010). Therefore, it is expected that companies dealing in products characterized by both high product complexity and specificity will be more willing to adopt OELS, which leads to the following hypothesis regarding the relationship between product characteristics and the OELS adoption:

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

Context of Exchange

It is 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). *Market turbulence* and *technology turbulence* 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). 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).

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). 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, a company will be motivated to implement 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, environmental turbulence is proposed to be positively associated with OELS adoption:

H2: Environmental turbulence ***positively*** *affects OELS adoption.*

Tie Structure

Tie structure describes the overall structure of the relationships among supply chain partners (Tang et al. 2011). Network relationships can range from loosely connected transactional exchanges to closely integrated long-term collaborative hubs (Burt 2009). 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). The literature has categorized tie strength as *structural strength* and *relational strength.* 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).

In relationships with high levels of structural strength, partners are inclined to mutually engage in activities to reallocate and combine their resources (Kim and Choi 2018), which will motivate the coadoption of OELS to facilitate the transfer of information and know-how. 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. Partners with strong relational bonds generally share common understandings and expect moral support and acceptance from others (Kim and Choi 2018), which will promote repeated contacts among supply chain partners and motivate companies to adopt OELS to utilize mutually available resources (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). Based on the above discussion, tie strength is considered to have a positive impact on OELS adoption:

H3: Strength of ties as a whole between a firm and its major suppliers ***positively*** *affects OELS adoption.*

Operational Performance

A firm's operational performance is highly contingent with its extent of IT competency, and this is reflected in their supply chain integration efforts through the adoption of technologies such as OELS (Liu et al., 2016). Research has long proposed the impacts of an organization's IT competency on their overall processing capability. Higher levels of IT competence makes it more easy for organizations to process and utilize useful information acquired through supply chain processes, which further improves their performances (Chakravarty et al. 2013). Furthermore, the ability of an organization to access updated, or at least timely, information serves as a key strategy that helps them solve various problems within their supply chain, such as poor customer service and the bullwhip effect. Internet-based technologies (e.g., OELS) has been confirmed in previous studies to give managers an improved ability to gain access to various important information including prices, delivery, and inventory information. OELS is therefore, not only useful as a tool for facilitating purchase orders, but also as a tool to achieve and manage various other organizational and operational objectives. Various studies (e.g., Saeed et al. 2005; Liu et al., 2016) have found that supply chain integration through internet-based technologies such as OELS aid organizations towards achieving improved performances. Based on the above discussion, OELS adoption is expected to improve operational performance, which leads to the following hypothesis:

H4: OELS adoption ***positively*** *affects a firm's operational performance.*

The hypotheses and research model are illustrated in Figure 1.

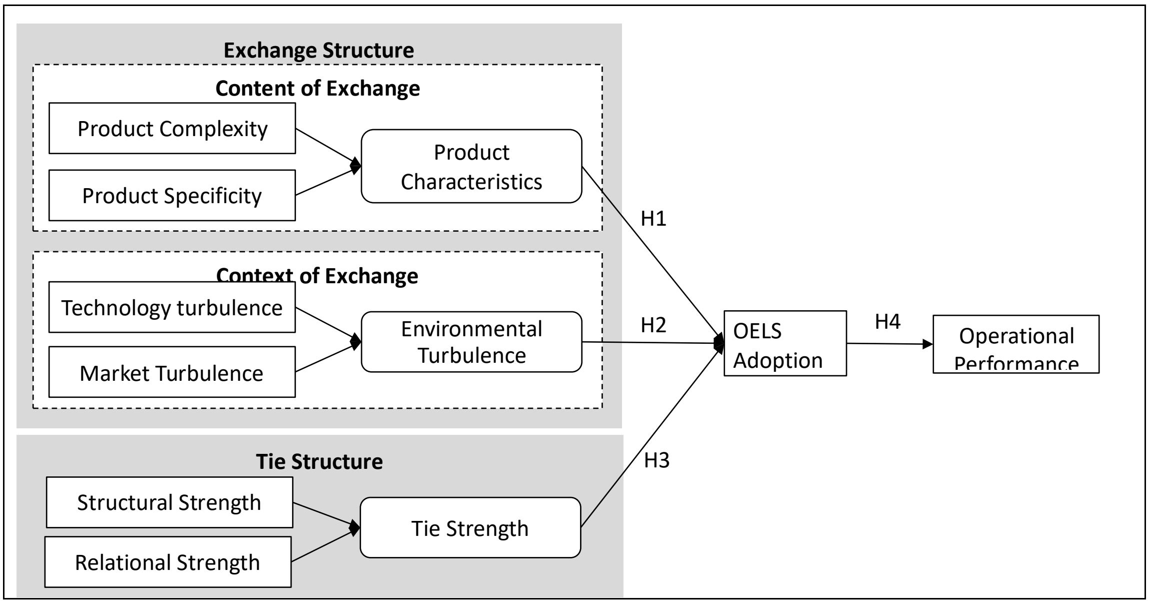


Figure 1. Research Model

Methodology

Measurement Development

To test the hypotheses, a survey instrument was developed to collect data from manufacturing companies operating in Mainland China. Product characteristics, environmental turbulence and tie structure were modelled as formative second-order constructs, and their sub-constructs were measured as reflective. Operational performance was assessed as a multi-time formative construct. The measurement items and the sources where they adapted from are shown in Table 1.

Table 1. Constructs and Measurement Items

Internal Assimilation		
AD1	Supplier selection (getting quotes, bid etc.)	Zhu et al. (2006) and Zhang et al. (2016)
AD2	Purchase order processing	
AD3	Procurement from suppliers (distribution, warehouse, shipping, logistics etc.)	
AD4	Invoicing and payment processing	
Operational Performance		
OP1	Decreasing product/service delivery cycle time	Liu et al. (2016)
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	
Product Complexity		
PC1	A large amount of information is required to describe the products	Malone et al. (1987) and Son and Benbasat (2007)
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		
PC1	The products need to be designed specifically to our needs	Malone et al. (1987) and Son and Benbasat (2007)
PC2	The products need to be customized (or tailored) specifically to needs of our firm	
PC3	The products are of value to only a small number of buyers	
Market Turbulence		
MT1	We continuously cater too many new customers	Kandemir et al. (2006) and Koo et al. (2006)
MT2	Demand and customer tastes are very difficult to forecast	
MT3	Our customers tend to look for new products all the time	
Technology Turbulence		
TT1	It is very difficult to forecast where the technology in our industry will be in the next 2–3 years	Kandemir et al. (2006), Koo et al. (2006), and Trkman and McCormack (2009)
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	
TT4	The rate of product/service obsolescence in our industry is very high	
Structural Strength		
SS1[a]	All in all, how often does your organization interact with these partners (on average over the past 3–5 years)?	Kim and Choi (2018)
SS2[b]	To what extent has your organization been interacting with these partners (on average over the past 3–5 years)?	
SS3[c]	How close has the working relationship been between your organization and these partners (on average over the past 3 years)?	
SS4[d]	Your organization is extensively engaged in joint projects with these partners	
Relational Strength		
RS1	Your organization trusts these partners to keep their promises	Ganesan (1994) and Kim and Choi (2018)
RS2	These partners have always been fair in their negotiations with your organization	
RS3	These partners always reciprocate the favors you do for them	
RS4	These partners are trustworthy organizations	

[a] 7-point anchor scale, 1 = once per year or less, 2 = 2-4 times per year, 3 = 5-8 times per year, 4 = 9-11 times per year, 5 = 1-3 times per month, 6 = 1-4 times per week, 7 = once per day or more; [b] 7-point Likert scale, 1 = Rarely, 7 = Every Time; [c] 7-point Liker scale, 1 = Very Distant, 7 = Very Close; [d] 7-point Likert scale, 1 = Strongly Disagree, 7 = Strongly Agree;

Data Collection

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 was decided to be the sampling frame to ensure that the sample could span the comprehensive spectrum of manufacturing industries. 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. The senior executives, such as the chief executive officer, chief technology officer, and senior operations managers, were identified as the key informants because they have adequate knowledge about their companies' overall operational and IT capabilities. After discarding the responses with excessive missing data and low confidence levels, the final sample consisted of 218 valid responses for analysis.

Data Analysis

Measurement Validation

To examine the measurement model, we began with the assessment of the reflective constructs in the study before assessing the formative constructs. For the reflective constructs, we examine their reliability, convergence validity, and discriminant validity. Table 2 shows the obtained values for the constructs Cronbach's alpha, composite reliability, and average variance extracted (AVE), which all exceed the cut-off values. Discriminant validity is also presented in Table 2, which shows the square roots of the AVEs (bold) are greater than the inter-construct correlation (horizontal), Therefore, the reflective items in our study satisfy the standard reliability and validity requirements.

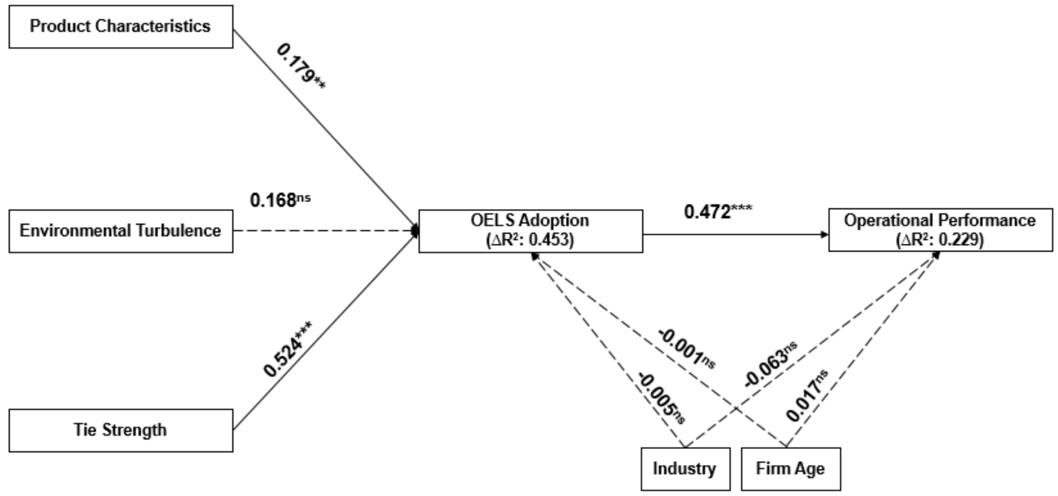
Regarding formative constructs, their assessment relies on the examination of the significance level of all their indicators, and an examination of inter-item collinearity. Each formative indicator is considered valid if it displays a significance (p value < 0.1), and is not found to have collinearity issues with VIF value that is greater than 0.5. While we do not present these results because of limited space, all the formative indicators used for the subsequent analysis reported significant p values (range: 0 - 0.093), and all VIF values were below 0.5 (range: 1.172 - 2.967). Therefore, we are able to conclude that the measurement model is valid, and can we can examine the structural model and our hypotheses.

Table 2. Fornell-Larcker Criterion

	Cronbach's Alpha	Composite Reliability	AVE	1	2	3	4	5	6
1. Market Turbulence	0.723	0.827	0.548	**0.741**					
2. Product Complexity	0.662	0.815	0.596	0.261	**0.772**				
3. Product Specificity	0.623	0.789	0.559	0.616	0.3	**0.748**			
4. Relational Strength	0.772	0.845	0.523	0.237	0.575	0.32	**0.723**		
5. Structural Strength	0.742	0.838	0.564	0.376	0.432	0.389	0.613	**0.751**	
6. Technology Turbulence	0.836	0.881	0.555	0.726	0.14	0.517	0.153	0.315	**0.745**

Preliminary Findings

Upon satisfaction with the measurement model, we proceeded to assess the structural model and determine whether our hypotheses are accepted. This was carried out by examining the inter-construct collinearity level to ensure there is no collinearity issue at the construct level, followed by an assessment of the significance of the path effects using a bootstrapping technique, and then the assessment of the adjusted R^2 values. With regards to the inter-construct collinearity assessment, it can be observed from Figure 2 that all VIF values fall between 1.032 and 2.022, furthermore, it can also be observed from table 3 that no correlation is up to 0.9, serving as further evidence of no collinearity. To assess our hypotheses, we carried out a bootstrap specifying 5000 sub-samples as recommended. We find that hypotheses 1, 3, and 4 are accepted, while hypothesis 2 is rejected on account of having an insignificant effect (p value > 0.1). We also observe that product characteristics, environmental turbulence and tie strength are together able to explain 45.3% of the variance in OELS adoption, while OELS adoption is able to weakly explain 22.9% of the variance in operational performance.



**p < 0.1; **p < 0.01; ***p < 0.001, straight lines: significant, dash lines: not significant*

Figure 2. Preliminary Results

Conclusion and Future Study

This study investigated the relationships between network properties and OELS adoption. The preliminary findings show supports for the influence of product characteristics and ties structure on OELS adoption. However, environmental turbulence had no significant effects on OELS adoption. Our future research will aim to explain the insignificant effect of environmental turbulence. It is also interesting to investigate whether there are moderation effects between different network properties. In addition, directions for future research also include to introduce more inter-organizational relationship factors, e.g., relationship length, network centrality, network size, to enhance the existing research model. It is also essential to understand the effects of OELS adoption on long-term firm performance to check whether the effects of OELS adoption are durable.

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