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ICT Stages and Moderating Effect of Technological Uncertainty

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Abstract: The impact of ICT in the supply chain has been given much attention in recent literature. Although ICT generally leads to performance gains, it is still unclear which specific aspects of ICT affect which specific aspects of supply chain performance. Therefore, this paper investigates the role of three subsequent ICT stages an organization can employ. It was expected that higher stages yield more benefits than lower stages. Moreover, the concept of technological uncertainty was expected to moderate these relationships. Industries with high uncertainty would benefit from the highest stage of ICT by attaining a competitive advantage, whilst firms performing in low technological uncertainty should employ lower stages. An empirical survey-based research was conducted amongst Chinese manufacturers. A supplier perspective was used and questions were related to the key buyer of the firm. Therefore, performance was measured on a dyadic level. The results show that all ICT stages lead to increased service performance, whilst no effect was found for cost performance. Additionally, a moderating effect was found between the highest stage of ICT and both types of performance. These findings confirm the positive impact of ICT and imply it has different effects on different types of performance. Moreover, ICT capability should be employed when the technological uncertainty is high, as it does not pay off in industries with low uncertainty.

Keywords: Supply chain, Information and communication technology, Service performance, Cost performance, Technological uncertainty, Empirical research

1. INTRODUCTION

Contemporary businesses make extensive use of ICT to exchange information, both between departments within the firm, as between firms in the supply chain [1]. Nowadays, some firms suffer from unrealized savings, wrong implementation strategies, delays or exceeding costs [2]. So far, the fast majority of the literature shows a positive, either direct or indirect, relationship between the use of ICT and supply chain performance, yet some found less evidence or even no relationship at all [3]. This inconsistency could be contributed to the variety of items used to measure both ICT and performance. Although the overall impact of ICT is consistently positive, it is still unclear which specific aspects of ICT affect which specific aspects of supply chain performance. In order to successfully implement ICT projects in the supply chain, it is essential to expose the underlying mechanisms leading to performance gains or losses. This paper proposes the use of a further categorization of ICT as an explanation for the variety of research results.

Zhang, Van Donk and Van der Vaart suggest the level of ICT in firms can be grouped into three different subsequent stages: ICT investment, ICT usage and ICT capability (2011). Surprisingly, this theory has not been explicitly tested ever since its development, even though it can be expected that each stage has a different degree of impact on firm performance. Whilst the two first stages of ICT do not match these criteria and can be easily mimicked by others, the latter employs a clear competitive advantage. Hence, it can be expected that each stage has a different degree of impact on firm performance, yet it still needs empirical evidence.

Furthermore, three different types of environmental uncertainty have been identified in the forms of supply, demand and technology. The impact of environmental uncertainty on the relationship between ICT and supply chain performance provides interesting results. Although the influence of supply and demand uncertainty have

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found academic back-up [4], the results of researches concerning technology uncertainty prove to be inconsistent. Some authors show that high-tech firms should develop IT-based supply chain integration in order to achieve performance [5], whilst others prove the contrary [6]. Apparently, it is still unclear in what way the degree of technological uncertainty has an effect on the implementation of ICT. This paper provides a new theoretical perspective, as the impact of technological uncertainty may differ per ICT stage.

The purpose of this paper is to gain more understanding in the specific roles of ICT stages in supply chains. In addition, the impact of technological uncertainty will be scrutinized. Consequently, the following research questions are posited: 1) Is there a difference between the stages of ICT and the effect on performance in supply chains? 2) To what extent is the relationship between the ICT stages and performance moderated by technological uncertainty? Therefore, this paper will introduce and discuss in details as follows.

2. THEORETICAL BACKGROUND

2.1 ICT in supply chains

ICT can be deployed for both internal uses, as for maintaining external relationships. Intra-organizational or internal ICT involves those information systems and technologies that plan, track and order components and products within the firm . Inter-organizational or external ICT is characterized by those information systems and technologies that link different organizations in a supply chain. Further research has proposed a different categorization of ICT: ICT investment, ICT usage and ICT capability. ICT investment is amount to intra ICT,"the technology-based infrastructure that acts as a conduit for facilitating transactions, sharing information with trading partners, coordinating activities and establishing governance structures between firms"[7]. ICT usage is amount to inter ICT, which can be defined as"information technologies and or practices used to share information within a firm. In general, this includes the databases and applications which facilitate integrating financial, accounting, and supply chain operations with a particular focus on logistics systems."[1]. ICT capability is the basis of information and communication technology, which contains not simply the resources of an organization, but the resources which cannot be imitated due to a deep embedding in organizational routines and practices [8].Therefore, resources and capabilities drive firm performance, if these are firm-specific, rare, non-imitate able and difficult to substitute . Whilst the two first stages of ICT do not match these criteria and can be easily mimicked by others, the latter employs a clear competitive advantage. Consequently, it may be expected that the different ICT phases play a different role in supply chains.

2.2 Supply chain performance

A wide variety of indexes has been used to measure the performance in a supply chain. The supply chain council identifies five categories: reliability, responsiveness, agility, cost and asset management efficiency (2013). According to Van der Vaart and Van Donk, these definitions are on an operational level, whilst performance can also be measured on a strategic level (2008). Strategic measurements reflect the effectiveness or efficiency of the conducted activities in a supply chain, like market share, turnover and financial performance. In this paper there is a focus on the relationship between the supplier and its key buyer on a dyadic level, hereby excluding all other customer relations. Therefore, supply chain performance will be defined based on the operational instead of the strategic level. A differentiation will be made between service performance on the one hand, and cost performance on the other. Service performance includes the reliability to complete processes as promised and the flexibility to respond to changing events and demands [9]. Cost performance implies all the costs that are associated with the operating processes [9]. Consequently, this paper will shed some light on the question which specific aspects of ICT affect which specific aspects of supply chain performance.

2.3 Technological uncertainty

Technological uncertainty reflects the perceived speed of technological change in a firm's industry. It concerns changes in the standards or specifications of products and can be characterised by rapid process obsolescence [10]. If the degree of technological uncertainty is high, technical requirements are hard to forecast accurately. The role of technological uncertainty in supply chains has been researched based on different hypothetic constructs. Technological uncertainty has proposed to be a direct predictor of performance or supply chain integration . However, the results diverge substantially, as some authors conclude that businesses performing in a technological unstable market benefit from ICT [5], whilst others prove the contrary [6]. On the one hand, high technological uncertainty demands high responsiveness to stay competitive, for which ICT can function as a quick information and integration tool [5]. On the other hand, it is argued that an organization enjoys greater returns from ICT in stable environments, as technology itself does not provide much flexibility [6].

2.4 Forming of hypotheses

2.4.1 ICT investment and performance

When considering ICT investment, this stage can increase sales, assets and equity and enhance the performance of a firm in general .Furthermore, it is indisputable that investments are necessary to form a solid ICT infrastructure, in order to be able to create business value [11]. Although this forms a basis necessary to proceed to the next stage, the effect of mere investments is limited in a supply chain context. ICT investment are internally focused and therefore rather a condition than a predictor of supply chain performance [12]. In this stage solely standard ICT techniques are employed, which can easily be mimicked by competitors and do not provide any sustainable competitive advantage. Indeed, Ward and Zhou did not find a significant relationship between ICT investment and delivery time, an aspect of service performance (2006). This leads to the hypothesis that investing in ICT is a necessary condition in supply chains, but not enough to directly increase performance.

Hypothesis 1a: There is no direct effect of ICT investment on service performance.

Hypothesis 1b: There is no direct effect of ICT investment on cost performance.

2.4.2 ICT usage and performance

By adopting ICT usage, suppliers and/or consumers are integrated in the exchange of information, which makes this stage inter-organizational instead of intra-organizational. ICT usage is still easy to imitate by competitors. Research involving this second stage of ICT shows mixed results, as some authors see a positive linkage with performance,whilst others did not find a direct effect. These contradictory findings could be explained by the fact that ICT usage is the middle stage, and it therefore somewhat overlaps with the first and third stage. Moreover, this study builds on the premise ICT usage already has some positive effects on certain aspects of performance, but it might not be enough for other types of performance. Concerning service performance, some positive effects of inter-organizational information integration were found by Wong, Lai and Cheng (2011). In contrary, no direct effect was found for its effect on cost performance [13]. Baihaqi and Sohal concluded that ICT usage leads to information sharing, which leads to collaboration, which leads to higher cost performance, classifying ICT usage as a far antecedent but not a predictor of cost reduction (2013). Therefore, it is hypothesized that this stage has a positive effect on service performance, but not on cost performance.

Hypothesis 2a: There is a direct positive effect of ICT usage on service performance.

Hypothesis 2b: There is no direct effect of ICT usage on cost performance.

2.4.3 ICT capability and performance

In this stage, both the intra-organizational, as the inter-organizational ICT of a firm are combined with other firm resources resulting in an important competence [3]. This way, value can be delivered towards the customers in a more cost effective way. Hence, it makes sense a direct positive linkage with the performance of an organization exists. Rai, Patnayakuni and Seth have found that an integrated IT infrastructure amongst supply chain partners enables firms to develop a high degree of integration, which in turn leads to significant and sustained performance gains (2006). Although supply chain integration might magnify the impact of ICT capability on performance, the mere presence of firm-specific resources could be enough to increase the profitability. Moreover, operational costs can be reduced by intangible information systems and information technology. Not every company succeeds in using ICT effectively and creating a real competitive edge. This paper posits the hypothesis that companies that do manage to reach this third stage, can directly expect some positive returns.

Hypothesis 3a: There is a direct positive effect of ICT capability on service performance.

Hypothesis 3b: There is a direct positive effect of ICT capability on cost performance.

2.5 The moderating role of technological uncertainty

The hypothesized relationship between ICT and supply chain performance may be contingent to the degree of technological uncertainty present in the industry. This section elaborates on the expected moderating effect of technological uncertainty on the hypothesized relationships between ICT usage and service performance, and between ICT capability and cost and service performance.

2.5.1 ICT usage and service performance

Ragatz, Handfield and Petersen suggested that information exchange and integrative strategies between suppliers and buyers are highly relevant in technological uncertain markets (2002). Hence, high levels of technological uncertainty may lead to more collaboration and the forming of alliances [14]. In order to be able to share information and increase the integration of both firms, ICT has proved to be an excellent medium. However, the question is whether the stage of ICT usage is sufficient to attain this demanded degree of integration. Vijayasarathy has investigated the effect of uncertainty on the relationship between technology use in the supply chain and supply chain performance (2010). He found that organizations in stable environments reap more benefits from ICT than organizations facing high uncertainty. The mere presence of external ICT technologies and systems may increase the service performance in industries with low technological uncertainty, but dynamic environments could require a higher stage of ICT. Therefore, the moderation of technological uncertainty is expected to be negatively related.

Hypothesis 4: The relationship between ICT usage and service performance is negatively moderated by technological uncertainty, i.e.

2.5.2 ICT capability and performance

Although ICT usage may not be sufficient in environments with high technological uncertainty, the stage of ICT capability could be adequate to yield performance gains. As previous research pointed out, ICT capability can improve the ability to exchange information quickly among buyers and suppliers. Technological uncertainty has a direct negative effect on cost results, which can, however, be mitigated by information sharing within the supply chain. The more technological turbulence a firm's industry experiences, the stronger the impact of IT analytic capability on collaboration [5]and on supplier performance. ICT capability could improve the service

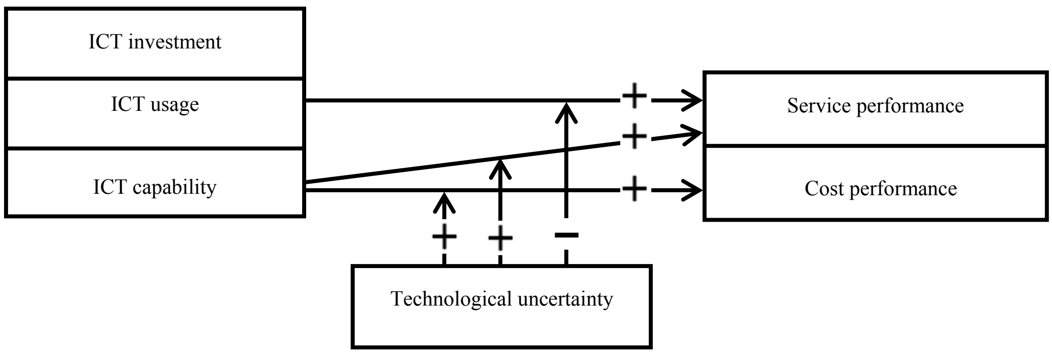

Figure 1. Conceptual model

provided towards customers and may compensate for the financial losses an organization would otherwise risk. Technological uncertainty might therefore positively moderate the relationship path between ICT capability and performance.

Hypothesis 5a: The relationship between ICT capability and service performance is positively moderated by technological uncertainty, i.e.

Hypothesis 5b: The relationship between ICT capability and cost performance is positively moderated by technological uncertainty, i.e.

3. METHODOLOGY

3.1 Data collection

The data for this research were gathered from Chinese manufacturers. In order to further guarantee the accessibility and responsiveness of companies, collaboration was initiated with two institutions: the China IT promotion institution and the Zhejiang Province enterprise association. This collaboration resulted in contact with 278 industrial suppliers from the China IT promotion institution, and 386 companies from the Zheijang Province enterprise association.

Before distributing the questionnaire, it was pre-tested by academics from the Operations Management department. Firstly,translating the questionnaires,then, comparing the questionnaires to ensure the content, readability and ambiguity. Lastly, They conducted structured interviews with six executives to make sure there were no remarks on the clarity and expression of the items. The questionnaire had to be filled out by the supply chain manager, Chief Information Officer or top level executive to ensure reliability. The data gathering process took place from December 2007 till April 2008 and comprised several steps. The questionnaires were distributed in a hardcopy version at the annual conference of the China IT promotion institution. Out of 152 distributed surveys, 124 were filled out, which forms a response rate of 81.6%. However, if a suitable respondent was not present, the survey was sent by post. Non-respondents were sent a reminder and an electronic version. Out of the remaining 126 target companies, 43 returned this survey (34,1%). Furthermore, the firms of the Zhejiang province enterprise association all received the questionnaire directly by post. This resulted in additional data from 172 companies, out of 386 (44,5%).

3.2 Sample profile and measure

Due to incompletely returned questionnaire, the final sample contains 320 respondents, resulting in an overall response rate of 48,2% (320 out of 664). The distribution of the respondents' positions is provided in table 1. The distribution of the different industry classifications based on SIC codes is shown in table 2, multiple items were using an interval level 5-points Likert scale.

Table 1. Respondents

Position of the respondent	Amount	Percentage
Supply Chain Manager	99	30.8
Chief Information Manager	96	29.9
Director	67	20.9
President/ Vice president	54	16.8
Others	4	1.6
Total	320	100

Table 2. Industry classification

Two-digit SIC code	Amount	Percentage
20. Food and kindred products	21	6.6
22. Textile mill products	47	14.7
23. Apparel and other products made from fabrics and similar	32	10
25. Furniture and fixtures	8	2.5
26. Papers & allied products	13	4.1
27. Printing, publishing and allied industries	7	2.2
28. Chemicals and allied products	29	9.1
29. Petroleum refining and related products	21	6.6
30. Rubber and miscellaneous plastics products	24	7.5
32. Stone, clay, glass and concrete products	3	0.9
33. Primary metal industries	9	2.8
34. Fabricated metal products except machinery and transportation equipment	17	5.3
35. Industrial, commercial machinery and computer equipment	23	7.2
36. Electronic, other electrical equipment and components, except computer equipment	31	9.7
37. Transport equipment	15	4.7
38. Measuring, analysing and controlling instruments; photographic, medical and optical goods etc.	11	3.4
39. Miscellaneous manufacturing industries	9	2.8
Total	320	100

Data specific calculations involve three aspects, 1)ICT: the items of ICT investment were adapted from Ward and Zhou (2006). ICT usage was measured by adjusting the scales of Li and Lin (2006) and Saeed, Malhotra and Grover (2005). The questions were related to the degree to which electronic external links were used for communicating with the key buyer, like internet, extranet and auto data capture systems. This stage therefore infers inter-organizational ICT. 2)Performance: the performance level was measured from the supplier perspective and was related to the key buyer of the organization. Service performance was measured by adapting items from Giménez and Ventura (2003). The items for cost performance were constructed following the same line of reasoning, including a rating for the improvement compared to three years ago, such as production, transport and administrative costs.3)Technological uncertainty: the questions for measuring technological uncertainty were adapted from Chen and Paulraj (2004). Examples are the need for technical modifications or production technology changes and the rate of process obsolescence.

3.3 Data analysis

The data were analysed using the statistics program SPSS 21.0. First, a factor analysis was conducted testing the construct validity of the concepts. The means, standard deviations and correlations were produced to describe the dataset. Next, multiple hierarchical regression analyses were conducted testing hypotheses 1,2 and 3, comprising the direct effect of each ICT stage on service and cost performance. The moderating effect of technological uncertainty was also tested using multiple hierarchical regression analyses.

4. RESULTS

4.1 Factor analysis

In order to test the construct validity of the items, a factor analysis was conducted . Both the Kaiser-Meyer-Olkin value (.87) as the Bartlett’s Test of Sphericity (3.333) indicated sufficient adequacy for a factor analysis ($p<.001$). In table 3 the results of the principal components analysis with a varimax rotation can be found. As a result six different factors have been identified. The first, ICT investment, consists of five technologies and systems used within companies to manage, plan and control manufacturing systems. The second, ICT usage, includes three communication items indicating an external connection with the key buyer. The third, ICT capability, contains seven indicators of the performance or efficiency of ICT systems and the degree to which this can be marked as a valuable resource. Service performance is measured by delivery time, delivery quantity and the responsiveness to needs and special requirements. Cost performance reflects the different costs related to the key buyer. Lastly, technological uncertainty contains items measuring the need for and frequency of changes and technical modifications.

Table 3. Principal components analysis

IItems	Factors 1	2	3	4	5	6
ICT investment (α= .813)						
- Forecast-Demand Management Software		.664				
- Advanced Planning and Scheduling (APS)		.765				
- MRP/MRP II		.717				
-Manufacture Execution System for Production Management		.651				
- Computerized Integrated Manufacturing		.659				
ICT usage (α= .754)						
- Use electronic mail with the key buyer				.733		
- Have an internet connection with the key buyer	.455			.689		
- Have an extranet connection with the key buyer		.414		.679		
ICT capability (α= .899)						
- Information technology investments and expenditures of our company	.740					
- Hardware performance of our company	.742					
- Operating systems performance of our company	.764					
- Business application software performance of our company	.722					
- Software maintenance efficiency of our company	.761					
- Application development cycle time of our company	.735					
- The efficiency of communication services provided by our ICT department	.600					
Service Performance (α= .693)						
- Responds to the key buyer needs in terms of product mix			.655			
- Responds to the special requirements of the key buyer			.644			
- Provides the quantities ordered by the key buyer			.681			
- Has a short delivery lead time			.682			
- Delivers on the agreed date			.588			
Cost Performance (α = .635)						
- The cost-to-serve the key buyer						.679
- The production costs related to the key buyer						.780
- The administrative costs related to the key buyer						.768
Technological Uncertainty (α= .648)						
- These products are characterized by a lot of technical modifications					.720	
- Our company frequently needs to carry out technical product modifications					.528	
- The rate of process obsolescence is high in our industry					.678	
- The production technology necessary to produce these products changes frequently					.676	
Eigenvalue	4.710	3.043	2.381	2.109	1.995	1.864
Percentage of variance explained	17.445	28.716	37.535	45.347	52.737	59.640

In total, the six factors explain the variance for 59.64% and have eigenvalues higher than the minimum criterion of 1 . The Cronbach alphas of the ICT stages all exceed the widely accepted cutoff value of .70, whilst the other factors are higher than the minimum recommended of .60.

4.2 Testing of hypotheses

The means, standard deviations and correlations are placed in table 4. The number of employees and annual sales of the organizations function as control variables. All variables have a significant correlation with one another, except for the control variables on technological uncertainty. This makes sense since this is an environmental variable. Cost performance does not correlate with any of the other variables. Furthermore, statistical assumptions such as normality and homoscedasticity were tested and not violated.

Table 4: Means, standard deviations and correlations

	Mean	Std. Dev.	1	2	3	4	5	6	7	8
1. Employees number	3.17	.89								
2. Annual sales	3.13	1.11	.789*							
3. ICT investment	2.32	.77	.515*	.543*						
4. ICT usage	3.05	.87	.241*	.297*	.395*					
5. ICT capability	2.97	.75	.534*	.462*	.561*	.539*				
6. Service performance	3.98	.40	.263*	.194*	.248*	.252*	.313*			
7. Cost performance	2.70	.57	-.049	.017	.059	-.004	-.064	.031		
8. Technological uncertainty	2.84	.66	.053	-.004	.151*	.293*	.336*	.229*	.201*	

* Significant at the 0.05 level (2-tailed),** Significant at the 0.01 level (2-tailed),*** Significant at the 0.001 level (2-tailed)

4.2.1 Direct model

Table 5 represents the results of the regression analyses testing the effect of the three different ICT stages on service and cost performance. Different effects were found on the two types of performance. ICT investment has a significant positive relationship with service performance (β=.09; p=.009), yet no such effect was found on cost performance (β=.07; p=.163). Consequently, hypothesis 1a has to be rejected, but support was found for hypothesis 1b. In addition, ICT usage has a significant positive relationship with service performance (β=.97; p<.001), but no effect oncost performance (β=-.006; p=.877). Thus, hypothesis 2a and 2b can both be accepted. ICT capability was also found to have a positive significant relationship with service performance (β=.129; p<.001), and no significant relationship with cost performance (β=-.046; p=.359). Therefore, hypothesis 3a is supported and hypothesis 3b is rejected. Since the beta is increasing per stage, the effect of ICT on service performance is stronger as higher levels of ICT are employed. This confirms the main premise of this paper.

Table 5. Regression analyses of ICT

Variables	Service	Cost	Service	Cost	Service	Cost	Service	Cost
	1		2.1 (I)		2.2 (U)		2.3 (C)	
1. Employee number	.130***	-.106	.122**	-.120*	.128***	-.107	.081*	-.089
Annual sales	-.013	.076	-.035	.059	-.024	.077	-.022	.079
2.1 ICT investment			.089**	.070				
2.2 ICT usage					.097***	-.006		
2.3 ICT capability							.129***	-.046
R^2	.070	.011	.090	.017	.110	.011	.112	.013
Adj R^2	.064	.004	.081	.007	.102	.001	.104	.004
F	11.862***	1.720	10.385***	1.800	13.080***	1.151	13.296***	1.427
ΔR^2	.070	.011	.020	.006	.041	.000	.042	.003
Δ F	11.862***	1.720	6.984**	1.951	14.505***	.024	15.107***	.842

* Significant at the 0.05 level (2-tailed),** Significant at the 0.01 level (2-tailed),*** Significant at the 0.001 level (2-tailed)

4.2.2 Moderating model

Table 6 shows the results of the regression analyses testing the moderating effect of technological uncertainty on the relationship between the ICT stages and performance measures. The findings report no moderating role of technological uncertainty on ICT investment and service performance (β=.057; p=.065), nor on ICT investment and cost performance (β=-.042; p=.365). Also, technological uncertainty does not function as a moderator between the relationships of ICT usage and service performance (β=.024; p=.473), and also not of ICT usage and cost performance (β=-.062; p=.221). This means hypothesis 4 should be rejected. However, a moderating effect was found on the relationships of ICT capability and service performance (β=.111; p<.001) and of ICT capability and cost performance (β=.202; p<.001). Consequently, hypotheses 5a and 5b can be accepted. To further examine the two-way interaction of ICT capability and technological uncertainty on cost and service performance, simple slope tests were conducted [16]. Conditional values of technological uncertainty were used, consisting of one standard deviation above and below the mean.

Table 6. Regression analyses of the moderating effect of technological uncertainty

Variables	Service	Cost	Service	Cost	Service	Cost	Service	Cost	Service	Cost	Service	Cost
	3.1 (I)		3.2 (U)		3.3 (C)		4.1 (I)		4.2 (U)		4.3 (C)	
1.Employee number	.103*	-.106	.118**	-.087	.084**	-.095	.097*	-.102	.116**	-.092	.078*	-.106
Annual sales	-.021	.037	-0.21	.054	-.012	.062	-.016	.034	-0.21	0.56	-.008	.070
2.1 ICT investment	.068*	.102*					.048	.116*				
2.2 ICT usage			.072**	.038					.068**	0.29		
2.3 ICT capability					.092**	.021					.073*	-.013
3.Technological uncertainty	.118***	-.182***	.101**	-.180***	.096**	-.173***	.110***	-.176***	.095**	-.196***	.052	-.254***
4.1 TU * ICT inv.							.057	-.041				
4.2 TU * ICT us.									.024	-.062		
4.3 TU * ICT cap.											.111***	.202***
R^2	.127	.060	.136	.050	.134	.048	.136	.063	.137	.055	.136	.096
Adj R^2	.116	.048	.125	.038	.123	.036	.123	.048	.124	.040	.150	.081
F	11.444***	5.046***	12.387***	4.182**	12.184***	3.977**	9.914***	4.200***	9.998***	3.651**	12.247***	6.633***
ΔR^2	.037	.043	.025	.040	.022	.035	.009	.002	.001	.005	.029	.047
Δ F	13.339***	14.553***	9.280**	13.141***	7.968**	11.487***	3.438†	.824	.516	1.504	10.961***	16.475***

- Significant at the 0.05 level (2-tailed),** Significant at the 0.01 level (2-tailed),*** Significant at the 0.001 level (2-tailed)

5. CONCLUSION

From a theoretical perspective, the contributions of this research are as follows. Firstly, it appears ICT has a different impact on different types of performance. Although all stages of ICT had a positive effect on service performance, no effect was found on cost performance. Secondly, remarkable is the positive effect of ICT investment on service performance. Although ICT in this phase is internally focused and was only expected to affect the performance on a firm level , it was not expected to be effective on a supply chain level[16]. Furthermore, the hypotheses concerning ICT usage were accepted, as a positive linkage was found with service performance and no relation with cost performance. The contradictory findings presented by previous literature might therefore be explained by the fact that ICT usage is the middle stage and possibly somewhat overlaps with the first and third stage. Concerning ICT capability, the positive effect on service performance was hypothesized, whilst the absent relationship with cost performance was not. Lastly, the findings concerning technological uncertainty may contribute to the existing body of literature about this concept, by offering a new perspective. Whilst no moderating effect was found for the first two stages, technological uncertainty appears to moderate the relationship between ICT capability and cost and service performance. Although ICT capability can lead to significant performance gains and a possible competitive advantage, its employment is not desirable in every industry. ICT investment and usage on the other hand, pay off no matter the degree of technological uncertainty.

From a managerial perspective, the implications of this research are two-folded. Firstly, the importance of ICT as a tool in supply chains has been confirmed. Even if a company solely invests in intra-organizational ICT, performance gains can be reached related to the service provided towards its customers. The usage of external ICT can further amplify this effect. However, attention has to be paid to the consideration of large-scale investments. If a company performs in an industry with high process obsolescence, a high change rate of technologies or need for technological modifications, it can be worthwhile to turn ICT in a firm capability. High technological uncertainty requires the ability to be responsive, and ICT can be a tool by which a competitive advantage is created. However, companies performing in industries with technological stability should be cautious, as too high investments in ICT are not expected to pay off.

The aim of this research was to scrutiny a possible difference between the stages of ICT and its effect on performance in supply chains. A distinct difference was found amongst the performance types. On a dyadic level each stage of ICT seems to have a direct positive effect on service performance, yet no significant effect on cost performance was found. This implies that the implementation of ICT is worthwhile, as the service towards customers increases whilst the costs do not alter much. The impact on service performance increases per stage, which might indicate the subsequence of the three stages. Moreover, the relationship between ICT and performance appears to differ between industries with high and low technological uncertainty. Although no moderating effect was found for ICT investment and ICT usage, the effect of ICT capability differentiated per situation. ICT capability only pays off in high-tech environments in terms of the service it provides. If ICT capability is adopted in a low-tech industry, it will yet bring along higher costs.

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