

The Driving Force of ICT Investment and Application in Supply Chain Management: an Organizational Perspective

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Abstract — It is widely accepted that the effect of information and communication technologies (ICT) on supply chain (SC) management and supply chain performance is a vital research area. However, what factors make companies do ICT investment and application is less investigated. This paper explores two different driving mechanism underlying SC performance: the relational and the transaction cost vie, furthermore this paper postulates that different country settings might be influential for the driving factors. By using Chinese and Dutch data, the analysis of the empirical data shows some support for the effect of different country settings and the applicability of different theoretical lenses in those settings.

Keywords - *ICT, relational view, transaction cost, supply chain performance*

I. INTRODUCTION

The key role of Information and communication Technologies (ICT) in facilitating effective supply chain management is well documented (for a recent review see [1]). Specifically, the positive influence of ICT on supply chain performance has been reported, either directly [2, 3] or indirectly [4-6]. However as the recent review of Zhang et al. (2011) [1] points out, many studies use aggregate measures for ICT and often mix both the internal facet of ICT and the external facet of ICT. We expand on this body of knowledge by separating the internal ICT facet from the external ICT facet and argue that the different antecedents for internal and external facets.

While there is a relatively abundant literature on the effects of ICT, less is known about what drives ICT investment and application. The current paper proposes two different theoretical lenses of relational network theory and transaction cost economics to argue that the same ICT investment and application. The ICT phenomena have two different drivers when it comes to comparing supply chains in the developed versus supply chains in emerging countries. More specifically, we propose and test the notion that the transaction cost perspective is more pertinent to the Dutch context (representing a developed country) while understanding the motivations and effects of ICT on supply chain performance. In sharp contrast, a relational/social network perspectives offer a more robust lens to examine ICT investments and their effects on supply chain performance in the context of China (representing an emerging country). To the best of our knowledge, this is the first investigation that compares Dutch and Chinese supply chains from such different theoretical perspectives with a specific emphasis on ICT and their effects on performance. The empirical part of our paper relies on original data gathered in both China and The Netherlands using the same questionnaire. Employing these two competing theories

across two diverse supply chain contexts offers a promising avenue of furthering our knowledge on the motivations and drivers for ICT and effectiveness of both internal and external ICT on supply chain performance. Due to globalization, it might be of interest not only to academics but also to practitioners to know if the drivers and mechanism of ICT are different across Dutch supply chains versus Chinese supply chains.

The remainder of this paper is organized as follows. The next section will develop the theoretical background of the paper. Then, we will describe the methodology. The fourth section will present the results. We conclude with a discussion of our results and concluding remarks.

II. THEORETICAL BACKGROUND

In order to arrive at the central proposition of this paper, we will first discuss the current literature that connects ICT to SC performance. Then, we will discuss the two underlying theoretical perspectives and use these to derive from these what drives the usage of ICT and how the usage of ICT helps to improve supply chain integration which improves SC performance. Finally we will discuss how different context and specifically different country cultures influence those mechanisms.

A. *The role of ICT in SC performance*

As stated in the introduction, the key role of ICT in improving SC performance is indisputable. A recent review by Zhang et al. (2011) [1] explores survey papers that investigate the ICT-SC performance relationship, distinguishing both direct and indirect models. Their review offers an interesting starting point for further research. Zhang et al. (2011) [1] conclude that while papers in general report a positive effect of ICT on SC performance it is hard to say what exactly makes ICT work in the SC context. More specifically, they conclude that the difference between inter- and intra-organizational ICT has been ignored in the research

reviewed. This is surprising as in the management information systems literature this difference is well known and described, e.g. Savitskie (2007) [7] and Ward and Zhou (2006) [8] distinguish between internal and external types of ICT. Zhang et al. thus suggest that intra- and inter-organizational ICT need to be studied by addressing questions such as: What are the separate effects of intra- and inter-organizational ICT and how do they impact on SC performance? Following a well-established idea in SC integration [9] we suppose that in general internal ICT investment will positively influence the effect of the application of inter-organizational ICT (IOICT). The idea is that before being able to use inter-organizational ICT to improve supply chain management, the internal ICT (e.g. an ERP system) should be implemented and used that serves to have all production related data and information available.

A second conclusion is that the review concludes that contextual factors have been ignored in this field. It is recommended to incorporate contextual variables to explore contingencies in the application of ICT and SCM and their relationship, which is in line with the call for further research reported in [4] and [10]. In this paper, we specifically aim to find the effect of different country contexts on this relationship as explained in the introduction.

B. ICT in a relational perspective

The relational view considers that the firm’s critical resources can be obtained and sustained over time from inter-firm resources and processes (i.e. synergistic combination of assets, knowledge, or resources/capabilities) that focus on dyadic personal assets [11]. In that perspective, effective relationships that cause increases in SC performance result from ongoing processes of relational exchange between trading partners characterized by continuous interactions and adaptations [12]. In order to make investments in ICT beneficial, they need to be preceded by intense socialization among network partners promoting the idea of trust and commitment. In some sense, trust and commitment become important pre-cursor conditions before any idea of ICT investments and subsequent improvement in SCM and SC integration can be entertained.

C. ICT in a transaction cost perspective

There is also a considerable literature that explains the drivers to supply chain technology investments from a transaction cost perspective [13, 14]. This perspective argues that asset specificity - i.e., firms making tangible investments that are specific to a buyer-supplier relationship which has no other residual value - can help explain the motivations for firms to make substantial investments in ICT.

Both from a cost and time perspective, these investments tend to be long term in nature and are largely irreversible at least in the short term horizon. This perspective has typically compared the alternatives of market versus internal bureaucracy while deciding on the make versus buy strategic decision. Based upon the above discussion on how ICT usage can improve SC integration (information sharing) and the description of the relational and transaction cost view,

firstly we explain how trust and asset drives ICT investment and enable supply chain and SC performance to improve.

D. The role of country specific characteristics

Since the seminal work of Hofstede (1980) [15], it is well-known that national cultures differ substantially. In general western and Asian cultures differ in a number of the dimensions distinguished by Hofstede. Comparing China and The Netherlands shows some striking differences [16]. Specifically on the dimensions Long Term Orientation China has almost three times the score of The Netherlands (118 vs. 44), on uncertainty avoidance China has a lower score (30 vs 53) while also the level of individualism is lower (20 vs. 80).

The most striking difference is in the long term orientation that is in sharp contrast with short term orientation. A long term orientation will drive companies to engage in relationship that they trust rather than making sudden changes and renegotiate existing or new deals with different partners. That makes us hypothesize that for the Chinese situation a more cooperative, relational and network based situation is valid. So, trust and cooperation might be a starting point for how internal ICT investment and IOICT application leads to better information sharing and increased performance. On the other hand the orientation on the short run, together with more risk-taking and more conflict based culture will make the transaction cost theory based model more valid. In other words, investing in asset-specific integration will influence how ICT both internal and external is used and how information sharing is influenced and leads to performance. We hypothesize that under the context of Western world which can be tested on Dutch data, the driving force from asset specificity is stronger. The whole picture of the research is shown in Figure 1.

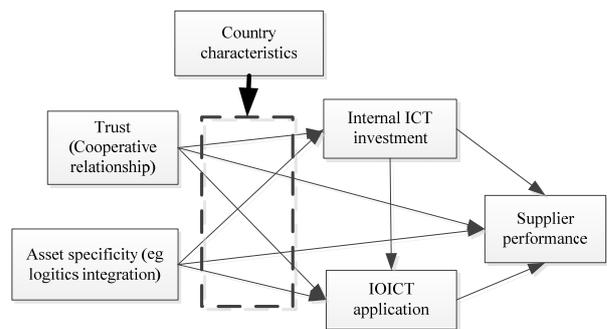


Fig. 1. Conceptual Model.

III. METHODOLOGY

The questionnaire has been developed and tested based on the items and scales from both supply chain management literature [9, 17] and ICT literature [8, 18, 19, 20]. Two ICT constructs represent internal ICT investment and IOICT application. Internal ICT represent the investment in such systems as MRP and ERP that are intended to streamline the flow of information within the organization, whereas IOICT

represent the application of external ICT to achieve the electronic linkages and cooperation between different organizations in supply chain. Information sharing is linked to the sharing of information between companies that help to better exchange plans and forecasts. Asset specificity refers to logistics integration which represents the investment in asset specificity and relates to the investments made in specifically adapting to the precise requirements of the customer and the synchronization of delivery activities (e.g. frequency). With regard to cooperative relationship, it is defined as the level of trust organizations, those are characterized by shared responsibility and flexibility in

arrangements to deal with unexpected situations [21]. Using items and scales from [22], the study measures supply chain performance in terms of service. As our target population is suppliers, we focus on how well the supplier satisfies the buyer’s requirements for the order quantities, special requirements, delivery lead times and advance notifications about late deliveries and stock-outs. Data were gathered in both The Netherlands and in China, resulting in a sample of respectively 112 and 320 respondents. Our respondents were suppliers from SIC 33-38 in their relationships with their most important buyer.

TABLE I. CFA RESULTS FOR MEASUREMENTS SCALES AND ASSOCIATED INDICATORS

Items	Factor					
	1	2	3	4	5	6
F1: Internal ICT investment: $\alpha = .77$, CR=.77, AVE=.46 (Please indicate to what extent these technologies used in your company) ^a						
Forecast-Demand Management Software	0.64					
Manufacture Execution System for Production Management	0.72					
Product Data Management software	0.70					
Computerized Integrated Manufacturing (CIM)	0.65					
F2: IOICT application: $\alpha = .84$, CR=.85, AVE=.53 (Please indicate the degree to which you agree with each statement) ^b						
We use information technology-enabled transaction processing with our key buyer. (e.g. EOS, POS)		0.75				
Inter-organizational coordination between our key buyer and our firm is achieved using electronic links		0.78				
We use electronic transfer of purchase orders, invoices and/or funds with our key buyer (e.g. EDI, RFDC- Radio Frequency Data Communications/Collection)		0.66				
We use advanced information systems to track and/or expedite shipments to our key buyer.		0.80				
We have online access to the planning system of our key buyer. (Arcs of integration: an international study of supply chain strategies)		0.63				
F3: Logistics integration: $\alpha = .79$, CR=.80, AVE=.50 (Please indicate the degree to which you agree with each statement) ^b						
Containers and packaging instruments of outgoing materials are adapted to the precise requirements of the key buyer			0.77			
We use packaging materials (pallets, containers, etc.) suited to the internal handling system of the key buyer			0.86			
We deliver to our key buyer frequently			0.63			
We deliver to our key buyer on a short notice			0.53			
F4: Cooperative relationship: $\alpha = .86$, CR=.86, AVE=.61 (Please indicate the degree to which you agree with each statement) ^b						
In most aspects of this relationship, the parties are jointly responsible for making sure that tasks are completed				0.78		
Problems that arise in the course of this relationship are treated as joint rather than individual responsibilities				0.82		
When some unexpected situation arises, the parties would rather work out a new deal than to hold each other to the original terms.				0.73		
It is expected that the parties will be open to modifying their agreement if unexpected events occur				0.79		
F6: Supplier performance: $\alpha = .65$, CR=.79, AVE=.50 (Provide an indication of the improvement of your organization’s performance relative to three years ago. In case the relationship with your key buyer is shorter than three years, please refer to the improvement of your performance since the start of the relationship) ^c						
Provides the quantities ordered by the key buyer						0.74
Has a short delivery lead time						0.66
Responds to the special requirements of the key buyer						0.69
Notifies the key buyer in advance about late deliveries or stock-outs						0.71
a: Scale: No use -significant use (1-5) b: Scale: Totally disagreed- totally agreed (1-5) c: Scale: Far worse-Far better (1-5)						

A. Factor analyses

Based on our preliminary data analysis, we performed confirmative factor analyses, forcing the items into five constructs CFA measurement model was used to further establish unidimensionality and construct validity. The model fit indices ($\chi^2/df = 2.63$, GFI= 0.89, CFI = 0.90, IFI=0.9, RMSEA = 0.07) show that the model fits the data well and hence establish unidimensionality. Cronbach’s alpha values of most constructs are around 0.80, only supplier performance has the value (0.65) is lower, but close to the widely accepted cutoff value of 0.70 and greater than the minimum recommended value of 0.60 [23]. Therefore, it seems save to conclude that measures are reliable. Additionally, composite reliability (CR) scores were computed to assess construct reliability [24]. The CR value of all factors greater than 0.70, implying that the variance captured by the factor is significantly more than the variance indicated by the error components. Therefore, we feel safe to conclude the theoretical constructs exhibit good psychometric properties.

IV. RESULTS

Before testing country effects, the basic model was tested using the entire data set. A covariance SEM analysis was conducted in AMOS. All goodness-of-fit indices of the model were acceptable (GFI = 0.91, IFI=0.92, CFI = 0.92, RMSEA = 0.05). Then, the coefficients of the basic model for the two countries were analyzed separately. Finally, the moderating effect of nationality was statistically tested. A common simple method to check the moderating effect is enforcing a constraint for the path coefficient to the analysis

model. If the magnitudes of the two path coefficients are significantly different in the two models, with and without constraints, this implies that these two coefficients are moderated by country. All the results are summarized in Figure 2 and Table II .

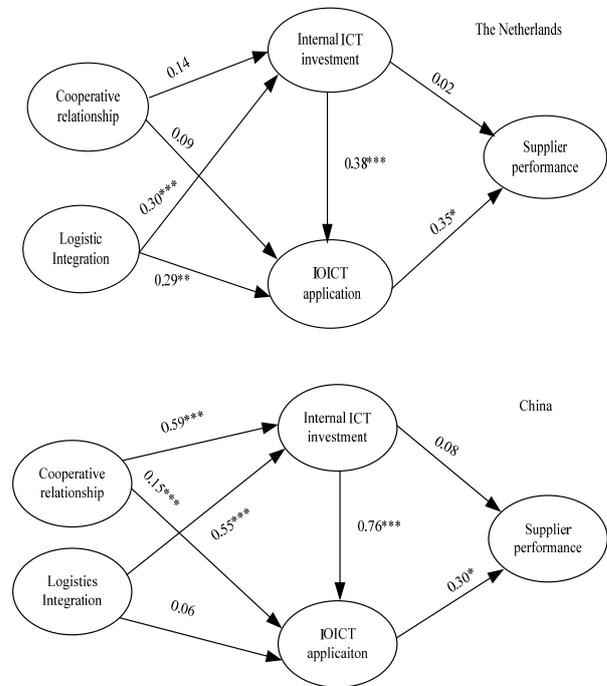


Fig. 2. Result of Chinese and Dutch data

TABLE II. RESULT OF STRUCTURAL EQUATION MODELING OF COMPETING MODELS

Paths in structural model	China Context	Dutch Context	Moderated By countries
Cooperative relationship → Internal ICT	0.59***	0.14	Yes
Cooperative relationship → IOICT application	0.15***	0.09	
Logistics Integration → Internal ICT	0.55***	0.30***	Yes
Logistics Integration → IOICT application	0.06	0.29**	
Internal ICT → IOICT application	0.76***	0.38***	Yes
Internal ICT → Supplier performance	0.08	0.02	
IOICT application → Supplier performance	0.30**	0.35**	
Model fit statistics			
χ^2/df	2.75	1.31	
GFI	0.90	0.88	
CFI	0.92	0.93	
IFI	0.92	0.93	
RMSEA	0.07	0.05	

All models have a reasonable fit with the data in terms of statistics, despite the somewhat small sample size for the Dutch data set. Under China context, cooperative relationship drives both the investment on internal ICT and IOICT application. Logistics integration has a significant relationship with internal ICT investment, however, has no influence on IOICT application. With regard to Dutch data, logistics investments seems to be antecedents for more internal ICT investment and IOICT application, but cooperative relationship enable neither internal ICT

investment nor IOICT application. With considering to the difference between China and the Netherlands, there are significant differences between cooperative relationship and internal ICT investment/ IOICT application, also logistics integration and IOICT application, which do mostly support our hypothesis. For the relationships between ICT and performance, it seems that IOICT application impact on supplier performance while internal ICT investments has no significantly direct relationship with supplier performance.

V. DISCUSSION AND CONCLUSION

This paper aims to explore the idea that different country contexts would influence the mechanisms through which ICT become effective. It is hypothesized that the for an emerging economy like China a more relational based theory would be able to explain how ICT be invested and applied, while for the developed world, as represented by the Netherlands, we expected that a transaction theory based perspective would explain the investment and application of ICT. We found strong support for this idea in the Dutch data, while the Chinese data support our most initial idea. It is only unexpected that both transaction theory and relational theory seem work for explaining the antecedent of internal ICT investment under China context. These finding firstly indicate that country characteristics do influent firms' decisions on ICT investments and application. For Chinese data, it is shown that trust between partners plays an important role in ICT investments and application. If the firms have closer cooperative relationship with their buyers, they are more willing to invest in internal ICT to achieve accurate information and then sharing between the buyers, which is more relation driven. With regard to Dutch context, the firms will invest more in internal ICT and achieve more integration through IOICT when they already spend money in achieving asset specificity with the buyers. Therefore, it can be concluded as transaction cost driven. Secondly, it confirms the difference existing between internal and external ICT. It is not only proved by the above results about the antecedents of ICT but also by the relationship between ICT and supplier performance. The results show that internal ICT investment does not effect on supplier performance while IOICT implementation does influence supplier performance improvement. The finding supports the arguments in previous studies that internal and external ICT has different facets. Inter-organizational ICT play the role as medium to transfer information and help communication across organizational boundaries and therefore directly increase supplier performance while internal ICT, which helps firms to enhance internal control capabilities and improve capacity of the system and development, is acted as the infrastructure to support information sharing and communication between partners but not directly impact on supplier performance.

The results of this study carry several implications for practitioners and researchers. As far as academic contributions, it will bring aspects of international business into the domain of operations and it might help understand if, why and how SC practices and ICT could and should be fitted to country specific characteristics. For practicing managers, our research could help better understand particular nuances of implementing ICT. Rather than using one approach for all countries, consultants and managers should realize that each country might need different ways to make ICT effective.

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