THE LEVELS OF INFORMATION TECHNOLOGY ADOPTION, BUSINESS NETWORK, AND A STRATEGIC POSITION MODEL FOR EVALUATING SUPPLY CHAIN INTEGRATION

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ABSTRACT

Implementing Supply Chain Management (SCM) requires a higher level adoption of computer applications and infrastructures to leverage intra- and inter-firm transactions via systems integration. Various solutions are provided by information systems (IS) vendors and different levels of implementation for firms to adopt. Nevertheless, few strategic models of decision making have been developed for industrial practitioners. This research proposes a model of IT adoption level based on a survey conducted in the industrial parks of Northern Taiwan. With the empirical data collected from Taiwanese enterprises, the authors discuss the proposed model by its applicability, limitation, and future research. Factors such as business network positions and firm sizes are drawn in to enhance current studies on IT adoption/Supply Chain Integration.

Keywords: Levels of IT adoption, B2B eCommerce, Business Network, Supply Chain Integration

1. Introduction

Supply Chain Management (SCM) has been an important topic in recent years and its development has a significant relation with utilising information technology (IT) across the boundaries of firms. According to Lee, et al. [1997], management of information technology can be an important remedy for inventory control and supply chain collaboration problems; it increases the visibility of demand throughout the physical supply chain and electronic linkages, and creates transparency of outsourced productions and operations. Nevertheless, firms along the entire supply chain have various intentions and perceived benefits in associated with IT investments, resulting in different degrees of information systems readiness. Consequently, understanding the intrinsic factors of the adoption of IT becomes essential and critical for those firms trying to extend and maximise the capability and utilisation of IT systems in facilitating logistics, collaborative designs, Original Equipment Manufacturing (OEM) and other interfirm business activities.

There are many solutions provided by IS vendors and among them, different levels of IT implementations corresponding to the complexity of infrastructures for firms to adopt. Still, few strategic decision making and categorising models have been developed for managers and industrial practitioners. In fact, IT-based IS integration in e-business context is a case of IT adoption. This research can be seen as an attempt to enrich the previous findings of the model of IT adoption. Formulated in another way, it tries to test, apply and extend the IT adoption model to the use of IT-based IS in integrating supply chain as the focus. In this paper, we propose a level of IT adoption model by conducting a survey in industrial parks of northern Taiwan. With the empirical data of Taiwanese enterprises, the authors discuss the proposed model in terms of its applicability, limitation, and future researches. Moreover, factors such as business network positions and firm sizes are drawn in to enhance current researches on Supply Chain Integration and B2B eCommerce implementation.

2. Knowledge niche in previous literature

Researches of IT adoption are scrupulously thought out and developed only at the theoretical level rather than at the practical level. Nevertheless, IT adoption has traditionally been cited as a significant factor in sustaining competitive advantage [Ferratt, et al., 1996; Loebbecke & Powell, 1998]. Motivations for a firm's adoption of IT include improvement of efficiency, protecting market share, assisting in innovative activities, and increasing productivity and profitability. Furthermore, IT usage is also a key focus of IS researches [Delong & McLean, 1992] that extant literature has shown its determinants empirically [eg, Adams et al., 1992; Davis, 1989&1993; Mathiesons, 1991]. Combining the findings of these two areas can provide direction for the decision making of information systems implementability in business sectors.

Several models of IT adoption and its impact have been proposed in the past. Most researches concentrate in IT adoption at certain levels, sectors, groups or other demographic information. For examples, Daniel & Wilson [2002] have compared the intention and benefits of eCommerce adoption by SMEs in the UK; Coombs et al. [1999] survey the three areas of best practice of adoption, level of organisational impact, and performance of the system; Karahanna et al. [1999] study the pre-adoption and post-adoption of IT process and conclude that attitudes of IT usage and the belief of its benefits are limited. In addition, extant researches on the technology acceptance model (TAM) [Davis et al., 1989; Venkatesh & Davis, 1996] further strengthen a complete idea of IT usage [Taylor & Todd, 1995]. Following this stream, there is more and more empirical data supporting TAM [Chau, 1996; Hu, et al. 1999; Keil et al., 1995] and its critical reviews about why to use IT [Legris et al., 2003].

It is difficult to evaluate the direct impacts and benefits of IT adoption based on business performance. The performance of business activities has been a sophisticated result originating from varied influences brought about by internal efforts and changing business surroundings. Within certain types of IT adoption, researchers recently notice the adoption levels, impacts, and factors associated with its decision making [Sohn & Wang, 1998]. Similarly, Mehrtens et al. [2001], note that IT usage in organisation is a part of organisational readiness, which influences levels of IT adoption interactively. Sufficient supports and readiness can accelerate the implementing processes and thus create mature environment for higher levels of IT adoption. Conversely, low organisational readiness deters firms from further integration across firms' boundaries. Other research findings can be seen in Iacovou et al.'s [1995] Electronic Data Interchange (EDI) adoption by Small and Medium Enterprises (SMEs), Sohn & Wang's [1998] adoption levels of Internet Market for computer retailing companies, and Daniel & Wilson's [2002] eCommerce adoption in British firms which differentiate intentions and benefits affecting the levels of the IT adoption.

Iacovou et al. [1995], reflecting on the previous works of IT adoption levels, say that the major impediment of EDI implementation for SMEs is inability. This reason makes SMEs reluctant to join the EDI community [Banerjee & Golhar, 1994; Smith, 1990]. In their work, empirical data is collected from different levels of adopters - namely unprepared adopter, ready adopter, coerced adopter, unmotivated adopter, and non-adopter. Similar to their work, Mehrtens et al [2001] further define the three factors mentioned earlier and also note the level of IT use in the organisation affecting organisational readiness in the Internet adoption by SMEs. In interfirm level of IT adoption, recent works have added trust and power in IT adoption [Hart & Saunders, 1999; Wang & Heng, 2002b]. Another stream of IT adoption research includes the successful factors of ERP systems, for example, Nah et al. [2001] survey the literatures and identify 11 factors for this level of IT adoption. Furthermore, those factors are mostly related to organisational readiness only. Perceived benefits and beliefs, which have been measured as determinants affecting the attitudes of adopters are seen as influencing the outcome of implementation [Karahanna, et al., 1999].

Gaps of SCM across firms' boundaries are hence due to their different levels of IT adoption and integration capabilities. Compared with large firms which have greater resources, SMEs are sometimes struggling with survivals rather than peacefully planning long-term strategies. It results in the caution and conservativeness of their investment actions. Implementing SCM requires a higher level of IT adoption - computer applications and infrastructure that leverage intra and inter firm process and systems integration [Pant & Ravichandran, 2001].

In an empirical analysis of the computer retailing firms [Sohn & Wang, 1998], a model for the levels of Internet Market adoption has been developed. It differentiates those targeted samples into non-adopters, intended to adopt, low level implementation, and sophisticated implementation. The interesting parts are that they add cost incentive and institutional support as major factors based upon the previous literatures. However, the above studies have ignored certain aspects of the real situations in reflecting IT adoption in industries. First, cost is a concern of relative factor but not absolute factor since large firms and SMEs probably have different resources to support IT implementation. Second, to divide firms into only low and high implementation does not correspond with the real situations. Last but not least, to access Internet markets and to adopt the Internet are not expensive when even broadband networking has become very cheap nowadays.

If a firm can afford to buy a computer, it is not really a problem to adopt the Internet at all from both technical and cost perspectives. Some literature [Mehrtens et al., 2001; Daniel & Wilson, 2002] has not considered this point carefully, in other words, whether or not those firms can adopt eCommerce or Internet technology as linked its correspondent IT adoption levels. Utilising Internet markets or other technology would only cost much if firms construct and maintain their own infrastructures such as fixed extranet, expensive databases (for instance, Oracle 9i), and marketing websites. In other words, there is a range of IT systems adoption, involving different levels of skills, resources, time frame, risks, commitment, etc. Here, we propose five levels to form a position model for evaluating current status of IT adoption for core firms and affiliate firms within the business network of supply chains [Wang & Heng, 2002a], namely, essential functions (Documentation), single department/operation process, cross departments/multi-process integration, Enterprise Integration Process (EIP) (i.e. ERP), and B2B Integration/Collaborative Business.

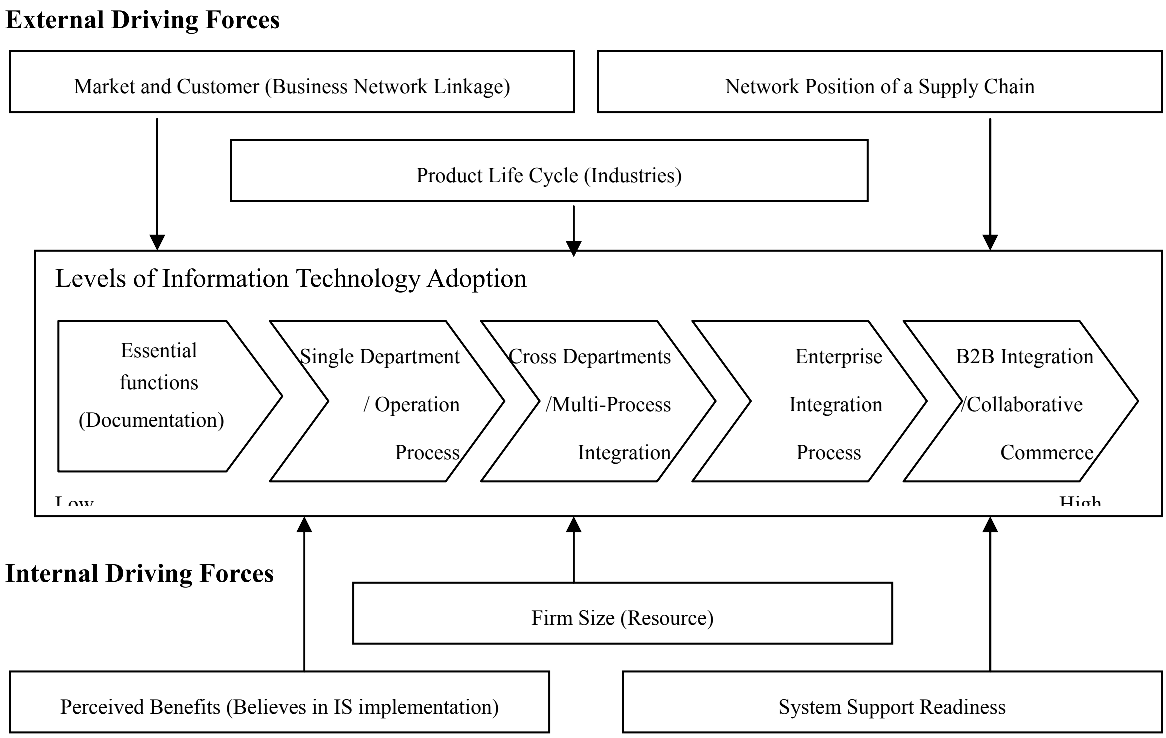

Figure 1 Research Model of IT adoption in the Supply Chain
Source: developed by this research

3. Levels of information technology adoption

3.1 Influential factors and hypotheses

Previous literature in IT adoption has proposed more and more factors, and their correlations have been used to give us formulas, e.g. - a cross-country study of e-business adoption by Zhu et al. [2002]. In some respects, those researches have provided insightful views for analysis in future study. However, their research findings have limited practical relevance for real situations in different levels of IT adoption. For example, one of Zhu et al.'s [2002] hypotheses is 'Larger firms are more likely to adopt eBusiness'. If people surf on the Internet, they will find out all types of eBusiness activities which have been created by small firms. A clever idea can make small enterprises successful with little investments of IT infrastructure, such as the inaugurator of search engine 'Yahoo.com!', and the famous Taiwanese cosmetic online retailer 'eBeauty'. They both started with very few resources and capital. As a matter of fact, regardless of what IT adoption level a firms has, it can adopt eCommerce and be Internet ready. Without carefully differentiating the levels of IT adoption so as to map those factors, models might be hardly practical. Therefore, we suggest that the internal and external factors identified in the previous literature should be integrated into those practical levels as portrayed in figure 1. It is also expected to examine those factors with adjustable scales to compare samples or static scales for a set of similar firms as cluster analyses. This model provides a new categorising method for IT adoption as well as considering the interfirm network relationships of supply chains. Those influential factors are as follows:

3.1.1 Internal factors

Firm Size / Capital (Resources)

As early as Zaltman et al. [1973], literature has revealed that the more formalised and centralised organisations (often the larger firms) are, the less likely they will be to initiate innovative adoption decisions but they will be better equipped to actually adopt innovations [Kennedy, 1983]. Size is an important variable in industrial organisation economics [Scherer, 1980]. It has been considered to be an adoption factor facilitator consistently [i.e. Damanpour, 1992] and used in IT adoption since researchers believe larger firms tend to have abundant resources, be more capable in bearing risks, and possess more power to urge trading partners to adopt IT [Zhu et al., 2002]. Hence,

H1: Firm size has positive influential power on the managers' decisions to implement higher levels of IT adoption.

System Support Readiness

System support readiness as a factor of IT adoption is often divided into many observed indicators, for example, Premkumar et al. 's [1994] system capability for EDI adoption and Sohn & Wang's [1998] existence of IT champions, top management support, and absorptive capacity for Internet Market adoption. Considering a firm to be a complete entity, Iacovou et al. [1995] and Mehrten et al. [2001] use system support readiness at the organisational level as a major factor affecting the levels of IT adoption. In their research, numbers of IT staffs, existence of IT championship, and existence of IT division are the variables to form the mechanism of statistical measurement. Therefore,

H2: Higher system support readiness gives an intention to implement higher levels of IT adoption.

H2-1: Clear IT strategy helps to build up higher levels of IT adoption.

H2-2: Strong support from top managers has positive influence on the implementation of higher levels of IT adoption

Perceived Benefits

Perceived benefit is an important incentive [Saunders & Clark, 1992; Son, Narasimhan & Riggins, 1999] for B2B eCommerce. In this issue, large firms indeed enjoy more efficiency in their business processes after project implementing. However, as for the affiliate firms and SMEs within the business network, their environments and opportunities have undergone more changes than expected, thereby creating uncertainty after the huge investment. IT adoption might not bring equal perceived benefits to all firms. It may weaken the resolve of many firms in going ahead with future plans. The perceived amount of monetary gains and other potential benefits is recognised as the scale of measurement. They are hypothesised as,

H3: Higher Perceived Benefits provide greater motivation to adopt higher level of informatisation process.

H3-1: A clear goal of IT adoption among network members has positive influence on the informatisation process.

3.1.2 External factors

Product Life Cycle (Industries)

Information technology has been viewed as an important tool to create efficiency and effectiveness. Industry type is often considered as affecting the relationships between IS integration and process improvement initiatives, because of the different competitive pressures faced by the manufacturing and service industries [Bhatt, 2000]. In some industries, product life cycles are relatively short. The two statements seem to have no relationship superficially but firms which make products with shorter life cycles might face more pressure from increasing supply chain visibility and vertical integration in order to get new products on the market in time. In fact, higher levels of IT adoption may be required under such a situation. By this factor, time scale by quarters has been used in the survey. It is proposed as,

H4: Firms with shorter product life cycle tend to adopt higher level informatisation process.

Network Position of a Supply Chain

Taking the business network formation [Liu & Brookfield, 2000] of a supply chain into consideration, core firms [Banerji, et al., 1998] normally deal with orders from outside the network boundaries [Wang & Heng, 2002b]. The closer to the core of a business network, the more collaborative activities are involved It is usually necessary that core firms are larger firms than those in the middle ranges of the network positions and this situation can be found in the Taiwanese machine tool industry when those firms cooperate to compete with large overseas firms [Liu, & Brookfield, 2000]. Thus, network position is regarded as a factor here and more studies in this direction are expected in the future [Christiannse & Markus, 2002; Wang & Heng, 2002b]. Therefore,

H5: A firm which is closer to the core firm has higher level adoption of informatisation process.

Business Network Linkage (i.e. market, partnership, and customer)

Dynamic (looser) or stable (fixed) interfirm linkage [Wang & Heng, 2002b] in the supply chain is also a consideration here. This area is explored in both cases from the angles of markets, partnership, and brand recognition as well as social aspects such as power, trust, resources interdependency [Saunders & Clark, 1992; Son, et al., 1999]. Combining with the previous factor, it is expected to modify current IT adoption models from the business network structure to test the dynamic degrees of linkages. This idea is similar to Fan et al. [2000], who note that the information systems solutions are affected by the dynamic degrees of the contemporary business environment. Therefore,

H6: Stable business network linkage has positive influence on adoption of the informatisation process.

H6-1: Interfirm collaboration and mutual IT adoption along the supply chain help to build a higher level of IT adoption.

3.2 Levels of IT adoption and research modus operandi

Combined with the main constructs, the levels of IT adoption are divided into five levels in this position model as (1) Essential Functions (Documentation) – computers with basic software packages like MS-Office and MS-Windows; (2) Single Department/ Operation Process – computer-based information systems for one type of operation process (i.e. accounting information systems); (3) Cross Departments/Multi-Processes Integration – several modules of computer-based information systems have been implemented to support multi-processes among departments (i.e. logistics, finance, and sales departments); (4) Enterprise Integration Process (EIP) – systems like Enterprise Resource Planning systems are developed to support organisational wide business activities; (5) B2B Integration/Collaborative Business – systems have interfirm links with other collaborative manufacturer, designer, suppliers, and customers. This highest level IT adoption used for interfirm communication and transaction is also named as Inter-Organisational Systems (IOS) [e.g., Grover, 1993], Electronic Data Interchange (EDI) [e.g., Lim & Palvia, 2001], or Business-to-Business integration (B2Bi) [e.g., Lee, et al. 1999]. These five levels thus are used to test several hypotheses as well as help to categorise samples for cluster analyses.

Table 1 Sample distribution

Industry / Capital (NT Dollars)	IT industry	Traditional Manufacturer	Total
< 80 million [a](SMEs[b])	23	16	39 (32.3%)
80 millions ~ 500 millions	19	7	26
500 millions ~ 1 billion	10	4	14
1 billion ~ 1.5billion	9	0	9
> 1.5billion	27	6	33
Total	88 (73%)	33 (27%)	121

3.3 Sample profiles

This research is conducted by surveying 713 firms from industrial Taiwanese firms located in the two northern counties – Hsin Chou and Tao Yuan which have a high density of industrial clusters and business networks. The survey was posted to divisional level managers in manufacturing and service firms in two batches. The mailing list was randomised by our research purpose. A total of 131 responses were received. Ten responses could not be used, as the respondents did not provide some key answers in the questionnaires, or in some other cases, background information required for categorising the analysis was not provided. Therefore, only 121 responses were identified as useful. The effective response rate was about 17.2%. However, seeing the nature of the questions spanning the

[a] NT = New Taiwanese Dollar
Exchange Rate on 14/12/2002 USD : NT = 1: 34.69

[b] The definition of SMEs is referred from *Taiwanese Small and Medium Enterprises, Department of SMEs Development, Ministry of Economic Affairs, Taiwan*

levels of IT adoption and business network areas, this response rate is not considered unusual.

3.4 Instrument development

Development of the survey instrument was done along the lines suggested by Churchill [1979] and conducted by other researchers in their empirical studies. Some of the item measurements were derived and adapted from extant research - e.g., perceived benefits & top management support [Angeles, et al, 2001], firm size [Zaheer & Venkatraman, 1994; Banerji & Sambharya, 1998], and network tiers [Pfohl & Buse, 2000] etc. Lacking quantitative tests, some constructs of the network aspect are adapted from pervious literature by structured interviews [e.g., network linkage: Saunders & Clark, 1992; Kambil & Short, 1994] or related research topic [network density: Antia & Frazier, 2001]. The development of the item for IT adoption levels is mentioned in O'brien's [2003] introduction of electronic enterprise systems where he notes that firms can adopt functional information systems or cross-functional information systems corresponding to the business needs. In appendix 1, we provide summaries of the measurement properties of the multi-item scales.

Content validity of all items, especially the new items, was carefully assessed. The instrument was revised based on feedback from five academicians and pilot tested with ten firms at divisional managers' level in Hsin Chou Science and Technical Park to ensure the reliability and validity. The pilot test included several structured interviews with IS managers or IT sales representatives. They carefully pointed out problems related to the items which were reviewed by three academicians previously. Based on their feedback, the problems were either rephrased or discarded. For conducting this research, all these variables were measured with 5-point interval scales which represent the current IT adoption status and related factors of the answering firms. Respondents thus were asked to mark an answer on each of the items from 1 to 5 to represent the relative standing of their firms on the industry. The adjustment of the questionnaire was made and the pilot test with 30 firms in Hsin Chu Science and Technical Park was conducted that shows a Cronbach's [1951] α value of 0.730 fulfilling the minimum requirement of 0.50. It led to the decision of sending the primary survey to the targeted samples after minor revisions of the questionnaire were made based on the response.

4. Data analysis and discussion

The data was analysed by SPSS v11. Some of the results are presented in the following tables. An appropriate Cronbach α value 0.802 had been reported as the reliability coefficient of the complete survey and the overall explainable variance of the model constructs is 58.785. Values of reliability are also provided for the different constructs of the model in Section 4.2 and table 3 that each of them is larger than the minimum requirement of α value .70. The survey result of IT adoption levels is briefly discussed in the following section.

4.1 Descriptive analysis

4.1.1 Comparison of firms in IT Industries and Traditional Manufacturers

Table 2-1 shows the average results of influential factors and the levels of IT adoption in those Taiwanese firms. Comparing with the position value of traditional industry mean 2.70, it can be seen that the IT industry overall has a higher level implementation of 3.70 – showing that most of them installed ERP systems and are about to further integrate systems in the supply chain level. Traditional manufacturers currently have departmental systems but are not yet integrated into the enterprise wide level.

The IT industry has a value of 3.86 in system support readiness. It means that most of the targeted samples have IT divisions or support groups in information systems installation and maintenance. In this item, traditional manufacturers only get 2.82, and it indicates that some of those firms even have no supportive IT staffs in the adoption processes of their information systems. According to both industries' perceived benefits of IT adoption, they are 3.61 and 3.30. Most firms believe that investing in new IT infrastructure can facilitate current business process and thus create potential advantages. The result confirms previous findings [Iacovou, 1995; Daniel, 2002] on the role of perceived benefits in generating intent and motivation for IT adoption.

The results reveal that the IT industry has shorter product lifecycles, 2.43 (6 ~ 12 months) compared with 1~2 years in the traditional manufacturing industry. The item consequently provides evidence that the IT industry faces higher and faster challenges in product innovation and supply chain integration. Network position shows the reality of the firms' location in a supply chain, and the tested firms in IT industry have an average position value of 3.30 with respect to the core firms or the first tier suppliers/collaborative manufacturers in the business network. It indicates that samples in the IT industry are closer to the global brand owner than traditional manufacturers. The interfirm dynamics was asked as network linkage. The IT industry is slightly higher than the traditional manufacturing industry; in other words, traditional manufacturers change less frequently their buyers and suppliers.

Table 2-1 Comparison of IT Industry and Traditional Manufacturers

Factors	IT Industry (n =88)		Manufacturers (n =33)	
	Mean	STD	Mean	STD
Firm size	2.98	1.61	2.18	1.50
System support readiness	3.86	.92	2.80	1.33
Perceived benefits	3.61	1.10	3.30	1.10
Life cycle of main products	2.43	1.17	1.84	1.17
Position in the Business Network	3.30	1.25	2.90	1.35
Network linkages	2.80	1.01	2.42	1.09
Levels of IT adoption	3.70	1.08	2.70	1.16

Table 2-2 Comparison of SMEs and Large Firms

Factors	Large Firms (n =82)		SMEs (n =39)	
	Mean	STD	Mean	STD
Firm size	3.60	1.30	1.00	.00
System support readiness	3.94	.947	2.82	1.18
Perceived benefits	3.60	1.15	3.35	1.01
Life cycle of main products	2.35	1.23	2.10	1.12
Position in the Business Network	3.50	1.15	2.53	1.33
Network linkages	2.68	1.03	2.74	1.09
Levels of IT adoption	3.81	1.00	2.69	1.15

4.1.2 Comparison of SMEs and Large Firms

If the firm size number is 1, based on the scale developed in this research, it is a SME (Total assets are smaller than 80 million New Taiwanese dollars[a]). The sample of large firms shows an average scale of 3.6, which stands for 500 millions to 1.5 billion NT dollars. Besides firm size, all the other measurement results of large firms have higher values than those SMEs except network linkages. Large firms are apparently located closer to the core firm of a business network than those SMEs or they are just the brand owners. Most large firms have implemented ERP systems and some have B2Bi platforms already. Network linkages are quite the same indicating that there is no difference among large firms and SMEs whether they have stable or dynamic interfirm relationships in the supply chain.

4.2 Hypotheses result and correlations

The hypotheses were tested by correlations and one way ANOVA analysis. The results are shown on table 3 and 4 respectively including the result of reliability test of each constructs.

4.2.1 Hypothesis on overall Firm Size / Capital

The test conducted on table 4 shows the results of one-way ANOVA test. Firm size's effect is significant at the 1% significance level which supports H1. Additionally, the relationship between firm size and IT adoption level is positive. Thus the main hypothesis is strongly supported. As a firm's size represents its potential capability to equip its IT facilities, it can help a firm to upgrade its IT adoption level.

4.2.2 Hypothesis on overall System Support Readiness

In line with previous literature [Premkumar et al., 1994; Iacovou et al., 1995], our results show that the system support readiness has positive effects on higher level of IT adoption at 1% significance level. Thereby, H2 is accepted. As system support readiness is a factor often divided into many sub determinants, we have also tested its sub-constructs H2-1 & H2-2 on IT strategy and top managers' support.

Both sub-constructs show strong support at 1% significance level by the test results. There are other proponents of those sub-constructs as mentioned in the previous sections [Sohn & Wang, 1998; Mehrtens et al., 2001]. The correlation table (table 4) again suggests that system support readiness has highest coefficient as 0.663 to the level of IT adoption.

[a] NT = New Taiwanese Dollar
Exchange Rate on 14/12/2002 USD : NT = 1: 34.69

Table 3 Test result of hypotheses

Hypotheses	Items	F	Sig.	α	Result
H1	**Firm Size**	7.427	.000	.812	Accepted
H2	**System Support Readiness**	23.567	.000	.768	Accepted
H2-1	**Clear IT Strategy**	10.049	.000	.773	Accepted
H2-2	**Top Managers' Support**	7.375	.000	.779	Accepted
H3	**Perceived Benefits**	8.424	.000	.779	Accepted
H3-1	**Clear Goals on IT implementation**	5.070	.001	.777	Accepted
H4	**Life Cycle of Main Products**	1.114	.353	.816	Rejected
H5	**Position in the Business Network**	4.646	.002	.803	Accepted
H6	**Network Linkages**	.049	.995	.822	Rejected
H6-1	**IT Adoption Along the Supply Chain**	6.152	.000	.787	Accepted

Table 4 Correlations of main factors

Variables	SIZE	SUPPORT	BENEFIT	LIFECYC	POSITION	LINKAGE	ITLV
SIZE	1	.492**	.168	.214	.357**	-.111	.450***
SUPPORT		1	.465	.151	.275**	.089	.663***
BENEFIT			1	.097	.273**	-.036	.446***
LIFECYC				1	.026	.019	.183**
POSITION					1	-.106	.339***
LINKAGE						1	.009
ITLV							1

*P < .10; ** P< .05; *** P < .01 (2-tailed).

4.2.3 Hypothesis on overall Perceived Benefits

Perceived benefit has been an important incentive [Saunders & Clark, 1992; Son, Narasimhan, & Riggins, 1999] for IT adoption in many studies. Yet previous studies do not consider the impacts on the levels of IT adoption. We conclude that perceived benefit plays an important role on higher level of IT adoption at the significance level 1%. From the ANOVA analysis, the establishment of a clear goal reduces the uncertainty of IT investment as this indicator is significant equally. Thereby, H3 and H3-1 both have empirical basis and can be a useful insight for managers' actions.

4.2.4 Hypothesis on overall Product Life Cycle

This hypothesis (H4) is not supported by data since the analysis does not show a significant result. However, the correlation between this item and IT adoption level still indicates positive output at 5% significance level. Also, the descriptive analysis indicates that the IT Industry has a higher IT adoption level and shorter product life cycle than those traditional manufacturers (table 2-1). It might indicate that shorter product life cycle brings more uncertainty as well as the need for catering supply chain visibilities – thus deterring some sample firms from further investments on IT infrastructure.

4.2.5 Hypothesis on overall Network Position of a Supply Chain

The core firm often acts as a resource base to an affiliate firm [Banerji & Sambharya, 1998]. Therefore, it is quite reasonable that this variable is related to firm size and support as shown in table 4. Based on Liu & Brookfield's [2000] study, core firms in machine tool industries are not necessarily large firms. Moreover, network position is considered an external factor to a firm. This is the reason why we look into this item separately to examine the level of IT adoption. H5 is supported at the 1% significance level with coefficient .339. According to the survey, core firms have more business transactions among the network members and mostly are brand owners. The result indicates that the closer a firm is to the core of a business network, the higher its level of IT adoption will be. On the other hand, affiliate firms and boundary firms of a business network might concentrate on either OEM or single component manufacturing. They have less interfirm business processes and lower levels of IT adoption.

4.2.6 Hypothesis on overall Business Network Linkage

H6 is rejected due to the high P value 0.995. The coefficient of correlation between this item and IT adoption level is almost zero. At least this report shows that long-term and stable relationships do not really motivate firms in constructing a higher level of IT infrastructure. Nevertheless, its associate proposition H6-1 of mutual IT adoption along the supply chain has been demonstrated as having an important influence on higher upgrades of IT adoption level. This is further supported by our preliminary interview with a hardware manufacturer which does not have stable relationships with many of its suppliers. When a new B2Bi platform with XML technology was introduced among its business network, many of its affiliate firms upgraded their IT adoption levels to fit the interface though they do not have relatively stable relationships.

5. A Position Model for the Evaluation of IT Adoption and Supply Chain Integration

Based on the empirical data and discussion, a conceptual model (Figure 2) is proposed to evaluate the current positions of firms within the business network. It is a multi-dimensional diagram which consists of phases supported by the influential factors of IT adoption. Here we still use all the factors described above although the correlation table shows that network linkage does not have significant relationship with IT adoption levels. The reason is simply because this item may still be relevant if B2Bi is further divided into four integration methods [Wang & Heng, 2002a] as *Open Process Integration, Direct Application Integration, Data Exchange Integration, and Close Process Integration (Business Process Integration)* that the first one does not require long-term buy-seller relationships as much as the other three. This preliminary model is therefore suitable for a decision maker or project planner of IT adoption since each of the B2Bi projects has its own integration methods.

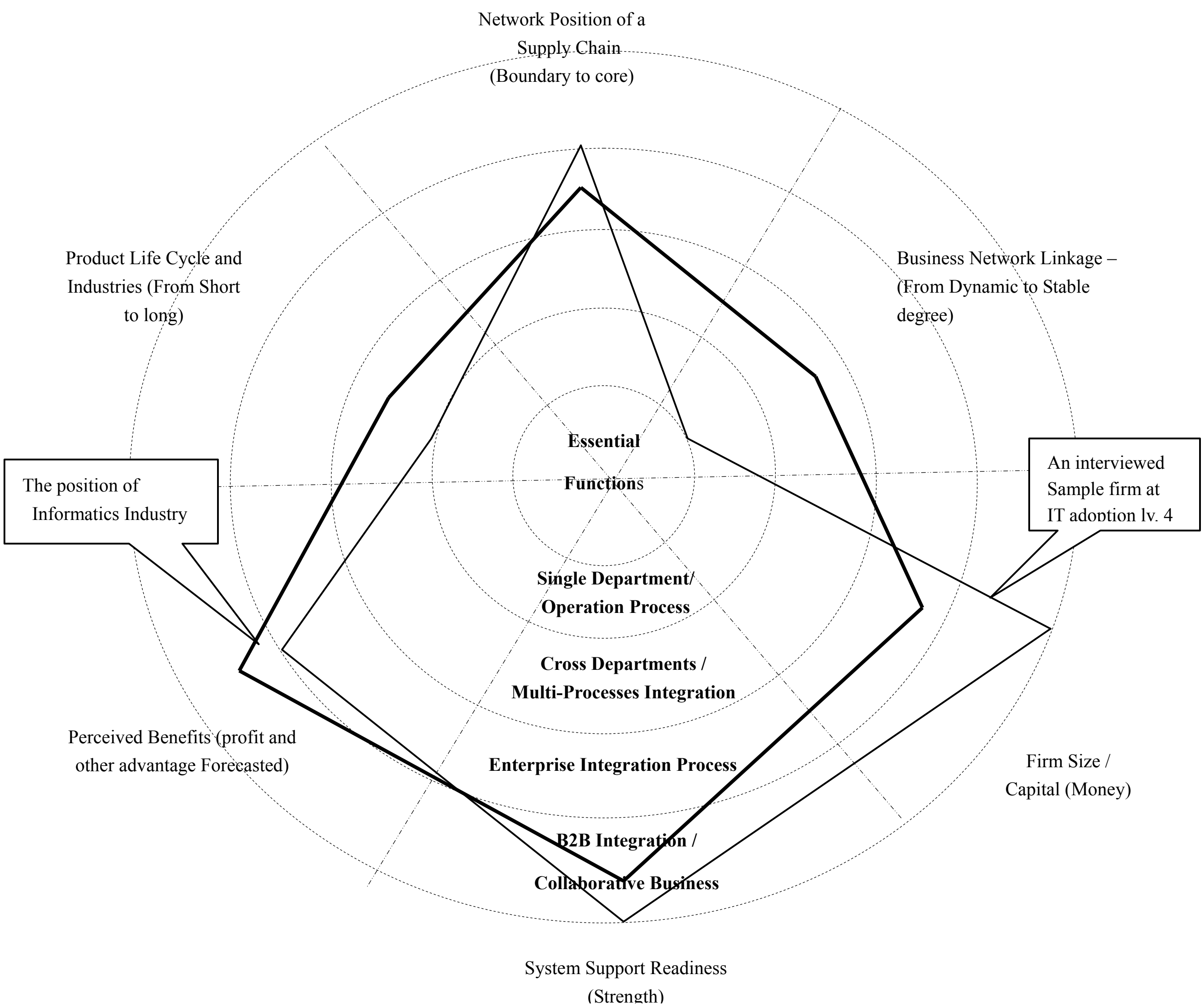

Figure 2 Position Model for the evaluation of IT adoption in Supply Chain

In order to draw a sample line on this diagram, an interview has been conducted in one firm which is a member of the Taiwanese PC systems manufacturers in Hsin Chou Science and Technical Park. We interviewed its CIO, senior account officer, and a senior IT engineer to find out where the target firm belongs in our position model. Some interesting results have been identified through the interviews. For instance, PC manufacturing is part of IT industry which normally has very short product life cycles. In order to gain supply chain visibility, firms in this industry exert a stronger pressure on adopting B2B integration/collaborative commerce. It is currently only at level 4 of IT adoption though it has sufficient systems' support readiness and abundant resources. It does not have the highest perceived benefits for further integration; it is an affiliate firm [Banerji & Sambharya, 1998; Wang & Heng, 2002b]; its network linkage is relatively dynamic; obviously, its product life cycle is quite long.

The results here are derived by comparing the factors described in the previous section, and should be viewed as guides so as to show the position of a firm's current IT adoption status. The model aims to provide an evaluating tool for industries to help the decision-makings for their current IT investment and budgets. For the IT planners, they can adjust their IT strategies with the reflection and comparison by plotting their competitors', customers', and suppliers' position lines. It can be used ideally to posit all types of firms onto this model, though practically many giant enterprises might already implement B2Bi since they have abundant resources and needs in linking with their strategic alliances. This model is based on aggregated information and is at least useful for the following stakeholders,

Core firms of the business network

Large firms or core firms of business networks can utilise it to target capable partners if certain levels of IT adoptions are required for further integration. For example, a core firm in the business network can survey its network partners to draw a diagram for the levels of IT adoption. By using current research data in the IT industry, B2Bi level is shown as in table 5 and then plotted on figure 2 as the bold line. It presents the average positions of influential factors of IT adoption. Managers can evaluate particular affiliate firms within the business network to see whether they have sufficient motivation and capabilities to upgrade current information systems into B2Bi level for supply chain integration.

Table 5 Group Statistics of IT Industry

Variables	ITLV	Mean	Std. Deviation	Std. Error Mean
SIZE	5.00	**3.88**	1.52	.31
SUPPORT	5.00	**4.54**	.78	.16
BENEFIT	5.00	**4.38**	.98	.20
LIFECYC	5.00	**2.80**	1.26	.26
POSITION	5.00	**3.88**	.99	.20
LINKAGE	5.00	**2.63**	1.25	.25

Affiliate firms of the business network

This model is expected for affiliate firms inside a business network in order to assess its internal capability and external pressures. The comparative samples are thus industries, other network partners, or competitors. By adopting this model, they may assess their surroundings in order to identify the necessary level of IT adoption in order to gain competitiveness in IT usage.

Government Entities

Government entities can utilise this model to survey the industrial development and information adoption. For example, in the context of understanding why the half of the expected participants withdraw from the A/B supply chain integration projects supported by Taiwanese government [Wang & Heng, 2003], this model may help to identify the proper scope of integration. According to the project scope, there were initially 3,948 firms involved, yet eventually only around 1,500 firms are still participating. Governmental resources and labour cost may be reduced if this model is refereed to assess project applicants by related government departments.

Systems Vendors

This model differentiates practical levels of IT adoption. Systems vendors can use this model to analyse potential markets. For instance, firms which have higher IT capability and adoption pressures might be interested in upgrading their adoption levels. Vendors thus have clearer targets to promote their information system solutions for enterprises.

Companies are seeking business process integration solutions that enable responsive and resilient value chains. Nevertheless, few decision models are provided in the contemporary researches, and indeed the business environment. The proposed model combines different aspects of IT adoption, network theory, and supply chain management so as to provide a strategic position for assessment. Analyses of factor regressions and mathematical models have also been computed during our research process. Notwithstanding, to dwell on those results can be taken up in another paper.

6. Conclusion

The main contribution of this study is to evaluate the insightful patterns of IT adoption by combining business network and supply chain theories. It is one of the studies with investigating the firms' internal and external motivations on the levels of IT adoption. This research reports the actual situations of IT adoption and supply chain integration that indicates the characteristics of firms in different IT adoption levels. It can also help to explain why some firms have not chosen to invest more resources on IT infrastructure for B2B Integration level.

Previous research has identified many factors for IT adoption in the past, but few strategic and evaluative position models are developed in order to anchor those strategically in regard to supply chain theories. With the result of our surveys, more directions can be further explored our desks such as the length of being a member of the supply chain, what is the co-ownership structure [resource interdependency: Galuti, 1999], and the success of adjusting firms' strategies by utilising this model. For the purpose of extending this model, the authors welcome cross-country studies with other researchers. The preliminary result may provide some insights for managers who intend to participate or who have already participated in the IT adoption in the supply chain. Our study can help them prioritise the important factors in establishing strategies. Factors identified in this study are from the literature review and empirical data. It is possible that additional factors for the model can be uncovered in future research. In addition, the levels of IT adoption would vary as firms grow and the environment changes.

This paper has reflected on extant literature and combined the theories of business network, levels of IT adoption, and the associated determinants into a position model as it applies to the strategic evaluations of supply chain integration. Both theoretical and industrial aspects have been explored by the analysis and discussion of the empirical data collected from the Taiwanese firms. It is hoped that more studies in this research domain be conducted with greater breadth and depth in the future.

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Appendix 1: The measurement properties of the multi-item scales

Factors	**Scale of measurement**				
	1	2	3	4	5
Firm Size / Capital (Resources)	< 80 million [a](SMEs[b])	80 millions ~ 500 millions NT Dollars	500 millions ~ 1 billion NT Dallors	1 billion ~ 1.5billion NT Dollars	> 1.5billion NT dollars
System Support Readiness	Very poor (No IT staff or employees with IT background)	Poor (No IT staff but sufficient employees with IT background)	Medium (Some IT staff appointed to support systems implementation)	Strong (Firms with IT division and employees with IT background	Very Strong (Firms with IT Championship sectors, fixed fiscal IT budgets)
Perceived Benefits (Believes in IS implementation)	Very Low (IS doesn't help much)	Low (IS can improve basic functions)	Medium (IS can enhance currently business Process)	High (IS can increase efficiency and effectiveness)	Very High (Provide Unique Competitive Advantage)
Product Life Cycle (Industries)	Very Short (< 3 months)	Short (3 to 6 months)	Medium (6 to 12 months)	Long (1 to 2 years)	Very Long (> 2 years)
Network Position of a Supply Chain	> 3rd tier supplier / Small OEM firms	3rd tier supplier / Small OEM firms	2nd tier supplier / collaborative manufacturers	1st tier supplier / collaborative manufacturers (ODM and OEM for Brand Owner)	Core Firms and Large firms (Brand Owner of Final Products or centre of network)
Business Network Linkage (Market and Customer)	Very Dynamic (Always Change Partner/Customer)	Dynamic (Often Change Partner/Customer)	Medium (Casual Changes in Partner/ Customer)	Stable (Seldom Changes Partner/ Customer)	Very Stable (Strong Links with Partner./Customer are necessary)
Levels of IT Adoption	Essential functions (Documentation)	Single Department/ Operation Process	Cross Departments / Multi-Process Integration	Enterprise Integration Process (eg, ERP)	B2B Integration / Collaborative Business

[a] NT = New Taiwanese Dollar
Exchange Rate on 14/12/2002 USD : NT = 1: 34.69

[b] The definition of SMEs is referred from *Taiwanese Small and Medium Enterprises, Department of SMEs Development, Ministry of Economic Affairs, Taiwan*