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The Impact of Information and Communication Technology (ICT) on the Dynamic Capabilities of Supply Chains

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This study aimed at empirically examining the impact of information and communication technology interaction intensity among supply chain members on the dynamic capabilities of organizations. The study took Taiwan's top 1000 manufacturers as the study population, whereas the relationship between the manufacturers and their suppliers was taken as the research unit, and the respondents consisted of the executives or senior procurement specialists dealing with suppliers in the organizations. LISREL was used to verify models and test their goodness-of-fit. In the data analysis, the parameters were estimated with the default maximum likelihood estimation method. Empirical results of this research can help businesses take a closer look into how the intensity of supply chain ICT interaction impacts the dynamic capabilities of the supply chain members, so that businesses can hold on to different intensities of their supply chain ICT interactions to increase the relationship commitment and trust among the supply chain members, and further promote their dynamic capabilities.

Keywords: Supply chain, Information and Communication Technology (ICT), relationship quality, dynamic capabilities, interaction intensity

JEL: L91, O14

The Information Communication Technology (ICT) has been widely applied in business administration since 1980. It plays a critical role in the business competence of a dynamic competitive environment, and its development patterns, scopes and techniques have become an important topic of academic studies (Ganju ***et al.***, 2016; Mensah ***et al.***, 2015). Although academics have paid attention to ICT's possible impact on business's dynamic capabilities, few of them took the supply chain and its ICT interaction intensity and relationship quality as the basis to explore the dynamic capabilities, lacking comprehension of essential intermediary factors within, such as relationship trust and relationship commitment (Mirkovski ***et al.***, 2016; Parida ***et al.***, 2016; Zhang ***et al.***, 2016; Azhar ***et al.***, 2015). In order to bridge these research gaps, this research takes the perspective of supply chain ICT

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interaction intensity, coupled with the viewpoints of social exchange theory and intermediary variables of relationship quality (trust and commitment), to construct a relationship-based integrated model for exploration of the dynamic capabilities formed through cross-organization interaction.

Based on the above discourse, this research goes through a review of the supply chain and ICT related literature for exploration of the ICT interaction intensity among supply chains and its consequent impact on the relationship quality development and dynamic capabilities. Accordingly, there are two objectives of this study:

1. Develops a relationship-based integrated model of dynamic capabilities.
2. Explores the ICT interaction intensity among supply chains and its impact on dynamic capabilities through the relationship quality.

The next section explains the theoretical background and hypotheses development. The research method and results are then reported. The final section discusses the theoretical and practical implications, the study limitations and future research direction.

LITERATURE REVIEW

The supply chain organizations interact with each other via ICT, which is basically a social exchange activity (Mirkovski ***et al***., 2016; Wu ***et al***., 2014). Through the interactive behaviors, knowledge or resources are communicated, meanwhile new knowledge or resources are needed to form dynamic capabilities (Nieves ***et al***., 2016; Tseng and Lee, 2014). In fact, the social exchange among the supply chain members is similar to the goods exchange in economics, except that the rewards or returns from social exchanges may not be in the form of money or tangible objects (Huo ***et al***., 2016; Carr ***et al***., 2012). In view of this, present research takes the social exchange theory as the basis, to which the intermediary variables of "relationship trust" and "relationship commitment" are added for an in-depth exploration of the impact of supply chain ICT interaction intensity on dynamic capabilities. Through the literature review, it is concluded that the supply chain ICT interaction intensity does impact the formation of relationship quality, whose intermediaries (relationship trust and relationship commitment) in turn affect dynamic capabilities. As a result, this research has established the following research model shown in Figure 1.

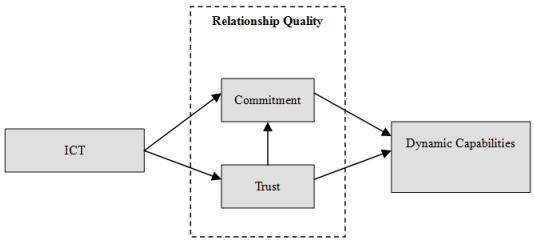

Figure 1: Research Model

In the development course of supply chain relationship, interaction is the core. With the advent of ICT emergence, more and more supply chain members interact with one another through the emerging technologies. Prior research suggests that the interaction intensity reflects the efforts made by sales representatives for maintaining open communication channels with customers, also indicates commitment of mutual relationship (Williamson, 1983; Schoenherr ***et al.***, 2014). Therefore, the interaction intensity among supply chains lead to a positive impact on the development of relationship among the supply chain partners.

Further, prior research suggests that the ICT facilitates information sharing among organizations, and enhances interaction among individuals, teams and organizations in different places to increase performance (Arvanitis and Loukis, 2015; St. John ***et al.***, 2016). Choy ***et al.*** (2003) argue that the application of ICT helps building relationship among supply chain members, and maturely applying ICT among supply chain members also helps in information and knowledge sharing with one another, without geographical constraints; meanwhile, smooth and timely communication is conducive to promote healthy interaction among the supply chain organizations, for a higher frequency and better quality of communication. Chen and Lin (2012) revealed that the ICT had a positive impact on the supply chain relationship quality. On the basis of the above discussion, the following hypotheses are proposed:

H_1: A stronger interaction intensity of supply chain ICT produces a higher relationship trust among the supply chain organizations.

H_2: A stronger interaction intensity of supply chain ICT produces a higher relationship commitment among the supply chain organizations.

In addition, the social exchange theory assumes that as the exchange process develops with time, the exchange parties will take the relationship commitment to express their trustworthiness in the exchange relationship. Based on the social exchange theory's interpretation of the relationship between trust and commitment, prior research argued that mistrust could lead to mutually reduced commitment on the exchange relationship, and

consequently transform a long-term exchange relationship to a short-term one (Vanneste ***et al***., 2014; Schoenherr ***et al***., 2015). Furthermore, trust could be seen as a deciding factor to commitment relationship and it could bring in a high value of collaboration, and therefore, the participating parties would intend to make commitment on mutual relationship (Pomponi ***et al***., 2015; Qu and Yang, 2015). Based on this scenario, this research concluded that the level of trust among supply chain organizations would impact the relationship commitment among the organizations. The following hypothesis then emerges:

H_3: A higher level of trust among the supply chain organizations produces a stronger relationship commitment among the organizations.

Dynamic capabilities are a set of norms or courses guiding allocation of resources, and through enhancement of supply chain partnership, the support from partners' resources and capabilities was acquired, and when the critical complementary resources were available, the capabilities of subsequent resources integration, allocation, deployment, update, learning and response were reinforced (Lee and Rha, 2016; Cheng ***et al***., 2014). Similarly, firms utilize supply chain network and strategic alliance to enhance mutual relationship, and further promote their competitiveness (Wang ***et al***., 2016; Kotzab ***et al***., 2015; Sheu and Gao, 2014).A better supply chain relationship quality would lead to a more positive impact on dynamic capabilities.

From the perspective of social exchange theory, Morgan and Hunt (1994) argued that in shaping the conception of relationship quality, the relationship commitment and trust were main variables, indicating that maintaining the relationship was critical, because partners would believe in sacrificing short-term interests for long-term ones. Ferro ***et al***. (2016), Ponder ***et al***. (2016), and Dedahanov and Rhee (2015) argued that in the studies of business vs. business, the "relationship trust" and "relationship commitment" were commonly used for the construct of relationship quality. The following hypotheses are thus proposed:

H_4: A stronger relationship commitment among supply chain organizations results in higher dynamic capabilities among the organizations.

H_5: A stronger relationship trust among supply chain organizations results in higher dynamic capabilities among the organizations.

METHODOLOGY

Measurement

All the items used in this research were based on the prior studies, and after group interviews with top management in related industries, the opinions from three experts as well as four industrial professionals were referenced for partial adjustment and modification of the contents and wording, in hope of matching up with the scenarios and theoretical basis of this research. All the latent variables were measured with multiple observable variables. For each observable variable, the respondent answered a set of given questions by a degree of consent on the 7-point Likert scale (1: strongly disagree; 7: strongly agree). The operational definitions of the research variables and referenced literatures are listed in the following Table 1.

Variable	Definition	Questions	Literature
ICT interaction intensity	Level of ICT interaction among supply chain organizations	4	Sethi and King (1994), Song ***et al***. (2007)
Relationship trust	The mental state of supply chain members' positive expectation from each other, with willingness of actively undertaking risks.	4	Bettencourt (1997), Crosby ***et al***. (1990), Doney and Cannon (1997), Morgan and Hunt (1994), Wang ***et al***. (2016)
Relationship commitment	Supply chain members' mental attachment to persistent relationship, with willingness of sacrificing short-term interests for maintaining the relationship.	4	Bettencourt (1997), Crosby ***et al***. (1990), Doney and Cannon(1997), Morgan and Hunt (1994), Wang ***et al***. (2016)
Dynamic capabilities	Efficiency, performance and fast response to external changing environment in the integration and utilization of corporate internal and internal resources	3	Teece ***et al***. (1997), Prahalad and Krishnan (2008), Wang ***et al***. (2016)

Table 1: Operational definitions of research variables and referenced literatures

Questionnaire design and sampling

Questions were fine-tuned through test run to avoid ambiguous wording and inappropriate asking, so as to increase the efficacy of the questions. The questions were modified by four industrial professionals and three academic experts, and then sent to 30 random samples picked from Taiwan's top 1000 manufacturers for test run, and the result was taken as the basis for further modification on rhetoric wording and to eliminate semantic barriers.

This research took Taiwan's top 1000 manufacturers as the study population, whereas the relationship between the manufacturers and their suppliers was taken as the research unit, and the questionnaire respondents consisted of the

manufacturers' executives or senior procurement specialists in charge of dealing with suppliers. To facilitate subsequent analysis, the manufacturers were also asked to select one of their most critical suppliers (with a largest procurement amount or highest interaction frequency) to answer the questions. From the top 1000 manufactures, 500 of them, i.e. 50 percent, were randomly picked as the samples, and the questionnaire was sent to the heads (presidents or general management) of the sampled manufacturers, who then relayed the questionnaire to their procurement executives or senior specialists responsible for dealing with suppliers, who then answered the questions based on their experiences and scenarios in dealing with their most significant suppliers. The questionnaire was sent out on March 1, 2016 via postal mails or personal deliveries, followed by three times of follow-up collections, and finally 129 effective copies of the questionnaire were collected, with a 25.8 percent effective recovery rate.

To examine possible non-response bias and sample representativeness, this research adopted the Armstrong and Overton's (1977) approach by separating the earlier recovered samples (65 copies) and the later recovered ones (64 copies), and took the manufacturers' number of employees, yearly revenues, and number of years in business for a chi-square test. The result showed that the two sets of recovered questionnaire copies revealed no significant difference, based on which it was inferred that the unrecovered questionnaire copies shall not constitute major errors of the research outcomes. In the effectively recovered copies, 85.1 percent of the respondents were associated to critical job positions related to supply chain, who were CEOs (3.5%), VPs (9.3%), directors (17.4%), managers (39.6%), and senor procurement specialists (15.3%).

Measurement Model

This research utilized LISREL 8.7 to verify models and test their goodness-of-fit (GF). In the data analysis, the parameters were estimated with the default maximum likelihood estimation (MLE) method. When applied to MLE, the data must meet the assumptions of multivariate normal distribution, under which the number of samples should be at least between 100 and 150 to be suitable for use (Ding ***et al.***, 1995). After ineffective samples were excluded, there were 129 effective samples, showing that the Q-plot distribution slope of standardized residuals did not violate normality assumption, and thus conformable to the above

requirements. Based on the approach suggested by Bagozzi and Yi (1988), this research selected four most representative indexes to evaluate the measurement model, described as follows:

-Validity of individual questions: This index evaluates the factor loadings of measurement variables vs. latent variables, i.e. verifying the statistical significance of each variable's loadings. In the analysis of factor loadings, the significance is verified with the *t*-test, where a larger *t*-value indicates a higher significance, and if the absolute *t*-value is greater than 1.96, it is deemed as significant. Table 1 shows that the standardized factor loadings of all the variables are greater than .5, and the *t*-values are all greater than 1.96, indicating a good quality of measurement by the questionnaire, i.e. high appropriateness of the questions.

-Validity of latent variables: It is composed of validity values of measurement variables, indicating the internal consistency of construct indexes, where higher validity means higher internal consistency of these indexes. Fornell and Larcker (1981) suggested the value should be greater than .60. In Table 2, it shows that the comprising validity values of the variables in the measurement model are all greater than .6, meanwhile, the comprising validity values of this research are between .68 and .87,

Construct	Questions	Factor Loadings	Standard Error	*t*-value	Validity	Average Variance Extracted (AVE)
ICT	I1: Supply chain partners interact regularly and irregularly via ICT	.60	.16	9.74	.68	.59
	I2: Supply chain partners maintain long-term cooperation via ICT	.63	.22	12.5		
	I3: Supply chain partners offer assistance via ICT.	.61	.19	11.4		
	I4: Supply chain partners provide appropriate information to one another via ICT.	.61	.18	11.3		
Trust (T)	T1: Active in assisting supply chain members.	.77	.12	15.3	.84	.76
	T2: Fairly treating supply chain members.	.79	.10	14.1		
	T3: Active in helping supply chain members solve problems	.68	.13	16.2		
	T4: Doing no harm to supply chain members.	.62	.15	12.2		
Commitment (C)	C1: Willing to maintain good cooperation with supply chain members.	.79	.10	17.5	.81	.72
	C2: Supply chain members are willing to provide appropriate feedback to the company.	.78	.11	15.3		
	C3: In making major decisions, supply chain members will look after the company's interests.	.62	.24	8.2		
	C4: Interested in having more cooperation with supply chain members.	.65	19	9.1		
Dynamic capabilities (DC)	DC1: Our company is efficient in integration and utilization of internal and external resources.	.72	.15	14.7	.87	.75
	DC2: Our company has a high performance of integration and utilization of internal and external resources.	.70	.12	13.4		
	DC3: Our company has fast response capabilities to external changing environment.	.67	.22	11.5		
χ^2/df =1.84; AGFI=0.80; NFI=0.90; NNFI=0.91; CFI=0.92; RFI=0.91; RMSEA=0.074						

Table 2: Measurement model analysis

indicating a good internal consistency of this research model.

-AVE of latent variables: The Average Variance Extracted (AVE) is the average explanatory power on variance of measurement variables against latent variables, and a larger AVE volume means a higher validity and convergence effect of latent variables. Fornell and Larcker (1981) suggested that the standard value should be greater than .5. In Table 2, it shows that the AVE of the variables in the measurement model are all greater than the standard value .5 (.59~.76), indicating that this research has decent validity and convergence effect of the latent variables.

-Discriminant validity: It is about the discrepancy of measurement between the questions under different constructs. According to Fornell and Larcker (1981), measurement of discriminant validity is based on the AVE of a construct, which is greater than the squared value of its construct coefficients correlated with that of other constructs. Values in Table 3 show conformity with the above evaluation standard, indicating a good discriminant validity. Take the minimum AVE dynamic capabilities (AVE value .52) for an example, the squared value of its dynamic capabilities and the largest correlated coefficients of other constructs is .17, which is less than .52, conformable to the evaluation standard.

Construct	ICT	Trust	Commitment	Dynamic Capabilities
ICT	.61			
Trust	.13	.77		
Commitment	.21	.18	.63	
Dynamic capabilities	.09	.15	.17	.52

Table 3: AVE and squared value of correlated coefficients

Structural Model

The analysis of structural model concerns the research model's GF and its overall explanatory power. In reference to the opinions of Bagozzi and Yi (1988) and Hair ***et al***. (2014), this research selected seven indexes for GF evaluation for the overall structural model, which are the ratio of chi-square to its degrees of freedom (χ^2/df), adjusted GF index (AGFI), normed fit index (NFI), non-normed fit index (NNFI), comparative fit index (CFI), relative fit index (RFI) and root mean square error of approximation (RMSEA). The result is shown in Table 4.

Bagozzi and Yi (1988) suggested that the ratio of chi-square to its degrees of freedom (χ^2/df) should

be no greater than 3 (Hair ***et al.***, 2014). This research reached a (χ^2/df) ratio of 2.57, less than the suggested value of 3, indicating the structural model used in this research is acceptable; meanwhile, other indicators are also conformable to the values suggested in most studies, such as AGFI ≧ .80 (.80), NFI ≧.90 (.90), NNFI ≧ .90 (.91), CFI ≧ .90 (.92), RFI ≧ .90 (.92), and RMSEA ≦ .08 (.07). Generally, the research model and observable data used in this research are all with decent GF. As shown in Table 5 and Figure 2, in the relationship of paths established for the constructs through SEM, the path values adopting standardized coefficients verify that the five hypotheses given in this research all reached a significant level (α =.01).

GF Index	Suggested Value	Literature Reference	Measurement Model	Structural Model
χ^2/df	≦ 3.00	Bagozzi and Yi (1988); Hair ***et al***. (2014)	1.84	2.57
AGFI	≧ 0.80	Hair ***et al***. (2014)	0.80	0.80
NFI	≧ 0.90	Hair ***et al***. (2014)	0.90	0.90
NNFI	≧ 0.90	Bentler (1990); Hair ***et al***. (2014)	0.91	0.91
CFI	≧ 0.90	Bentler (1990); Hair ***et al***. (2014)	0.92	0.92
RFI	≧ 0.90	Bentler (1990); Hair ***et al***. (2014)	0.91	0.92
RMSEA	≦ 0.08	Hair ***et al***. (2014)	0.074	0.079

Table 4: Index GF in the structural model

	Hypotheses	Path Coefficient	*t*-Value
H_1	A stronger supply chain ICT interaction produces a higher relationship trust among the supply chain organizations.	.09**	4.97
H_2	A stronger supply chain ICT interaction produces a higher relationship commitment among the supply chain organizations.	.13**	5.18
H_3	A higher trust among the supply chain organizations produces a stronger relationship commitment among the organizations.	.18**	7.66
H_4	A stronger relationship commitment among the supply chain organizations produces greater dynamic capabilities among the organizations.	.13**	6.13
H_5	A higher relationship trust among the supply chain organizations produces greater dynamic capabilities among the organizations.	.15**	8.91

* $p < .05$
** $p < .01$

Table 5: Verification of the research hypotheses

RESULTS

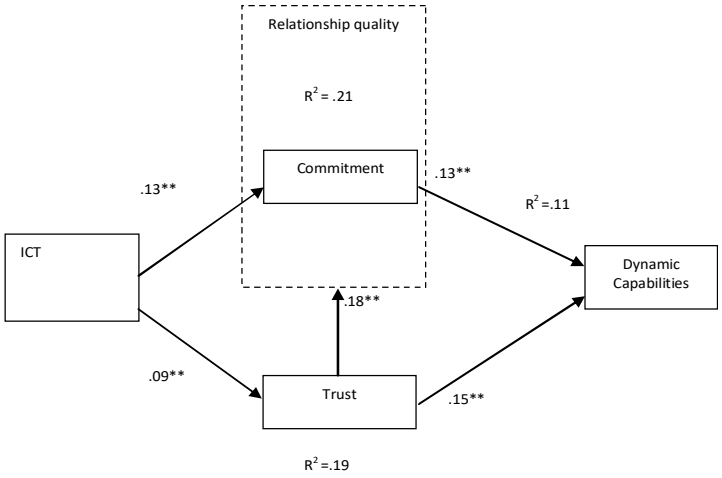

Figure 2: Result of verification on hypotheses

In facing a dynamic competition environment, the business thinking is no longer limited to internal dynamic capabilities; it has further extended to external sources of dynamic capabilities among supply chain members. Based on the principles of social exchange theory, this research applied the relationship trust and relationship commitment of relationship quality as intermediary variables to explore the impact of ICT interaction intensity among supply chain members on the dynamic capabilities of organizations. Through the literature review, this research proposed five hypotheses, and all of them have been supported by empirical data. This research revealed that a stronger ICT interaction among the supply chain organizations results in commitment among the organizations; a higher trust among the supply chain organizations brings in a stronger relationship commitment among the organizations; a higher trust among the supply chain organizations produces greater dynamic capabilities of the organizations; and a stronger relationship commitment among the supply chain organizations increases the dynamic capabilities of the organizations.

CONCLUSION AND SUGGESTIONS

Information and Communication Technology (ICT) plays a critical role in business competence of dynamic competition environment, and as a result, the ICT development patterns, scopes and techniques have become an important academic study. Although some academics have paid attention to ICT's possible impact on business dynamic capabilities, few of them took the supply chain and its ICT interaction intensity and relationship quality as the basis to explore the dynamic capabilities, lacking comprehension of essential intermediary factors within, such as

relationship trust and relationship commitment. Therefore, setting out from the perspective of social exchange theory, this research took the Taiwan's manufacturing industries as the study object, added with two intermediary impact factors of relationship trust and relationship commitment, for an in-depth exploration into the impact of ICT interaction intensity and supply chain relationship quality on dynamic capabilities. In the light of literature (Sheu and Gao, 2014; Wang ***et al***., 2016; Zhang ***et al***., 2016), the findings of the research suggested that the ICT interaction intensity goes through the intermediary variables of supply chain relationship quality, relationship trust and relationship commitment to impact the dynamic capabilities of organizations.

The empirical results of this research can help businesses take a closer look into how the intensity of supply chain ICT interaction impacts the dynamic capabilities of the supply chain members, so that businesses can hold on to different intensities of their supply chain ICT interactions to increase the relationship commitment and trust among the supply chain members, and further promote their dynamic capabilities. The empirical results revealed that the ICT interaction intensity among the supply chain members seems to be a critical source of the external dynamic capabilities of the supply chain members. This finding may be an important enlightenment to many businesses. In other words, the ICT interaction intensity among the supply chain members seemingly contributes to the significant increase of shaping up external dynamic capabilities of the supply chain members.

Being a cross-sectional study, the study does not explore longitudinal effects of the supply chain ICT interaction intensity in shaping up the dynamic capabilities. This is left for subsequent studies to make it up. In addition, this research takes Taiwan's top 1000 manufacturers as the sample objects, and therefore further empirical studies may be needed to extend the exploration into other industries or small-and-medium businesses.

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