The best scope of e-commerce diffusion in a supply-chain operational environment: A global empirical study

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Abstract

E-commerce is applied in a supply-chain operational environment in order to integrate internal information and improve supply-chain coordination. However, many researchers and practitioners remain unable to advise how best to characterize the scope of e-commerce diffusion in a supply-chain operational environment; should it be diffused to the supplier, customer, both, or others? This study involved a practical investigation of e-commerce diffusion in a supply-chain operational environment. In this study, we adopted the International Manufacturing Strategy Survey (IMSS) database and tested 491 global samples from the IMSS. The test results indicated that e-commerce should be completely diffused to the supplier and customer, and the majority of competitive performance will be satisfied by complete diffusion.

Keywords: Supply-chain coordination, e-commerce, diffusion scope, information, competitive performance.

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1. Introduction

In the manufacturing industry, supply chain management (SCM) is a powerful means for improving a firm's competitiveness and performance. Through close integration between upstream suppliers and downstream customers, related internal activities or operations such as production and manufacturing, delivery and logistics, purchasing and selling can be streamlined. SCM can strongly affect competitive advantage in a globally competitive environment.

However, firms at various stages in the supply chain will experience conflicts in cooperation if each has a different practical objective, and conflict will adversely influence supply-chain coordination and integration. In order to minimize conflict, the related literature indicates that supply-chain coordination must be a priority. Coordination means that partner firms must mutually coordinate transaction-related activities in their respective internal supply-chain operational environments [6].

Successful coordination can reduce conflict and establish a close connection between partner firms, further enhancing the supply chain's practical ability to satisfy market requirements, win customer satisfaction, achieve competitive performance, and gain further competitive advantage. Many business practice cases rely on the presumption that better coordination among supply-chain stakeholders results in greater customer satisfaction of market requirements. For example, Hewlett-Packard and Dell Computers have gained ground together through their dexterous manipulation of supply-chain coordination and mass customization. Therefore, if all firms in the supply chain behave in a manner that increases total supply-chain profits, supply-chain coordination must improve [5].

Firms know that coordination will decide the success or failure of supply-chain integration and practice. In order to improve coordination, information integration plays an important role. In fact, if partner firms wish to coordinate and integrate any internal supply chain activities, firms at various stages must share related information and fully integrate with other partner firms. If information integration is lacking, firms at various stages in the supply chain will find it difficult to understand the requirements of other partner firms and cooperate in overall internal supply-chain activity.

In recent years, more researchers have argued that in order to improve information integration between firms in the supply chain, e-commerce can be a powerful tool. Using e-commerce through Information Technology (IT) such as the Internet, firms can develop information integration mechanisms such as Business-to-Business (B2B) and Business-to-Customer (B2C). Through these mechanisms, firms at various stages in the supply chain can immediately share and mutually integrate information. Most empirical tests show evidence that the use of e-commerce improves information integration when e-commerce is adopted in supply-chain coordination [9] [10] [14] [15] [17] [19] [20] [23] [24].

Based on the above, the application of e-commerce in a supply-chain operational environment is widely accepted. Although there is evidence that e-commerce can improve information integration for supply-chain coordination, there are important questions that need to be asked about how to characterize the scope of effective e-commerce diffusion in a supply-chain operational environment. The term diffusion is generally defined in terms of the practical adoption of e-commerce. Therefore, in a supply-chain operational environment, the scope of e-commerce diffusion can be

defined as “the level of the practical adoption of e-commerce by partner firms at various stages in a supply-chain operational environment”.

To the best of our knowledge, e-commerce should be completely diffused to all partner firms in the supply-chain operational environment if supply-chain coordination is to be successful improved through e-commerce; it also means that all partner firms should adopt and develop e-commerce mechanisms in order to coordinate and integrate related information with other partner firms in the supply-chain operational environment. However, existing studies still lack evidence of the effective scope of e-commerce diffusion. Otherwise, different scopes of e-commerce diffusion are adopted in supply-chain operational environments in the real world, leading to different supply-chain coordination results and performance. However, which scopes of e-commerce diffusion will lead to supply-chain coordination and achieve the best performance?

Based on the discussion above, this study investigates and analyzes different scopes of e-commerce diffusion in a supply-chain operational environment. For its objective empirical testing, this study uses large samples from the global International Manufacturing Strategy Survey (IMSS) database. The remaining part of this paper is structured as follows: Section 2 contains a literature review and develops the study’s hypothesis, Section 3 describes our methodology, Section 4 describes the empirical test results and discussion, and Section 5 draws our conclusions and indicates directions for further research.

2. Literature review

Based on the introduction, this section will review related theories in order to

develop a complete research conceptualization and a hypothesis for this study.

2.1 Importance of e-commerce for supply-chain coordination

Firms can improve their coordination with partner firms through e-commerce. Using the B2B model of e-commerce, firms can share information with each other via the Internet or through dedicated electronic communication lines. Therefore, the e-commerce approach is assumed to be a powerful method for improving supply-chain coordination and integration activities, with many researchers taking this for granted [12] [21].

Much of the research literature in this domain supports the idea that e-commerce can improve supply-chain coordination. For example, [4] found that e-commerce mechanisms can improve coordination and supply-chain integration between suppliers and customers. [2] and [7] indicated that through an integrated supply-chain system and the use of IT, a firm is able to combine complementary resources into a synergic bundle that will generate higher rents for all partners. [1] argued that efficient information integration plays a key role in electronic supply-chain management. This research supports the effectiveness of e-commerce playing an important role in supply-chain coordination.

2.2 The best scope of e-commerce diffusion for the improvement of supply-chain coordination

The diffusion of e-commerce has been accepted by many business organizations and operations [8] [13]. Especially in supply-chain management and the integration of partner firms [3], the diffusion of e-commerce improves information coordination. [11] [16] [22] indicated that e-commerce can be applied to improve information integration

for related supply-chain internal functions or activities. The adoption and diffusion of e-commerce in a supply-chain operational environment can reduce uncertainty and improve coordination, and ensure the coordination results align with majority performance.

Although the diffusion of e-commerce can efficiently improve supply-chain coordination, the scope of its efficient diffusion must be defined. In fact, we often find more than one scope of e-commerce diffusion. Different supply-chain coordination results will be produced if different scopes of the diffusion of e-commerce are adopted in supply-chain operational environments. Which scope of e-commerce diffusion can lead to the best coordination results? Is it adopted by many partner firms? Is it adopted between many manufacturers and suppliers or customers?

When the scope of e-commerce diffusion is completely extended to suppliers and customers in the supply-chain operational environment, the coordination results will satisfy the majority of competitive performance needs. [3] found that firms adopting a large scope of e-commerce diffusion will lead to better supply-chain coordination results. [25] indicated that when the diffusion scope of e-commerce is completely extended through many firms' adoption of e-commerce, this will lead to the better performance of business operations. As result of [25], we can deduced that if many partner firms at various points in the supply chain adopt a large scope of e-commerce diffusion, the coordination results will be improved.

We understand that e-commerce can assist in coordination, leading to improved competitive performance. However, e-commerce should be completely diffused, with the largest possible scope, if supply-chain coordination is to be successful. It also means that all partner firms should adopt and develop e-commerce in order to

coordinate and integrate related information with other partner firms in the supply-chain operational environment. This leads to the hypothesis that we wish to examine in this paper:

Hypothesis 1: As the diffusion scope of e-commerce extends to upstream suppliers and downstream customers, the coordination results can be efficiently improved in order to align with majority performance.

3. Methodology

3.1 Survey database and test samples

This study is based on data from the International Manufacturing Strategy Survey (IMSS-IV) database. The IMSS is an international cooperative research network focusing on manufacturing strategy (MS) research. It gathers data about practices and performance related to manufacturing strategy in a global setting, as well as data pertaining to practices in supply-chain management. There have been four phases in the growth and evolution of IMSS. The first iteration (IMSS-I) was carried out and completed from 1992–1994, with the participation of 600 firms in 20 different countries. The second iteration (IMSS-II) was carried out from 1996–1998, with the participation of 703 firms in 23 different countries. The third iteration (IMSS-III) was carried out from 2000–2002, with the participation of 585 firms in 17 different countries.

The fourth iteration (IMSS-IV) was published in 2005. IMSS-IV was designed to involve researchers from around the world, including Western and Eastern Europe, the Americas, and various regions of Asia and Africa. The primary method of gathering data is by questionnaire, and surveys in this iteration focus upon ISIC 28–35: ISIC

28 – manufacturing of fabricated metal products (271 responses); 29 – machinery and equipment (147); 30 – office, accounting and computing machinery (16); 31 – electrical machinery and apparatus (92); 32 – radio, television and communication equipment and apparatus (39); 33 – medical, precision and optical instruments, watcher and clocks (29); 34 – motor vehicles, trailers and semi-trailers (68); 35 – other transport equipment (41). The total responses number 711 firms from 23 different countries. In 2006, Taiwan joined IMSS and provided 50 samples. Of all of the samples in IMSS, a total of 761 firms were analyzed in this study.

We eliminated 270 firms from the test samples, whose responses were not complete. Only 491 of the 761 (65%) total responses are included in the analysis in this paper. The global test sample distribution is as follows: America – 102 samples (20.77%), Asia – 105 samples (21.38%), Oceania – 24 samples (4.9%), Eastern Europe – 62 samples (12.63%), and Western Europe – 198 samples (40.33%).

3.2 Operationalization variables and independent construct measurement

This study aims to investigate and analyze different scopes of the diffusion of e-commerce in a supply-chain operational environment, and explore which scope of e-commerce diffusion is applied to supply-chain coordination in order to align with majority competitive performance. The operationalization variables in this study involve different scopes of the diffusion of e-commerce, and performance.

In this study, we try to define different scopes of the diffusion of e-commerce through the e-commerce adoption level in supply-chain operational environments. IMSS provides eight kinds of e-commerce items to investigate in regard to the adoption level of e-commerce by the supplier and customer, including: (1)

scouting/pre-qualification, (2) auctions, (3) RFx (request for quotation, proposal, information), (4) data analysis (audit and reporting), (5) access to catalogues, (6) order management and tracking, (7) content and knowledge management, and (8) collaboration support services. To ensure that test variables meet the research requirements, we further analyze the validity of their content and construct. Content validity represents the sufficiency with which a specific domain of content was sampled [18]. To test content validity we used the independent sample *t-test*, and the test results indicated significance for eight variables in the supplier and customer. All test results are shown in Table 1.

A construct validity test was applied to check the internal consistency of the variable. All variables of e-commerce were combined and developed for each construct of the scope of e-commerce diffusion, therefore we adopted construct validity to ensure that different variables of e-commerce could be combined. To verify the results of the construct validity we used factor analysis. The test results indicated that Kaiser-Mayer-Olkin (KMO) measures of performance adequacy were 0.858 (supplier) and 0.881 (customer). Bartlett's test of sphericity was significant for e-commerce in the supplier and customer. Factor loading for e-commerce in the supplier and customer exceeded 0.40, and the results of Cronbach's α in both factors exceeded 0.7. The results are shown in Table 1.

Table 1: Validity of content and construct in e-commerce

Supplier				E-commerce items	Customer			
Mean	**S.D.**	**Sig.**	Loading		Loading	**Mean**	**S.D.**	**Sig.**
2.59	1.17	0.000**	0.825	Scouting/ pre-qualify	0.711	2.40	1.23	0.000**
1.73	0.95	0.000**	0.616	Auctions	0.836	1.82	1.04	0.000**
3.03	1.27	0.000**	0.673	RFx (request for quotation, proposal, information)	0.660	3.00	1.26	0.000**
2.68	1.14	0.000**	0.571	Data analysis (audit and reporting)	0.648	2.66	1.21	0.000**
3.10	1.14	0.000**	0.421	Access to catalogues	0.520	2.82	1.28	0.000**
3.04	1.18	0.000**	0.789	Order management and tracking	0.824	2.99	1.35	0.000**
2.64	1.08	0.000**	0.847	Content and knowledge management	0.841	2.57	1.19	0.000**
2.57	1.08	0.000**	0.820	Collaboration support services	0.835	2.67	1.23	0.000**
			0.831	Cronbanch's α	0.857			
			4.721	Eigenvalue	5.109			
			59.012	Percent of variation	63.861			

** Significant at the p<0.01 level
* Significant at the p<0.05 level

Following the test results of content and construct validity, we further developed different scopes of e-commerce diffusion in a supply-chain operational environment through eight levels of e-commerce adoption. Using factor scores for the level of supplier and customer adoption of e-commerce, we classified each sample into either the upper, middle, or lower quartiles, as seen in the following figure. The results of the classification show different scopes of the diffusion of e-commerce in a supply-chain operational environment.

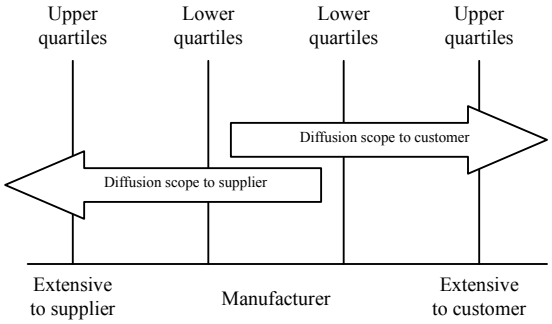


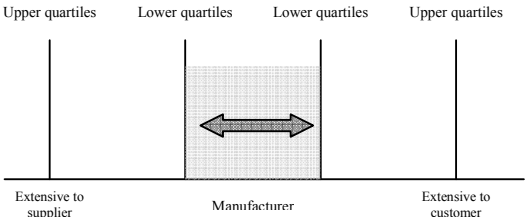
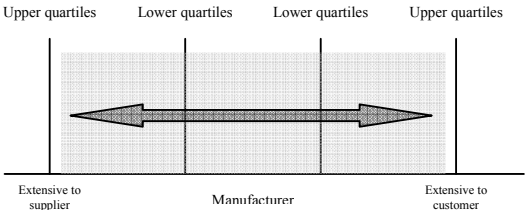
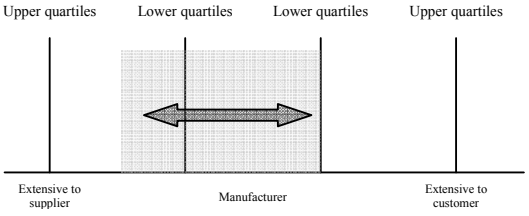
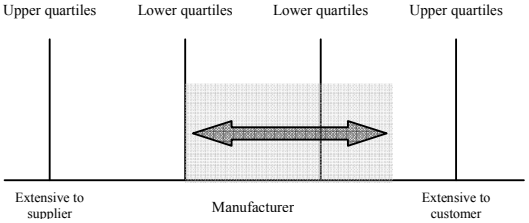
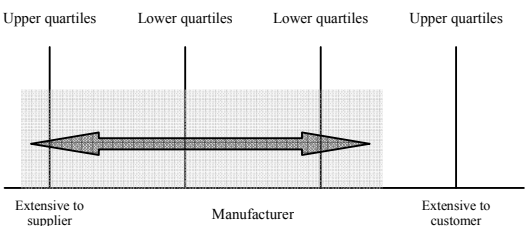
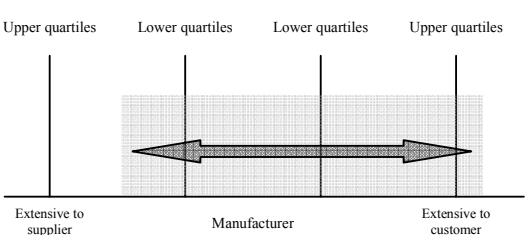
Fig. 1. Classification standard of e-commerce diffusion scope

The quartiles were then used to sort the 491 samples into six different diffusion scopes of e-commerce. First, respondents that were in the bottom quartiles for both suppliers and customers were named "Inward-facing". Second, respondents whose suppliers and customers were above the lower quartiles, with a trend towards the upper quartiles, were named "Outward-facing".

Third, respondents that reported suppliers above the lower quartiles and below the upper quartiles, and customers in the bottom quartiles, were named “Gathered to supplier-facing”. Fourth, respondents that reported customers above the lower quartiles and below the upper quartiles, with suppliers in the bottom quartiles, were named “Gathered to customer-facing”.

Fifth, respondents that reported suppliers in the upper quartiles with customers above the lower quartiles and below the upper quartiles, were named “Complete to supplier-facing”. Sixth, respondents that reported customers in the upper quartiles and suppliers above the lower quartiles and below the upper quartiles were named “Complete to customer-facing”. These groups are shown in Table 2.

Table 2: Operationalized variables for the six scopes of e-commerce diffusion

Scope of e-commerce diffusion	Definition of diffusion scope
	Inward-facing: Samples were classified in the lower quartiles for both suppliers and customers
	Outward-facing: Samples were classified above the lower quartiles for suppliers and customers, with a trend towards the upper quartiles for suppliers and customers
	Gathered to supplier-facing: Samples were classified above the lower quartiles but below the middle quartiles for suppliers, and in the lower quartiles for customers
	Gathered to customer-facing: Samples were classified above the lower quartiles but below the upper quartiles for customers, and in the lower quartiles for suppliers
	Complete to supplier-facing: Samples were classified in the upper quartiles for suppliers and below the upper quartiles for customers
	Complete to customer-facing: Samples were classified in the upper quartiles for customers and below the upper quartiles for suppliers

Furthermore, we will further classify sample groups into six scopes of e-commerce diffusion. Except for the factor score distribution to simply classify sample groups into different scopes of e-commerce diffusion, we also adopted

K-means cluster analysis to classify sample groups into different scope of e-commerce diffusion. However, we found that the classified results differ between factor score and K-means in this study, for judge best result of sample classified; therefore we will advance to analysis.

We will analyze the results of the factor score and K-means using discriminant analysis, which was used to judge suitable samples classified results. In the factor score results, the distribution indicated that 59 samples are inward-facing, 318 samples are outward-facing, 47 samples are gathered to supplier-facing, 29 samples are gathered to customer-facing, 11 samples are complete to supplier-facing, and 27 samples are complete to customer-facing. For the K-means, the results indicated that 78 samples are inward-facing, 232 samples are outward-facing, 61 samples are gathered to supplier-facing, 39 samples are gathered to customer-facing, 34 samples are complete to supplier-facing, and 47 samples are complete to customer-facing.

To ensure the results of the classification, this study uses discriminant analysis as a check. As seen in Table 3, discriminant analysis of factor scores confirmed the results as inward-facing (100%), outward-facing (66.7%), gathered to supplier-facing (89.4%), gathered to customer-facing (89.7%), complete supplier-facing (100%), and complete customer-facing (100%). After correcting, we further tested these classified results. The results of discriminant analysis in K-means indicated that the classified results of inward-facing (72.7%), outward-facing (74.3%), gathered to supplier-facing (69.6%), gathered to customer-facing (68.7%), complete supplier-facing (81.3%), and complete customer-facing (82.4%). Comparing results of discriminant analysis in factor score and K-means, we can ensure the results of factor score classification are more correct than K-means. Based on the above results, we will select the samples

classifying results of the factor scores to test in the next section.

Table 3: Results of discriminant analysis

	Cases	Inward-facing	Outward-facing	Gathered to supplier-facing	Gathered to customer-facing	Complete supplier-facing	Complete customer-facing
Inward-facing	59	59 (100%)	0	0	0	0	0
Outward-facing	318	6 (1.9%)	212 (66.7%)	19 (6%)	24 (7.5%)	30 (9.4%)	27 (8.5%)
Gathered to supplier-facing	47	5 (10.6%)	0	42 (89.4%)	0	0	0
Gathered to customer-facing	29	3 (10.3%)	0	0	26 (89.7%)	0	0
Complete supplier-facing	11	0	0	0	0	11 (100%)	0
Complete customer-facing	27	0	0	0	0	0	27 (100%)

76.8% of original grouped cases correctly classified
76.8% of cross validated grouped cases correctly classified

In addition to testing and identifying different scopes of e-commerce diffusion through observation of the practical adoption of e-commerce, a goal of this study was to explore which type of diffusion scope of e-commerce will drive the coordination results to align with the majority competitive performance, therefore the operationalization variables include competitive performance.

IMSS provides 20 performance indices, including 7 cost performances, 4 quality performances, 5 delivery performances, and 4 flexibility performances. Cost performance includes unit manufacturing cost, procurement lead time, procurement costs, labour productivity, inventory turnover, capacity utilization, and overhead costs. Quality performance includes manufacturing conformance, product quality and reliability, employee satisfaction, and environmental performance. Delivery performance includes time to market, product innovativeness, customer service and support, delivery speed, and delivery dependability. Flexibility performance includes product customization ability, volume flexibility, mix flexibility, and manufacturing lead time. To ensure that the sample of the 491 firms meets the study requirements, we further analyze the validity of their content. Also, we test the classified results for 20 competitive performances by construct validity test results.

We used the *t-test* to test content validity, and the test results indicated that all of the test variables are significant. In addition to content validity, we also measured construct validity through factor analysis, testing the content consistency of performance. In terms of the performance, four classified results of performance were tested: cost, quality, delivery, and flexibility. The test results indicated that Kaiser-Mayer-Olkin (KMO) measures of performance adequacy were 0.874 (cost), 0.730 (quality), 0.765 (delivery), and 0.713 (flexibility). Bartlett's test of sphericity was significant for the four requirements of the market and customers. Factor loading for all four requirements exceeded 0.60, and the results of Cronbach's α for all four factors exceeded 0.7. The results are shown in Table 4.

Table 4: Content validity, construct validity, and reliability in performance

Competitive performances	Cost	Quality	Delivery	Flexibility	Mean	S.D.	Sig.
Procurement lead time	0.761				2.61	0.82	0.000**
Labour productivity	0.742				2.92	0.80	0.000**
Unit manufacturing cost	0.717				2.73	0.82	0.000**
Inventory turnover	0.685				2.71	0.80	0.000**
Procurement costs	0.675				2.60	0.83	0.000**
Overhead costs	0.652				2.53	0.81	0.000**
Capacity utilization	0.631				2.82	0.90	0.000**
Product quality and reliability		0.790			3.07	0.84	0.000**
Manufacturing conformance		0.767			2.98	0.83	0.000**
Employee satisfaction		0.758			2.56	0.84	0.000**
Environmental performance		0.730			2.75	0.81	0.000**
Delivery speed			0.818		3.03	0.92	0.000**
Delivery dependability			0.767		3.03	0.91	0.000**
Time to market			0.742		2.85	0.86	0.000**
Customer service and support			0.721		2.95	0.87	0.000**
Product innovativeness			0.636		2.85	0.87	0.000**
Mix flexibility				0.808	2.99	0.88	0.000**
Volume flexibility				0.800	3.15	0.88	0.000**
Product customization ability				0.711	2.91	0.84	0.000**
Manufacturing lead time				0.608	2.82	0.85	0.000**
Cronbanch's α	0.821	0.759	0.791	0.715			
Eigenvalue	3.395	2.320	2.732	2.170			
Percent of variation	48.498	58.004	54.635	54.240			

** Significant at the p<0.01 level

* Significant at the p<0.05 level

4. Results and discussion

4.1 Test results

The six different scopes of e-commerce diffusion were evaluated using

regression analyses to test for significant correlation with 20 competitive performances. The test results indicated that the diffusion scope of inward-facing is applied to improve supply-chain coordination and integration; it can drive coordination results to align significantly and achieve manufacturing conformance with quality performance ($F = 6.014$, $p < 0.05$). The diffusion scope of outward-facing can connect with majority competitive performance when it is applied to improve supply-chain coordination. These performances include unit manufacturing cost ($F = 8.918$, $p < 0.01$), procurement lead time ($F = 5.304$, $p < 0.05$), procurement costs ($F = 14.441$, $p < 0.01$), labor productivity ($F = 4.470$, $p < 0.05$), and overhead costs ($F = 3.872$, $p < 0.05$) in cost performance; manufacturing conformance ($F = 7.799$, $p < 0.01$), product quality and reliability ($F = 10.327$, $p < 0.01$), employee satisfaction ($F = 5.029$, $p < 0.05$), and environmental performance ($F = 6.639$, $p < 0.05$) in quality performance; customer service and support ($F = 4.292$, $p < 0.05$), and delivery speed ($F = 6.812$, $p < 0.01$) in delivery performance; product customization ability ($F = 6.286$, $p < 0.05$), mix flexibility ($F = 6.914$, $p < 0.01$), and manufacturing lead time ($F = 6.873$, $p < 0.01$) in flexibility performance. Test results of inward-facing and outward-facing are shown in Table 5a.

Table 5a: Coefficient for inward-facing, outward-facing, and performance

	Inward-facing			Outward-facing		
	β	t-value	R^2	β	t-value	R^2
Cost performance						
Unit manufacturing cost	-.018	-0.135	0.000	.166	2.986**	0.027
Procurement lead time	-.057	-0.430	0.003	.128	2.303*	0.017
Procurement costs	-.050	-0.381	0.003	.209	3.800**	0.044
Labour productivity	-.014	-0.108	0.000	.118	2.114*	0.014
Inventory turnover	.055	0.414	0.003	.013	0.229	0.000
Capacity utilization	-.065	-0.494	0.004	.107	1.908	0.011
Overhead costs	.048	0.364	0.002	.110	1.968*	0.012
Quality performance						
Manufacturing conformance	-.325	-2.593*	0.106	.155	2.793**	0.024
Product quality and reliability	-.044	-0.330	0.002	.178	3.214**	0.032
Employee satisfaction	-.005	-0.039	0.000	.125	2.243*	0.016
Environmental performance	.102	0.775	0.010	.143	2.577*	0.021
Delivery performance						
Time to market	-.052	-0.396	0.003	.098	1.757	0.010
Product innovativeness	.106	0.806	0.011	.064	1.137	0.004
Customer service and support	-.197	-1.518	0.039	.116	2.072*	0.013
Delivery speed	-.100	-0.756	0.010	.145	2.610**	0.021
Delivery dependability	-.088	-0.667	0.008	.068	1.203	0.005
Flexibility performance						
Product customization ability	-.002	-0.015	0.000	.140	2.507*	0.020
Volume flexibility	-.101	-0.770	0.010	.085	1.524	0.007
Mix flexibility	.069	0.520	0.005	.146	2.630**	0.021
Manufacturing lead time	-.102	-0.774	0.010	.146	2.622**	0.021

** Coefficient is significant at the 0.01 level (2-tailed).
* Coefficient is significant at the 0.05 level (2-tailed).

The diffusion scope of gathered to supplier-facing cannot improve the coordination of the supply-chain. When the diffusion scope of gathered to customer-facing is adopted to improve supply-chain coordination, product innovativeness ($F = 6.190$, $p < 0.05$) can be aligned and achieved. Test results of gathered to supplier-facing and gathered to customer-facing are shown in Table 5b.

Table 5b: Coefficient for gathered supplier-facing, gathered customer-facing, and performance

	Gathered to supplier-facing			Gathered to customer-facing		
	β	t-value	R^2	β	t-value	R^2
Cost performance						
Unit manufacturing cost	-.100	-0.673	0.010	.432	2.488*	0.187
Procurement lead time	.065	0.435	0.004	-.115	-0.600	0.013
Procurement costs	-.075	-0.503	0.006	.198	1.049	0.039
Labour productivity	-.007	-0.047	0.000	.063	0.327	0.004
Inventory turnover	.065	0.439	0.004	.177	0.932	0.031
Capacity utilization	-.056	-0.376	0.003	-.036	-0.187	0.001
Overhead costs	-.145	-0.981	0.021	.137	0.719	0.019
Quality performance						
Manufacturing conformance	-.122	-0.828	0.015	-.151	-0.792	0.023
Product quality and reliability	-.009	-0.062	0.000	-.070	-0.367	0.005
Employee satisfaction	-.052	-0.351	0.003	.243	1.303	0.059
Environmental performance	-.184	-1.252	0.034	.129	0.675	0.017
Delivery performance						
Time to market	.203	1.392	0.041	.172	0.910	0.030
Product innovativeness	.168	1.145	0.028	.431	2.483*	0.186
Customer service and support	.024	0.163	0.001	.166	0.872	0.027
Delivery speed	-.120	-0.808	0.014	.184	0.970	0.034
Delivery dependability	-.016	-0.110	0.000	.140	0.734	0.020
Flexibility performance						
Product customization ability	.096	0.649	0.009	.075	0.391	0.006
Volume flexibility	.009	0.060	0.000	.024	0.125	0.001
Mix flexibility	.047	0.313	0.002	.255	1.370	0.065
Manufacturing lead time	-.090	-0.605	0.008	.246	1.321	0.061

** Coefficient is significant at the 0.01 level (2-tailed).
* Coefficient is significant at the 0.05 level (2-tailed).

With the diffusion scope of complete to supplier-facing, procurement costs ($F = 5.331$, $p < 0.05$), inventory turnover ($F = 31.041$, $p < 0.05$), capacity utilization ($F = 7.792$, $p < 0.01$), overhead costs ($F = 4.848$, $p<0.05$) of cost performance, manufacturing conformance ($F = 4.895$, $p < 0.05$), and product quality and reliability ($F = 8.714$, $p < 0.05$) of quality performance can be aligned and achieved when the diffusion scope of complete supplier-facing is applied to improve supply-chain coordination. When the diffusion scope of complete customer-facing is adopted to improve supply-chain coordination, time to market ($F = 5.480$, $p < 0.05$), customer service and support ($F = 4.647$, $p < 0.05$), delivery speed ($F = 3.992$, $p < 0.05$) of delivery performance, and product customization ability ($F = 4.417$, $p < 0.05$), manufacturing lead time ($F = 4.371$, $p < 0.05$) of flexibility performance can be aligned and achieved. Test results of complete to supplier-facing and complete to customer-facing are shown in Table 5c.

Table 5c: Coefficient for complete to supplier-facing, complete to customer-facing, and performance

	Complete to supplier-facing			**Complete to customer-facing**		
	β	t-value	R^2	β	t-value	R^2
Cost performance						
Unit manufacturing cost	-.032	-0.095	0.001	.028	0.138	0.001
Procurement lead time	.088	0.265	0.008	.294	1.538	0.086
Procurement costs	.592	2.202*	0.350	.244	1.258	0.060
Labour productivity	-.014	-0.108	0.000	.203	1.034	0.041
Inventory turnover	.681	2.791*	0.464	.187	0.952	0.035
Capacity utilization	.880	5.571**	0.775	.192	0.978	0.037
Overhead costs	.610	2.309*	0.375	.176	0.894	0.031
Quality performance						
Manufacturing conformance	.594	2.212*	0.352	.211	1.078	0.044
Product quality and reliability	.701	2.953*	0.492	.219	1.123	0.048
Employee satisfaction	-.037	-0.111	0.001	.158	0.799	0.025
Environmental performance	.137	0.415	0.019	-.002	-0.009	0.000
Delivery performance						
Time to market	.259	0.805	0.067	.424	2.341*	0.180
Product innovativeness	-.497	-1.717	0.247	.256	1.323	0.065
Customer service and support	.045	0.134	0.002	.396	2.156*	0.157
Delivery speed	.041	0.124	0.002	.371	1.998*	0.138
Delivery dependability	.229	0.705	0.052	.053	0.265	0.003
Flexibility performance						
Product customization ability	-.157	-0.477	0.025	.387	2.102*	0.150
Volume flexibility	-.347	-1.111	0.121	.176	0.894	0.031
Mix flexibility	-.140	-0.425	0.020	.020	0.101	0.000
Manufacturing lead time	-.142	-0.429	0.020	.386	2.091*	0.149

** Coefficient is significant at the 0.01 level (2-tailed).
* Coefficient is significant at the 0.05 level (2-tailed).

4.2 Findings and discussion

Firstly, the hypothesis test results indicate that outward-facing can drive the coordination and integration results of the supply-chain in order to align with majority competitive performance. As outlined in the definition in Table 2, the diffusion scope of outward-facing is extended to the upstream supplier and downstream customer. In the regression analysis test results, we found outward-facing most effectively drives competitive performance compared to the other five diffusion scopes of e-commerce. Our test results indicate that our hypothesis – "As the diffusion scope of e-commerce extends to upstream suppliers and downstream customers, coordination results can be efficiently improved in order to align with majority performance" – cannot be rejected.

Independent firms at various stages in the supply chain need to share related information in order to improve coordination with other partner firms, therefore firms must establish an information flow and sharing mechanism. Based on the related literature, we know that e-commerce can efficiently improve supply-chain information sharing and integration, and lead to improved coordination results. However, a high level of e-commerce diffusion must be maintained. This means that firms at various stages should all adopt and develop e-commerce mechanisms in order for partner firms to all use e-commerce to share and integrate related information in the supply-chain operational environment.

If firms at various stages adopt e-commerce at a low level, this will shorten the scope of e-commerce diffusion, making it difficult for firms to share related information with other partner firms. The diffusion scope of e-commerce should be completely extended to all suppliers and customers in the supply-chain operational

environment if firms wish their coordination results to align with and satisfy majority competitive performance.

Second, some diffusion scopes of e-commerce do not completely cover both upstream suppliers and downstream customers. However, when the scope of e-commerce diffusion complete covers at least one direction, the coordination results can still align with more specific competitive performance. For example, the diffusion scope of complete supplier-facing can lead the coordination and integration results of the supply chain to align more with cost and quality competitive performance; otherwise, the diffusion scope of complete customer-facing can lead the coordination and integration results to align more with delivery and flexibility competitive performance.

If the diffusion scope of e-commerce has not been complete extended, when the diffusion scope completely extends in at least one direction (supplier or customer), the supplier or customer coordination result can still be successfully improved, and the coordination results can satisfy some specific area of competitive performance. However, the above results also indicate that different coordination and integration directions will influence a specific area of competitive performance. Therefore, when firms consider achieving in a specific area of competitive performance, firms can consider the above results in order to select an appropriate diffusion scope of e-commerce and improve their supply-chain coordination and integration.

Third, e-commerce diffusion scopes that are shorter have difficulty in improving supply-chain coordination results and align with majority competitive performance. In fact, short diffusion scopes may possibly result in information integration being limited in the supply-chain operational environment. When the information

integration scope is limited, it also leads to difficulties in partner firms' efforts to coordinate and integrate with other partner firms. As [5] indicated, lack of coordination and integration between partner firms will cause a "bullwhip effect". If the bullwhip effect still exists in the supply chain, although consumption of the end product may be stable, orders for raw materials will be highly variable, increasing costs and making it difficult for supply to match demand, influencing the whole of competitive performance.

In this study we found that inward-facing, gathered to supplier-facing, and gathered to customer-facing diffusion scopes will drive shortened information integration scopes. These three diffusion scopes of e-commerce will make it difficult to improve supply-chain coordination and integration results in order to align with majority competitive performance.

5. Conclusion

This study investigated and analyzed different scopes of the diffusion of e-commerce in a supply-chain operational environment, and explored which type of e-commerce diffusion scope will drive supply-chain coordination and integration resulting in majority competitive performance. The study is based on samples from the International Manufacturing Strategy Survey (IMSS) database, explored through empirical tests.

E-commerce is applied in a supply-chain operational environment in order to integrate internal information for the improvement of supply-chain coordination as an approved strategy. However, many researchers and practitioners remain unsure about how to characterize the best e-commerce diffusion scope in the supply-chain

operational environment; should it be diffused to supplier, customer, both, or others? We at least know that the e-commerce practice scope should be diffused to extend to the upstream supplier and downstream customer. However, existing studies still lack related evidence and tests. This study aimed to test and explore the above, and as a result we propose some solutions to the above problems.

The test results showed that the diffusion scope of outward-facing extends to suppliers and customers, and when firms adopt this diffusion scope of e-commerce in order to improve supply-chain coordination, it can drive supply-chain coordination and integration results and align with majority competitive performance. The test results provide evidence that when the diffusion scope of e-commerce is balanced and extended to upstream suppliers and downstream customers, this can lead to the best coordinated result and align with majority competitive performance.

In addition, this study defined another five scopes of e-commerce diffusion. When different e-commerce diffusion scopes are applied in order to improve supply-chain coordination, the coordination results will align with different competitive performance. From these different alignment results, we observed the different diffusion scope adopted that will lead to competitive performance.

The above findings have some important implications for theory and managerial practice. In terms of theory, although we characterized outward-facing as the best e-commerce diffusion scope in a supply-chain operational environment, the other five e-commerce diffusion scopes (gathered inward-facing, supplier-facing, gathered customer-facing, complete supplier-facing, complete customer-facing) will lead to coordination result that can align with performance. When these e-commerce diffusion scopes are applied to improve supply-chain coordination, the coordination

results are difficult to align with the majority. Therefore, when related research explores the alignment relationship between supply-chain coordination and e-commerce, perhaps the five types of e-commerce diffusion scope should be considered, and how they will influence the test results.

This study also has several important implications for managers. The test results indicated that the outward-facing e-commerce diffusion scope can drive supply-chain coordination results in order to align with majority performance. Based on the above results, firms understand that e-commerce should be complete diffused in a supply-chain operational environment. The diffusion scope of e-commerce should not be limited in scope or direction, because a short diffusion scope will influence information integration and lead to poor coordination results. Although a specific diffusion scope such as complete supplier-facing or complete customer-facing can drive coordination results to align with more specific competitive performance, a non-balanced diffusion scope in e-commerce will make it difficult to align with majority competitive performance. Therefore, when firms try to diffuse e-commerce in order to ensure that supply-chain coordination is successful improved, they should consider the above test results.

As our results indicate, some issues should be further explored in future research. First, this study aimed to consider different diffusion scopes of e-commerce, and further explore which type of diffusion scope of e-commerce can drive supply-chain coordination results to align with competitive performance. This study also explored the different diffusion scopes of e-commerce that will drive supply-chain coordination to align with performance. Although this study showed that e-commerce scope should be diffused to extend to the upstream supplier and downstream customer, if

manufacturers want to improve supply-chain coordination and integration through e-commerce, why are more manufacturers trying to develop other diffusion scopes in the real world? Is information technology ability barrier? Or is others barrier? Future research may explore this question deeply.

Secondly, as shown in Table 5, we found that different e-commerce diffusion scopes can be applied to improve supply-chain coordination, which will lead to different results and levels of competitive performance. Through the observation of different alignment results, although the outward-facing diffusion scope can lead to supply-chain coordination results that satisfy the majority of competitive performance, there are still elements of competitive performance that cannot be achieved through the outward-facing type. Perhaps future research can explore why.

Third, as the test results show, we found that the majority of cost and quality performances can be aligned through the complete supplier-facing diffusion scope being applied to supply-chain coordination, which also means that when information integration is limited in terms of the coordination of suppliers and manufacturers, the coordination results of suppliers and manufacturers will influence cost and quality performance. We also found that the majority of delivery and flexibility performances can be aligned through the complete customer-facing diffusion scope being applied to supply-chain coordination, which also means that when information integration is limited in terms of the coordination of customers and manufacturers, the coordination result of suppliers and manufacturers will influence delivery and flexibility performances. But what about when information integration between suppliers and manufacturers cannot satisfy delivery and flexibility performance? What about when information integration between customer and manufacturers cannot satisfy cost and

quality performance? And why? Perhaps future research can also explore these questions.

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