Optimization of an Indicator System for Measuring E-commerce Development: A Further Study at Firm Level

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Abstract—**Although the topic of e-commerce measurement belongs to one of research priorities in e-commerce, we lack a measurement framework for e-commerce benchmarking at firm level, especially studies on important indicators explained by the actual state of e-commerce in enterprises. In this study, an indicator system is developed based on key factors found in past studies and derived from related theories, and an empirical study is made to optimize the indicator system. First, a theoretical model is presented, including 8 hypotheses; second, e-mail survey, online survey and telephone interviews are conducted in firms of 16 industries, and 156 cross-sectional samples covering 11 cities and regions in Shaanxi province in China are gathered; third, statistic analyses are made to test the theoretical hypotheses. Finally, the validity of the model is examined in terms of the relationships to e-commerce development with the data, and an optimized indicator system is obtained, which is less computationally intensive and more practically prone to application in e-commerce measurement and evaluation.**

Index Terms—**e-commerce, measurement, indicator system, optimization, validation, data analysis**

I. INTRODUCTION

The studies on e-commerce measures in the literature focus on 3 aspects: first, measuring e-commerce technology penetration, and some indicators are used such as access to the Internet, and the types of information and telecommunications technologies [1]; second, measuring e-commerce impact on firm performance [2], a lot of factors are studied; third, measuring support of e-commerce on business activities, a little pioneering has attempted to derive new e-commerce metrics based on business processes [3].

The purpose of this study is to identify the more significant indicators by the actual state of e-commerce activities implemented in firms. Selection of a set of most appropriate indicators is especially important in building a parsimonious model – an optimized indicator system, which is less computationally intensive and more practically prone to application in e-commerce measures.

II. BACKGROUND

There have been a lot of studies on the adoption and impact of IT and e-commerce practices in different sectors of the economy in the literature. Although these studies vary in terms of the nature of the technology, research methodology, and measures of e-commerce adoption, they have examined a wide variety of innovations in different contexts, and provided a rich foundation for our study.

For e-commerce adoption, the prior studies of focus on three aspects: first, explaining the decision to adopt e-commerce; second, explaining the adoption process as a whole, from taking the decision to adopt the innovation to the implementation and full development of commercial operations on the Internet; third, analyzing the final result of the adoption process – e-commerce impact on firm's performance and efficiency.

Through an empirical study of 286 firms, Beatty et al et al [4] identified the factors affecting e-commerce adoption in large and medium firms – perceived benefits, complexity, technical compatibility, organizational compatibility, and top management support.

Hong et al [5] developed a conceptual model for assessing e-commerce adoption and migration by technology diffusion theory and the TOE (Technology–Organization–Environment) framework, suggesting that technology integration, web functionalities, web spending, and partner use were significant adoption predictors.

Grandon et al [6] proposed a research model according to the TAM (technology acceptance model), and determined four factors influencing e-commerce adoption: organizational readiness, external pressure, perceived ease of use, and perceived usefulness.

Developing an integrated model of IS (Information System) adoption in SMEs, Thong [7] specified four groups of variables as primary determinants of IS (Information System) adoption – CEO (Chief Executive Officer), IS, organizational characteristics, and environmental characteristics. He highlighted the fact that the technological innovation literature has identified many variables as possible determinants of organizational adoption but this "suggest that more research is needed to identify the critical ones".

Based on the literature, Vilaseca-Requena et al [8] examined various types of factors previously considered by the past studies, such as competitive environment, organizational characteristics, strategic orientation, innovative capacity, managers' characteristics, IT equipment possessed, etc. They considered that research

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needed to continue advancing in the study of e-commerce adoption.

Some research teams of international organizations, such as Cisco's Net Impact Research Series, UNDP-APDIP (United Nations Development Programme - Asia-Pacific Development Information Programme), European Commission, etc, have made huge contribution to the diffusion of Internet and e-commerce, especially on that of ICTs (Information and Communication Technologies).

These studies offer valuable variables but are of little help in understanding how firms rely on e-commerce to support their ongoing activities. Some pioneering work has been done on e-commerce activities as a whole and on e-commerce business processes and capabilities. Zhu et al developed metrics for measuring e-commerce adoption [2], consisting of four dimensions: information, transaction, customization, and supplier connection. They examined the validity of the metrics in terms of the relationships to firm performance with data from 260 manufacturing companies, and found a significant relationship between e-commerce adoption and some measures of firm performance. Elia et al. was one trying to derive e-commerce metrics based on business processes [10]. The proposed metrics included 36 eBPs (business processes carried out in an electronically mediated environment) covering the five generic functions: product development, engineering and design; procurement/purchasing; sales, marketing and after-sales service; production/operations; and distribution and logistics, and also been used in their work of B-to-B e-commerce adoption trajectories.

Such a line of inquiry falls within the realm of exploratory research for several reasons. First, fewer studies measure e-commerce development based on business processes; second, there is a lack of an integrated model for assessing IT effects on firm's e-commerce development level, third, the research may be different in terms of different technologies, organizational and environmental contexts, and different research methods, though a large variety of variables have been studied. To our knowledge, no prior study has gauged the IT effects on e-commerce success.

III. MEASUREMENT MODEL AND HYPOTHESES

A. Measurement model

On the basis of analyzing the theoretical explanations of past studies, a measurement model (Fig. 1) was proposed for e-commerce development measures in firms by building upon the TOE (Technology–Organization–Environment) framework. Eight constructs derived from prior studies and related works were proposed as potential variables to evaluate the degree of e-commerce adoption.

B. Hypotheses

Technological factors. Many past studies have examined relative advantage, complexity, and compatibility as innovation characteristics. However, we lack evidence showing whether it will be still have a role

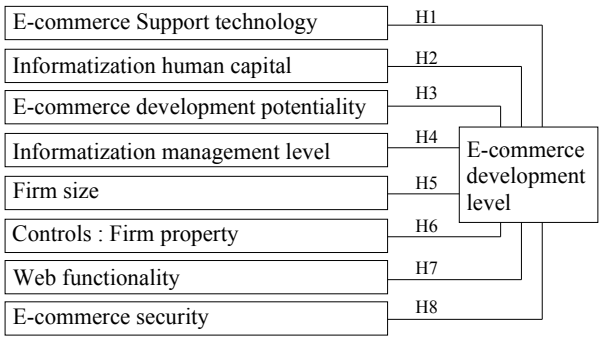

Figure 1. The proposed measurement model.

in explaining the degree of that the firm engages in e-commerce activities. Moreover, there's little evidence showing the relationship once IT technology support and related human capital are regarded as technological factors. Some researchers argue that operationalization could have been strengthened if the amount of IS investment were measured [7], and that firms with higher web budget are more likely to adopt e-commerce as well as migrate offline transactions to the online platform [4]. Also, expertise has been found to be an important factor in the adoption of new technologies and to be positively related to adoption in the literature [3]. Therefore, we develop the three hypotheses:

H1. E-commerce support technology is positively associated with e-commerce development level.

H2. Informatization human capital is positively associated with e-commerce development level.

H3. E-commerce development potentiality is positively associated with e-commerce development level.

Organizational factors. Three factors were considered here. First, the literature is replete with studies that reinforce the importance of top management support for IT assimilation [2], and has evidences that those who allocate organizational resources influence innovation adoption and that a top management support to be critical for creating a supportive climate and providing adequate resources for adoption of new technologies [9]. Several studies have found that firm's strategic orientation can play an important role in the adoption and extent of new technologies [10], and that firms assigning a strategic value to their innovation efforts are likely to succeed in effectively managing their innovation process [2]. Second, firm size, generally assessed by the number of employees, has been shown by many studies to impact the adoption of new technologies and larger firms are found to have greater slack in resources and are able to experiment with new innovations [9]. Although Kimberly suggests that four measures can be used as size [11], little studies use financial resource or input/output as a measure of size. We lack solid conclusions how they influence e-commerce adoption. In addition, we want to see if there is difference between governmental firms and others on e-commerce. Hence, we offer the three hypotheses:

H4. Informatization management level is positively associated with e-commerce development level.

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H5. Firm size is positively associated with e-commerce development level.
H6. Firm property is associated with e-commerce development level.

Environment factors. Two factors are considered in the study. Web functionalities help firms provide real-time information to customers, update product offerings and make price change, facilitate self-service via online account management and research tools, and conduct online transactions with suppliers [12]. Firms that are capable of providing more web functionalities which can make customers and trading partners more willing to conduct transactions online are likely to have more successful e-commerce. Previous research has shown that security issues may act as an impediment to future business development [13]. However, the evidence is weaker when the object of analysis is the adoption of the Internet for commercial purposes [14]. Moreover, we lack arguments capable of explaining how these factors affect e-commerce penetration. Therefore, we propose the two hypotheses:
H7. Web functionality is positively associated with e-commerce development level.
H8. E-commerce security is positively associated with e-commerce development level.

IV. RESEARCH DESIGN

A. Data and sample

158 cross-sectional samples were gathered by means of e-mail survey, online survey and telephone interview during 2006 to 2007, which respondents were CIO, and Information and Supply and Sales and Finance Managers in firms covered 11 cities and regions in Shaanxi and 16 industries among which six industries (manufacturing, petrochemical, electronic power, coal, colored metal, and medicine) accounted for 71%. Large- (listed in the category of 1588 large-sized firms in China in 2002) and medium- and small-sized (Production value<50 millions) firms accounted for 21%, 64% and 15% respectively; governmental, joint- stock, private, and other firms accounted for 75%, 17%, 4%, and 3% respectively.

Survey instruments were developed to measure the variables, which were pilot-tested at first to ensure that the questions were being properly interpreted and that the survey format was in order. Questionnaire consisted of 4 parts: (1) Firm background including firm name, industry type, firm size (assets, production value, sales value, number of employees), a contact person and his e-mail address, a telephone number, and an address; (2) IT foundation including Internet access mode, online transaction, number of IT staff, IS and its cost, recent plan of IS and related investment; (3) IT management and security issues. A seven point Likert-type scale ranging from strongly disagree to strongly agree was utilized; (4) e-commerce business processes and Web function. Online survey, by which websites were connected, was used to determine the rank score.

The main sample represented six sectors – electronic power, manufacturing, petrochemical, coal, colored metal, and medicine – which percentage was 71% and the ratio of IT investment was 89.2%. For the six sectors, the annual net value of fixed assets, annual production value, and annual sales revenue accounted for 91%, 90%, and 85% respectively; and their ratios of IT investment were 33%, 23%, 20%, 6%, 4.4%, and 2.8% respectively.

A lot of sample firms adopted IS applications, but most of them belong to simple systems, such as finance management, OA, CAD, HRM, etc. The adoption ratio of Integrative systems like ERP, MIS, and MRP/MRPII was lower, and applications of CRM and SRM were scarce.

For IT applications in different sectors, manufacturing focused on CAD and CAM, and have use ERP, PDM, CAPP, CAQ more than those of other sectors, accounting for 48.1%, 70.6%, 64.7%, and 71.4% respectively; Electronic power concentrate on OA, MIS, and HRM, and medicine were interested in ERP and logistic management.

The main work of IT functional dept was to supply day-to-day technical support, lacking of IT strategy research and management. Among the respondents, 17.7% believed a lack of ability to organize project implementation, and 41.2% thought that level of expertise needed to be improved, and 21% considered a lack of ability to communicate and coordinate with other dept., and 47.9% suggested that development and utilization of information resources should be strengthened.

B. Variables and constructs

Dependent variable. E-commerce has been defined in many ways depending on the different context and research objective of author [6]. In this study, it is defined as the use of Internet and related technologies to support business processes (TABLE I). E-commerce development level (named EDL) was measured by the degree of business processes, which value was the number of e-commerce business processes implemented by a firm, an integer in the interval [0,14].

Independent variable. Factors were measured by

TABLE I. E-COMMERCE BUSINESS PROCESSES IN FIRMS.

Category	Business processes
Website	(1) Having a domain name;
Information release online	(2) Firm introduction; (3) Product or service information; (4) Prices of products or services;
Search online	(5) Finding supply or demand information, products or services or prices; (6) Find new suppliers/customers;
Negotiation online	(7) Negotiating contracts (price, volume, etc.) with suppliers or customers;
Transaction online	(8) Buying or selling products or services by e-catalogs, e-auction, e-calls for tenders, orders from suppliers or customers;
e-Payment	(9) e-Payments to suppliers or from customers;
Logistic	(10)Transportation and logistic management;
Customer service online	(11) Offering after-sales services and technical support, and accept customer feedback;
Internet access	(12) Wideband or private line connection;
Collaboration online	(13) Transferring documents and technical drawings, collaborative engineering;
Business communication	(14) Having an e-mail system.

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TABLE II. INDICATOR NORMALIZATION RULE

Indicator value \ Final score	1	2	3	4	5	6	7
EDL(number)	0	1-2	3-5	6-9	10-12	13	14
IN1(number)	0	1	2-3	4-5	6-7	8-9	≥10
IN2(10 thousand RMB)	0	0-10	10-100	100-500	500-1000	1000-2000	≥2000
IN3(10 thousand RMB)	0	0-10	10-100	100-500	500-1000	1000-2000	≥2000
HR1(number)	0	1-4	5-8	9-11	12-14	15-17	≥18
HR3(Yuan RMB)	0	＜500	500-1000	1000-1500	1500-2000	2000-2500	≥2500
ES(million RMB)	＜1	1-50	50-100	100-500	500-1000	1000-10000	≥10000
DP1(number)	0	1	2-3	4-5	6-7	8-9	≥10
DP2(10 thousand RMB)	0	0-10	10-100	100-500	500-1000	1000-3000	≥3000

using multi-item indicators aiming to capture the underlying theoretical domain of the constructs aiming to capture the underlying theoretical domain of the constructs. Some were measured by using seven-point Likert-type scale ranging from strongly disagree to strongly agree, and others had to be normalized according to the rule (TABLE II).

E-commerce support technology (IN), measured by 3 indictors: ①IT application capability (IN1), scored the number of IT systems carried out by one firm; The systems covered major IT functional areas, including OA, CAD/CAM/CAPP, MRP/MRPII, PDM, HRM, financial management, inventory management, MIS/ERP, CRM, SRM, BI, etc; If MIS/ERP was more complete, the value could be the number of its subsystems; ②e-commerce technology investment (IN2), was the investment for the existed IT systems; ③informatization investment (IN3), was the investment during the last 5 years.

Informatization human capital (HR), measured by 3 indictors: ①IT employees (HR1), was the number of employees in Information Department; ②employee train (HR2), was evaluated by mentimes of IT training; ③employee income (HR3), was average salary of employees engaged in informatization.

E-commerce development potentiality (DP), measured by 2 indictors: ①potential IT application capability (DP1), scored the number of IT systems planning to be implemented by one firm, like IN1; ②potential Investment of e-commerce technology (DP2), was the intended investment for planned IT systems, like IN2.

Informatization management level (MS), measured by 5 indictors: ①top-level manager support (MS1); ②strategic planning (MS2); ③function of information dept. (MS3); ④standardized operation flow (MS4); ⑤leaders' knowledge related (MS5); evaluated by their degrees.

Firm size, measured by 2 indictors: ①production capability (ES1), expressed by production value per year; ②asset (ES2), evaluated by net value of fixed assets.

Web functionality (US), measured by 3 indictors: ①user service support (US1), examined by 7 functions: contact telephone, user feedback, technical support, after-sales service, free service, online alternation, and multi-lingual support; It scored 1 to 7 depending on how many functions existed on a website; ②web integration (US2), examined by 6 functions: order processing, online payment, remote service, collaborative office, logistic delivery, and sales/procurement automation, scored like US1; ③details of products/services (US3), evaluated by the details of products/services on a website.

E-commerce security (SE), measured by 3 indictors: ①network security (SE1); ②security facilities (SE2); ③Virus infection (SE3); evaluated by their degrees.

Control variable. Firm property was coded into binary variables so as to know whether the difference between governmental firms and others is more significant on e-commerce development level.

The indicator system designed was showed in Fig. 2.

C. Data analysis methods

Reliability analysis and factor analysis were employed to identify underlying indicators and dimensions of the model, which could then be used as independent variables to facilitate interpretation of findings; multiple regression

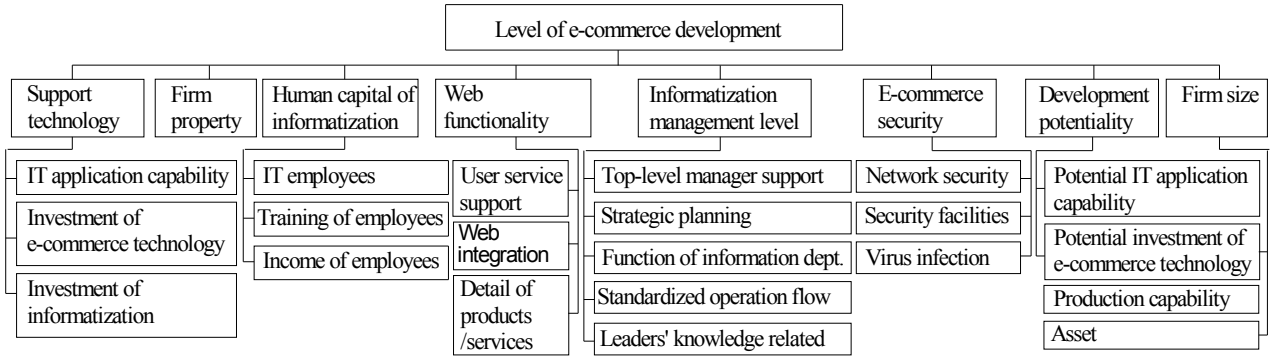

Figure 2. An indicator system for e-commerce development measurement in firms.

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analysis was used to test the hypotheses H1 to H7 because of the multiple-value dependent variable e-commerce development level.; t-test was exploited to compare mean values in order to examine the hypothesis H8.

V. RESULTS

A. Reliability analysis

The values of alpha varied from 0.70 to 0.93 (TABLE III) which were higher than the 0.7 threshold considered as minimum normally, indicating high reliability of the measures. Three indicators (HR3, US2 and MS5) were eliminated because their values of CITC (Corrected Item Total Correlation) were less than 0.5.

B. Factor analysis

Principal component extraction with varimax rotation and required eigenvalues above 1.0 were used. By the Kaiser eigenvalues criterion, 6 factors that collectively explained 80.695% of the variance in all indicators were extracted.

Convergent and discriminant validities were tested by factor loadings (TABLE IV), which were highly (>0.60) on their associated factors (0.50 or higher should be considered as a cut-off value), and also much higher on the associated factors than on any other (with no cross loading greater than 0.35). Two indicators (IN3 and HR2) were dropped from the model according to the validity rules.

Meanwhile, because one indicator (HR1) did not load on the intended factor as expected and seemed to has the same construct as other two indicators (IN1 and IN2), a new variable corresponding to the Component 1 consisting of the three indicators was constructed, which named e-commerce foundation (EI) and reflected the investment of technology and human capital in e-commerce. Finally, the two hypotheses (H1 and H2) were revised into a new hypothesis

H12. E-commerce foundation is positively associated with e-commerce development level.

TABLE III. RESULTS OF RELIABILITY ANALYSIS.

Variable	Indicator	CITC	Alpha
IN	IN1	0.6489	0.7925
	IN2	0.7885	
	IN3	0.5029	
HR	HR1	0. 5358	0.7012
	HR2	0. 6043	
	HR3*	0. 4441	
US	US1	0.7548	0.7360
	US2*	0.3658	
	US3	0.6650	
MS	MS1	0.5228	0.7997
	MS2	0.6645	
	MS3	0.5885	
	MS4	0.6622	
	MS5*	0.4829	
ES	ES1	0.7144	0.8334
	ES2	0.7144	
SE	SE1	0.8258	0.9340
	SE2	0.8789	
	SE3	0.8951	
DP	DP1	0.7738	0.8699
	DP2	0.7738	

TABLE IV. RESULTS OF FACTOR ANALYSIS.

	Component					
	1	2	3	4	5	6
IN1	.794	.207	.270	.117	-.021	.241
IN2	.856	.161	.098	.314	.096	.068
IN3*	.467*	.090	.192	.518*	.298	-.175
HR1	.835	.009	.086	.108	.109	.159
HR2*	.629*	.199	.178	.544*	.269	-.040
SE1	-.007	.867	.138	.194	-.017	.281
SE2	.198	.909	.177	.002	.093	.104
SE3	.174	.914	.152	.059	.017	.132
MS1	-.031	.142	.682	.350	-.285	.008
MS2	.163	.069	.789	.003	.092	.272
MS3	.138	.217	.723	.131	.280	-.024
MS4	.237	.137	.781	-.026	.118	.154
ES1	.307	.052	.138	.785	.154	.178
ES2	.149	.082	.020	.880	.046	.112
DP1	.067	.075	.127	.058	.914	.071
DP2	.164	-.011	.054	.211	.876	.141
US1	.148	.222	.093	.142	.089	.865
US3	.169	.261	.269	.049	.136	.805
Eigen Value	6.675	2.417	1.601	1.529	1.211	1.092
Var. Explain	37.084	13.428	8.895	8.494	6.728	6.065

C. Regression analysis

With the six factors as independent variables, the multiple regression equation was

$$EDL=0.124+0.219EI+0.171US+0.159MS+0.140SE+0.063DP+0.074ES. \quad (1)$$

The results indicated that all the six factors ($\beta>0$, $p<0.5$) were positively associated with EDL, especially EI ($\beta=0.306$, $p<0.001$), US ($\beta=0.285$, $p<0.001$), MS ($\beta=0.187$, $p<0.002$), and SE ($\beta=0.186$, $p<0.003$), meaning that these variables had more significant impacts on e-commerce development level. Therefore, the hypotheses H1 to H8 except H6 were supported.

The results of the further stepwise regression (Criteria:Probability-of-F-to-enter≤0.05, and Probability-

TABLE V. RESULTS OF MULTIPLE REGRESSION.

	Unstandard-ized Coef		Std. Coef			Collinearity Statistics	
Model	B	Std. Error	Beta	t	Sig.	Toler-ance	VIF
1(Const.)	.393	.020		19.99	.000		
EI	.393	.040	.618	9.750	.000	1.000	1.000
2(Const.)	.285	.023		12.54	.000		
EI	.284	.038	.446	7.468	.000	.843	1.186
WF	.307	.042	.433	7.259	.000	.843	1.186
3(Const.)	.204	.030		6.876	.000		
EI	.247	.037	.389	6.599	.000	.792	1.263
WFI	.295	.041	.416	7.270	.000	.838	1.193
IM	.159	.040	.217	3.940	.000	.907	1.103
4(Const.)	.160	.032		4.484	.000		
EI	.223	.037	.351	5.995	.000	.758	1.320
WF	.272	.040	.383	6.756	.000	.808	1.237
IM	.154	.039	.211	3.945	.001	.906	1.104
ES	.109	.035	.171	3.125	.002	.871	1.148
5(Const.)	.142	.033		4.330	.000		
EI	.214	.037	.336	5.767	.000	.747	1.339
WF	.247	.041	.348	5.979	.000	.748	1.338
IM	.159	.039	.217	4.097	.000	.904	1.106
ES	.112	.034	.175	3.249	.001	.869	1.150
DP	.088	.040	.117	2.185	.030	.880	1.137

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of-F-to-remove ≥0.100) showed that the importance rank were EI, US, MS, SE and DP, and that only ES seemed to be a less important factor because it did not enter (TABLE V). As the results showed that there was no multi-collinearity among the variables because of the smaller VIP (close to 1) or greater Tolerance (>0.7), the rational use of multiple regression was confirmed.

D. t-Test

The results of t-test (F=0.413, Sig.=0.521>>0.05) pointed out that the equal variances should be accepted (TABLE VI), so t=-0.935 (p=0.351>>0.05) in the first line (Equal variances assumed) was chosen. It was showed that the two means were not significantly different because 0 was in the interval of the mean difference, [-.0852, .0304], indicating that there was no significant difference between the governmental firms and others on e-commerce development level. Therefore, the H6 was refused.

VI. Discussion and Conclusion

A. Findings

As a result, 5 less important indicators and one non-significant variable (Firm size) were removed by reliability and factor and regression analyses, as well as Firm property not associated with e-commerce development level tested by t-test, which is the same as the result of the prior studies [15].

The first significant was e-commerce foundation which reflected technology and human capital investment. This verified that a firm with more prior experience from IT application was more prone to adopt new e-commerce technology [16], and that the more investment for technology and knowledge allowed new e-commerce technology to be more assimilated and exploited [17]. While, firms that do not have the IT expertise might be unaware of new e-commerce technologies or may not want to risk their adoption. When firms adopted more IS with related investment and accumulated more expertise and experience, it would lower the barriers about specialized knowledge and technical skills and be more confident to use e-commerce to a greater extent.

The second significant is web functionality which denoted web-service provided by a website was. It was suggested that a firm, which was able to provide more web functions to support user services, e.g. providing more detailed information and conducting online transactions, would have better capabilities for e-commerce [5]. This indicated that a firm with more functionality was more likely to provide good services to customers and business partners who would become more willing to conduct transactions online, and then to use e-commerce to a greater extent.

The third significant was informatization management. The result confirmed: (1) top- managers' positive attitudes toward e-commerce adoption would facilitate EC development [6]; (2) integration between IT planning and business strategies was significant for e-commerce construction [16], and the role and function of IT dept. also had the significant influence on e-commerce development;; (3) to standardize operation flow in line with e-commerce application was an approach towards e-commerce success [18].

The fourth significant was e-commerce security. This might infer that the higher level of e-commerce security, the more benefits e-commerce technology would bring to firms, and then, firms would like to participate in more e-commerce initiatives. This supported the result from a survey of e-commerce in 1999, conducted by Price Waterhouse Coopers, which showed that concern about security/privacy was perceived as the third most important barrier to the use of e-commerce.

The final was e-commerce development potentiality, meaning potential IT capability and resource tended to be a determinant. It indicated that a firm with more potential support from IT was more capable to acquire new technologies and to engage in a learning process so as to enter an advanced stage [16]. This proved that a more IS budget on related hardware, software, and internal staff support helps to secure the necessary resources for continuous development and extension of e-commerce [5]. It validated that through investing in continuous learning and technology development, and firms can assimilate more and more related knowledge, and utilize new technologies to a wider and deeper extent [17].

Firm size seemed to be less significant. Hence, it was not the determinant of e-commerce. This showed that although a firm with more production capability and asset was prone to invest more in IT adoption, it couldn't be validated that a firm with smaller size was certain to have a lower e-commerce level.

In conclusion, the optimized indicator system (Fig. 3) consisted of 5 variables which were found to be significant in explaining e-commerce development level, including 14 indicators.

B. Limitations

There may be two limitations in the work. On one hand, the sample may be biased toward medium-sized firms which exceed 2 in 3, this may prevent one from making comprehensive generalizations. On the other hand, the e-

TABLE VI. Results of independent samples test.

	Levene's Test for Equality of Variances		t-test for Equality of Means						
								95% Confidence Interval of the Difference	
	F	Sig.	t	df	Sig.(2-tailed)	Mean Difference	Std. Error Difference	Lower	Upper
EDL Equal variances assumed	.413	.521	-.935	154	.351	-.0274	.02926	-.0852	.0304
Equal variances not assumed			-.979	70.8	.331	-.0274	.02794	-.0831	.0282

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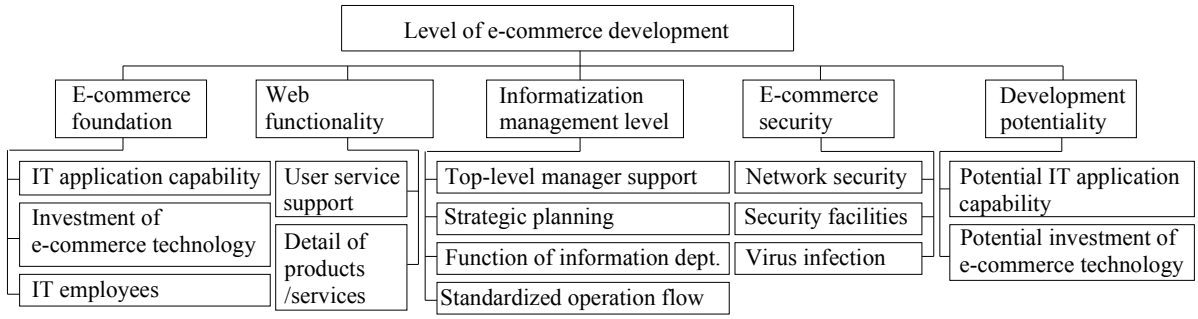

Figure 3. The optimized indicator system.

commerce definition and the choice of variables might be not enough.

C. Implications for research

The work builds upon prior research but is different in three ways:

First, there is little research like this which measures e-commerce development by the degree of business processes and the dependent variable is a multiple-value one, though past empirical studies have used a variety of dependent variables which are normally considered by the literature as a process consisting of a number of stages, for example, adopters (non-adopters, potential adopters, and adopters) [5], entry timing (pioneer, early adopter, early majority, late majority, laggard) [4], website development – four generation (information and catalog, database, transaction, integrated site) [19].

Second, our study provides the impetus for future research. It may be different in terms of different contexts and research methods. In our study, IT effects were assessed by IT resource, management, and environment, which was different from those in literature. Besides, some variables have not the same meaning as those in literature though they have the same name. In addition, our model was developed out of an integration of various perspectives using the technological innovation literature as a reference discipline. The model was then empirically tested using multivariate statistical techniques compared with the majority of previous research using bivariate correlation analysis. Future research can build on and extend the proposed integrated model by including other potential factors from the different contexts, and it will be necessary to explore other mathematical functions, either in the same factors or in new one.

Third, our findings will also help a better understanding of the determinant factors for firms and government and propose a quantitative basis for them to determine favorable policies and conditions for expanding their e-commerce applications and generating more benefits, since researchers have been exploring what business conditions firms should provide would be right for e-commerce success, and what factors would facilitate or inhibit business processes migrating toward Internet from traditional channels [20].

VII. CONCLUSIONS

As e-commerce represents a highly pervasive innovation that is leading to significant changes in the traditional ways of doing business, there is a growing demand to understand the current e-commerce development. People want to know: how the effects of investment on e-commerce by governments and firms and e-commerce development can be evaluated; and what policies should be made by government and what conditions should be owned by firms, are able to promote e-commerce development. So, it is important to build a right model for comprehensive measures of e-commerce development.

Several contributions emerge from the study. First, the author has attempted to derive an improved indicator system for evaluating e-commerce development by an empirical study approach by which the more significant indicators can be identified from the actual state of e-commerce activities implemented in firms. The optimized indicator system contributed by the work may represent valuable efforts. Second, the study seeks to help managers and researchers to be more effective in e-commerce measures so that a healthy environment can be built to be in favor of e-commerce development. The findings may offer them an initial framework for e-commerce measurement and evaluation at firm level.

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