EXPLORING THE EFFECTS OF ADVANCED MANUFACTURING TECHNOLOGY AND E-COMMERCE IN THE ALIGNMENT OF SUPPLY CHAIN COORDINATION AND COMPETITIVENESS PERFORMANCE

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ABSTRACT

The objective of this study is to empirically identify various alignments strategies through various adoption levels between advanced manufacturing technology (AMT) applications and e-commerce settings in supply chain context, and then test what alignment strategies that will have significant influence on supply-chain coordination outcomes. Based on the test result, we can justify the optimal alignment strategy for the improvement of coordination activities. Using the data from the International Manufacturing Strategy Survey (IMSS) database, we analyzed 497 samples and classified seven types of alignment strategies by different adoption level of AMT and e-commerce. The test results indicated that alignment of broad adoption level of AMT and the equivalent broad adoption level of e-commerce can certainly influence the coordination efforts among partner firms and make improvement in supply chain efficiency. We also found that, e-commerce plays a more important key role in the alignment process.

***Keywords*:** Supply chain coordination, advanced manufacturing technology (AMT), e-commerce, strategy alignment

1. INTRODUCTION

In the domain of manufacturing, supply chain management (SCM) is a contemporary and [1]critical tool for a firm's competitiveness and performance. Through close integration efforts between partner firms of upstream and downstream in the areas such as production, delivery, purchasing, inventory management, and sales, SCM empowers a company to enhance its own competitive capability.

However, partner firms as the owner of various operations stages in a supply chain may have conflicting goals, and this conflict may adversely undermine the integration of operations. Therefore, if all firms in the supply chain determine to cooperate in the pursuit of global optimization, the efforts for coordination must be made [3].

Supply chain coordination refers to the ability of a firm to coordinate transactional activities with supply chain partners in each related internal action [4]. This also means that partner firms in the supply chain must communicate one another in the events pertaining to the operational activities what take place in the supply chain. Doing so leads to better synchronization of pertinent internal operations and decision making, therefore, enhances the firm's ability to satisfy market requirements, win customer satisfaction, and further gain competitive advantage. Ghiassi [7] argued that the synchronization of

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supply chain internal activities can achieve the benefit of time-to-market, quick response, and better communication and flexibility/reliability in component supply.

Business practices underpin the presumption that better coordination among supply chain partners results in greater customer satisfaction in the market. For example, Hewlett-Packard and Dell Computers gain ground owing to their dexterous manipulation of supply chain coordination and mass customization. To achieve the better performance, a firm must make every effort to improve the efficiency and effectiveness of coordination tasks within their supply chain.

In order to obtain better supply chain coordination results, in the recent years researchers argued that the adopting advanced manufacturing technology (AMT) can make coordination improvement between partner firms in the supply chain [5] [9] [13] [20]. AMT encompasses mainly technologies related to computer-aided-manufacturing (CAM) and computer integrated manufacturing (CIM) systems, which depend upon information flow along communication lines within a computer local area network (LAN). LAN connects the production equipment and other facilities in the manufacturing site. The actions taken by manufacturers to apply some components of AMT enables operational departments to readily coordinate each other thanks to the connectivity furnished by LAN, and further build an optimal internal operations mode in terms of cost, quality and delivery. Therefore, in the earlier period, AMT applications did influence and drive the coordination and integration on the operational level in the manufacturing context. In the era of e-business bolstered by the Internet, literature in research indicated that AMT also benefits the coordination among supply chain partners' internal operations given AMT facilities have been installed at their site.

E-business is defined as "…not just the buying and selling of goods but also servicing customers (B2C model), collaborating with business partners (B2B model), and conducting electronic transactions within an organization" [25]. To successfully coordinate each partner's internal operations, information technology plays a critical role to direct the information flow in-between to augment the scope of cooperation. However, in the supply chain environment partners are legitimately independent entities, without the common communication protocol they can get connected with intranet or LAN in each partner's site to share information and data. In recent years, many firms have introduced e-commerce settings for connectivity and accomplishment has been so encouraging that more and more firms decided to follow the suit. They trusted that firms adopting e-commerce setting to work with AMT in congruence enables better coordination associated with internal operations [20] [21].

However, an empirical study [21] demonstrated that firms always consider their incumbent resources to decide the scale and scope of AMT and e-commerce set-up, and this act of differentiated investment incurs different level of influence upon coordination outcomes. Based on the above discussion, the objective of this empirical study is to identify various alignments strategies encompassing the combination of different adoption levels of AMT and adoption levels of e-commerce, and then test whether these alignments strategies exert different extent of influence upon supply chain coordination outcomes. By the test result we can deduce which alignments strategy can significantly improve the coordination of related internal operations among supply chain partner firms. This study is based on large samples from the International Manufacturing Strategy Survey (IMSS) database, a global research network initiated by London Business School.

The remaining part of this paper is structured as follows. Section 2 is the literature review and the hypothesis. In section 3 we describe the methodology. Section 4 is the empirical test results and discussion. Finally, we draw our conclusion and indicate directions for further research.

2. LITERATURE AND HYPOTHESIS

2.1 Supply chain coordination and AMT

Globalization aggravate competition beyond the boundary of domestics market, firms continuously exploit supply chain management to build capabilities to cope with the volatile market situation and tough competition. However, the formation of a supply chain is out of different legitimately independent firms, company aiming to enhance competitive capability by driving the cooperation of partners must focus on the resolution how to improve coordination efforts in the internal operations of partners firms [3]. In fact, the coordination means the mutual communication for internal transaction-related activities within supply chain operational environment [4]. These related transaction-related activities between partner firms in-

clude buyer-vendor, production-distribution, and inventory management [1] [15] [22]. Therefore, the successful coordination of activities determines the effective and efficient supply chain collaboration [11].

To improve coordination outcomes in terms of partner firms' input, researchers and practitioners tried very hard to develop the concept, technologies, tools and whatever can make progress. Recently, researchers have identified that the adoption of advanced manufacturing technology (AMT) can effectively lead to the cohesion of partner firms and support better coordination for internal transaction-related activities in the supply chain operational environment. Sun [24] regarded ATM as the computer-aided technologies used in a firm where manufacturing is the major activities, where information flow along communication network embedded in firms' information technology infrastructure connects the activities in different department, production process, or parts material flow. Chase [2] and Sun [24] indicated that, the different sorts of AMT applications will construct different internal operations context. Therefore, different AMT applications spectrum will render different pattern of involving compatible internal operations. For example, when firms adopt ERP, internal department, process, or parts will coordinate and improve related production operations; when CAD/CAE/CAPP are adopted, product design operations will be coordinated and improved; when NC/CNC or FMS are adopted, the fabrication/assembly operations will be coordinate and improved [24].

Based on the finding of influence of AMT upon internal operations coordination, most researchers [6] [9] [19] [28] also found the AMT applications in the supply chain operational environment will further promote the level of coordination. [9] took flexible manufacturing system (FMS) as the example to describe how the flexibility and responsiveness can be developed and influence the relationship between manufacturers and downstream firms, and further lead to a more harmonized coordination results. Literature in research presented much more varieties AMT adoption patterns in supply chain operational environment, they also evidenced that the adoption of AMT in one company may encourage others to install AMT facilities. A good example is the application of RFID. Porter. [19] and Zhang [28] stated that the introduction of RFID can influence incurs closer coordination and integration of product flow between supply chain partner firms to ensure the performance of inventory management in the supply chain context. On the other hand, Dyer [6] indicated that computer numerically controlled (CNC) machine tools and CAD/CAM systems can influence collaborative manufacturing relationships between the supplier and manufacturer, or the buyer and manufacturer, and further achieve the related performance such as delivery and flexibility.

2.2 Alignment between AMT and e-commerce for coordination improvement

Although AMT applications coheres partner firms together to influence and effectively coordinate the related internal operations, however, the contribution of AMT in the influence on coordination between partner firms can be extended via the intervention of information technology. In the beginning, AMT can influence manufacturing process and lead to better coordination results in the areas of information flow within a computer local area network (LAN) or Intranet to connect the production equipments and other facilities in the manufacturing site. However, to make progress in coordination, AMT applications must work closely with the latest network infrastructure and new technology within partner firms' plant.

For the past decade, e-commerce plays setting an important role for information flow and further leads to effective coordination between partner firms. E-commerce originated from conventional electronic data interchange (EDI), and was then supported by the modern Internet or World Wide Web to develop Business-to-Business (B2B) or Business-to-Customer (B2C) connectivity. Using the B2B model of e-commerce, firms within a supply chain can share information with each other using the Internet or dedicated electronic communication lines. Therefore, the e-commerce approach is supposed to be a powerful means to improve supply-chain coordination. Many researchers [7] [8] [10] [12] [14] [16] [17] [18] [23] [26] [27] found that most firms adopt e-commerce technology to connect partner firms for improved information flow between partner firms in the supply chain operational environment. Research works such as [5] [20] [21] also found by empirical test that, in the real world, when firms adopt AMT to guide partner firms for coordination in the supply chain operational environment, firms usually align e-commerce activities with AMT applications. They also found that the synergy is available when firms adopt e-commerce in congruence with AMT.

2.3 Effect of different alignment between AMT and e-commerce for improved coordination

Based on above discussion, we understand that aligning e-commerce with AMT enables improved coordination outcomes for partner firms in a supply chain. However, considering the constraint of incumbent resources, firms in the real world always employ different adoption level of AMT application and e-commerce setting [20] [21]. They are: narrow, middle, and broad level of adoption (Figure 1). Narrow adoption level implies that the deployment of AMT and e-commerce applications is still unable to influence the coordination of partner firms upstream and downstream; broad level of AMT and e-commerce adoption is just the antipodes, means that the deployment of AMT and e-commerce applications to be able to influence completely the coordination of partner firms upstream and downstream; Middle adoption level means the deployment of AMT and e-commerce applications is able to influence but in-complete for the coordination of partner firms upstream and downstream. In fact, different alignment strategies of using different adoption level for AMT and e-commerce in each partner firms in the supply chain will bring out quite different extent of contribution in coordination outcomes.

There also exists a possibility that in case supply chain partners employ incompatible adoption level for AMT and e-commerce, the global optimization could be jeopardized. Since coordination involves all of partner firms, if a company makes determination to influence and drive all partner firms to attain coordination by AMT, then adoption level of AMT must be broad throughout the supply chain operational environment. By the same token, to take advantage of synergy the adoption level of AMT should be in congruence with that of e-business setting to complement each other and the adoption level of e-commerce must be also broad in supply chain operational environment. We make presume that

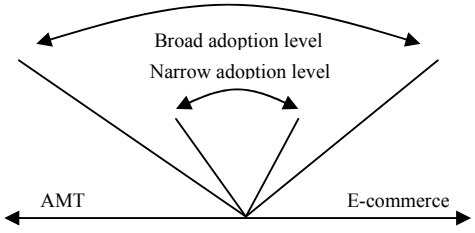


Figure 1. Adoption level of AMT and e-commerce in the supply chain context

if a company wants to reach the optimal coordination result with partner firms, both the adoption level of AMT and e-commerce must be broad and compatible. Hereby, this study will test following the hypothesis:

H_1: The alignment of broad adoption level for AMT and broad adoption level of e-commerce can significantly improve the coordination outcomes between partner firms in supply chain.

3. RESEARCH DESIGN

3.1 Survey database and test samples profiles

This study is based on the International Manufacturing Strategy Survey (IMSS-IV) database. The IMSS is an international cooperative research network focusing on manufacturing strategy (MS) research. It gathered data about firms' practice and operational performance related to manufacturing strategy in a global setting, and data pertaining to supply chain management practice are also collected. As for the survey methodology, the IMSS project employed questionnaire of five-point Likert scale as the means of measurement.

There are four phases in the 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 survey of this iteration focuses 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 the 2006, Taiwan start to

joint IMSS and replenish 50 samples for IMSS, therefore, all of samples in IMSS total number 761 firms. These data were used in this study.

We eliminated 264 samples whose responses were not complete or with missed values for variables of e-commerce, AMT, and supply-chain coordination. To sum up, only 497 of the 761 total responses are included in the analysis in this paper. In the sample profiles, approximately 38.66% (191) of samples were manufacture of fabricated metal products; 20.65% (102) of samples were manufacture of machinery and equipment; 3.24% (16) of samples were manufacture of office, accounting and computing machinery; 12.55% (62) of samples were manufacture of electrical machinery and apparatus; 5.87% (29) of samples were manufacture of radio, television and communication equipment and apparatus; 3.85% (19) of samples were manufacture of medical, precision and optical instruments, watches and clocks; 9.11% (45) of samples were manufacture of motor vehicles, trailers and semi-trailers; 6.07% (30) of samples were manufacture of other transport equipment. Otherwise, the average employment of sample firms was 17832 employees.

3.2 Construct measurement

In terms of research purpose and objective, this study involves the testing of three variables: supply-chain coordination outcomes, AMT adoption level, and e-commerce adoption level.

For supply-chain coordination, IMSS includes eight kinds of coordination activities with suppliers upstream and customers downstream, including: (1) share inventory-level knowledge, (2) share production planning decisions and demand forecast knowledge, (3) order tracking/tracing, (4) agreements on delivery frequency, (5) dedicated capacity, (6) require supplier/customer(s) part to manage or hold inventories of materials at manufacturing site (e.g., vendor-managed inventory, consignment stock), (7) collaborative planning, forecasting and replenishment, and (8) physical integration of the supplier into the plant, to measure the effectiveness of coordination and integration operation. Based on IMSS, this study will test these eight kinds of coordination activities. For these eight kinds of coordination activities, we first test data distribution. Test results indicated that “physical integration of the supplier into the plant” data of supplier and customer are non-normal distribution; therefore, we drop “physical integration of the supplier into the plant” from supplier/customer coordination activities. The other seven kinds of coordination activities, we further test content and construct validity. Content validity means the sufficiency with which a specific domain of content was sampled. In the content validity, we use *t-test* to test. Test results indicated that all of coordination activities of supplier and customer show significant results.

In addition to content validity, all coordination activities of supplier/customer will be developed for each construct in this study. However, before developed, we must check for seven coordination activities data construct. For checking the data, we first adopt exploratory factor analysis (EFA) to test. EFA result indicated that the Kaiser-Meyer-Olkin measures of sampling were 0.804(supplier) and 0.874(customer), KMO results excess 0.50, means result very good. In addition to KMO, the Bartlett test of sphericity were 903.654 (supplier) and 1266.586 (customer) with significance levels of $p < 0.01$, means test result can be accepted. For ensured EFA results, we further test reliability. Test results indicated that reliability of supplier and customer excess 0.7, reliability results can be accepted. Second, we adopt confirmatory factor analysis to test construct. Test results indicated that single factor loading for the seven supplier and customer coordination activities integrate with supplier and customer coordination. Results of content validity, EFA, reliability, and CFA have shown in Table 1.

In the AMT aspect, IMSS includes ten kinds of AMT applications: (1) stand-alone CNC machines, (2) machining centers, (3) automated parts loading/unloading, (4) automated parts loading/unloading, (5) automated storage-retrieval systems (AS/RS), (6) flexible manufacturing/assembly systems/cells (FMS, FAS, FMC), (7) computer-aided inspection/testing, (8) product/part tracking and tracing (bar codes, RFID), (9) integrated design-processing systems (CAD, CAE, CAM, CAPP), and (10) engineering databases and product data management systems to measure the extent of adoption and diffusion level of AMT. For these ten kinds of AMT applications, we first test data distribution. Test results indicated that “automated parts loading/unloading” and “automated storage-retrieval systems (AS/RS)” data are non-normal distribution; therefore, we drop “automated parts loading/unloading” and “automated storage-retrieval systems (AS/RS)” from AMT. Other eight AMTs, we further test content and construct validity. In the content validity, we use *t-test* to test. Test results indicated that all of AMTs show significant results. In addition to content validity, all AMT applications will work together with each alignment construct with e-commerce setting in

Table 1. Result of EFA and CFA for coordination activities

t-test	Supplier	Coordination items	Customer	*t-test*
0.000**	0.561	CA1. Share inventory level knowledge	0.665	0.000**
0.000**	0.652	CA2. Share production planning decisions and demand forecast knowledge	0.615	0.000**
0.000**	0.770	CA3. Order tracking/tracing	0.786	0.000**
0.000**	0.586	CA4. Agreements on delivery frequency	0.528	0.000**
0.000**	0.741	CA5. Dedicated capacity	0.753	0.000**
0.000**	0.806	CA6. Require supplier/customer (s) part to manage or hold inventories of materials at manufacturing site (e.g. Vendor Managed Inventory, Consignment Stock)	0.855	0.000**
0.000**	0.811	CA7. Collaborative Planning, Forecasting and Replenishment	0.827	0.000**
	0.793	Cronbanch's α	0.854	
	3.139	Eigen value	3.746	
	44.840	Percent of variation	53.517	

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

Table 2. Result of EFA and CFA for AMT

AMT	Factor loading	*t-test*
A1. Stand-alone/NC machines	0.315	0.000**
A2. Machining centers	0.508	0.000**
A3. Automated parts loading/unloading	0.548	0.000**
A4. Flexible manufacturing/assembly systems – cells (FMS/FAS/FMC)	0.480	0.000**
A5. Computer-aided inspection/testing	0.615	0.000**
A6. Product/part tracking and tracing (bar codes, RFID)	0.570	0.000**
A7. Integrated design-processing systems (CAD-CAE-CAM-CAPP)	0.621	0.000**
A8. Engineering databases, Product Data Management systems	0.563	0.000**
Cronbanch's α	0.754	
Eigenvalue	2.987	
Percent of variation	37.342	

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

Table 3. Result of EFA and CFA for e-commerce

t-test	Supplier	E-commerce	Customer	*t-test*
0.000**	0.554	E1. Scouting/ pre-qualify	0.649	0.000**
0.000**	0.627	E2. RFx (request for quotation, proposal, information)	0.615	0.000**
0.000**	0.748	E3. Data analysis (audit and reporting)	0.798	0.000**
0.000**	0.587	E4. Access to catalogues	0.556	0.000**
0.000**	0.751	E5. Order management and tracking	0.765	0.000**
0.000**	0.814	E6. Content and knowledge management	0.847	0.000**
0.000**	0.819	E7. Collaboration support services	0.836	0.000**
	0.874	Cronbanch's α	0.881	
	4.021	Eigen value	4.145	
	57.439	Percent of variation	59.212	

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

this study; therefore, we must ensure the all AMTs can be integrated with single construct. In the data construct, we first adopt exploratory factor analysis (EFA) to test. EFA result indicated that the Kaiser-Meyer-Olkin measures of sampling was 0.760, KMO result excesses 0.50,

means result very good. In addition to KMO, the Bartlett test of shyericity was 952.364 with significance levels of $p < 0.01$, means test result can be accepted. For ensured EFA results, we further test reliability. Test result indicated that reliability of AMT excesses 0.7, reliability results can be accepted. Second, we adopt confirmatory factor analysis to test construct. Test results indicated that single factor loading for the eight AMTs integrate with AMT. Results of content validity, EFA, reliability, and CFA have shown in Table 2.

In the e-commerce, IMSS provides eight kinds of e-commerce technology to investigate the adoption level of e-commerce in suppliers and customers: (1) scouting/pre-qualify, (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. As eight kinds of e-commerce technology of supplier and customer, we first test data distribution. Test results indicated that "auctions" data of supplier and customer are non-normal distribution; therefore, we drop "auctions" of supplier and customer from e-commerce. Other seven e-commerce technologies of supplier and customer, we further test content and construct validity. In the content validity, we use *t-test* to test. Test results indicated that all of e-commerce technologies of supplier and customer show significant results.

In addition to content validity, e-commerce technology will are combined and developed for each alignment construct with AMT in this study; therefore, we must ensure the all e-commerce technologies of supplier and customer can be integrated with single construct. In the data construct, we first adopt exploratory factor analysis (EFA) to test. EFA result indicated that the Kaiser-Meyer-Olkin measures of sampling were 0.882 (supplier) and 0.895 (customer), KMO results excess 0.50, means result very good. In addition to KMO, the Bartlett test of shyericity were 1583.197 (supplier) and 1722.908 (customer) with significance levels of $p < 0.01$, means test result can be accepted. For ensured EFA results, we further test reliability. Test results indicated that reliability of supplier and customer excess 0.7, reliability results can be accepted. Second, we adopt confirmatory factor analysis to test construct. Test results indicated that single factor loading for the seven e-commerce technologies of supplier and customer integrate with supplier and customer. Results of content validity, EFA, reliability, and CFA have shown in Table 3.

3.3 Operationalization variables – alignment strategies of different adoption level

We further tried to define different alignments strategies from test samples. Through the factor score for e-commerce technology adoption level and AMT adoption level, we establish a measurement model to classify different alignments between AMT and e-commerce technology. The measurement model has shown in Figure 2. In the Figure 2, the left is to measure AMT adoption level, and the right is to measure e-commerce technology adoption level. Adoption level can be classified three quartiles including upper quartile, middle quartile, and lower quartile. As figure 2, we classified each sample into either the upper, middle, or lower quartiles. Quartiles were then used to sort the 467 samples into the seven different alignments. Classified results indicated that 36 (7.24%) samples are sorted into first type alignment strategy. In the first type of alignment strategy, adoption level of both AMT and e-commerce technology are in the lower quartiles with 266 (53.52%) samples sorted into the second type alignment. The second type alignment strategy was in the middle quartiles with both adoption level of AMT and e-commerce technology. 9 (1.81%) samples are sorted into the third type of alignment. The third type of alignment is in the upper quartiles with both adoption level of AMT and e-commerce technology. 58 (11.67%) samples are sorted into forth type alignment. The forth type of alignment was in the middle quartiles with adoption level of AMT and lower quartile adoption level with e-commerce technology. 59 (11.87%) samples are sorted into the fifth type alignment. Fifth type alignment was in the lower quartiles with adoption level of AMT and middle quartile adoption level with e-commerce technology. 45 (9.05%) samples are sorted into sixth type of alignment.

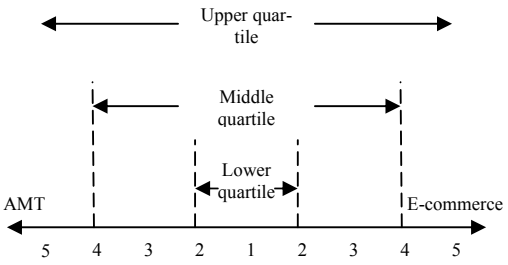


Figure 2. Classification of alignment type based on the survey measurement for AMT and e-commerce

Table 4. Results of discriminant analysis (before)

	Cases	Alignment 1	Alignment 2	Alignment 3	Alignment 4	Alignment 5	Alignment 6	Alignment 7
Alignment 1	36	36 (100%)	0	0	0	0	0	0
Alignment 2	266	0	188 (70.7%)	0	17 (6.4%)	23 (8.6%)	16 (6.0%)	22 (8.3%)
Alignment 3	9	0	0	9 (100%)	0	0	0	0
Alignment 4	58	10 (17.2%)	0	0	48 (82.8%)	0	0	0
Alignment 5	59	4 (6.8%)	0	0	0	55 (93.2%)	0	0
Alignment 6	45	0	0	6 (13.3%)	0	0	39 (86.7%)	0
Alignment 7	24	0	0	1 (4.2%)	0	0	0	23 (95.8%)

80.1% of original grouped cases correctly classified
79.5% of cross-validated grouped cases correctly classified

Table 5. Results of discriminant analysis (after)

	Cases	Alignment 1	Alignment 2	Alignment 3	Alignment 4	Alignment 5	Alignment 6	Alignment 7
Alignment 1	69	69 (100%)	0	0	0	0	0	0
Alignment 2	97	0	95 (97.9%)	0	0	0	0	2 (2.1%)
Alignment 3	43	0	0	43 (100%)	0	0	0	0
Alignment 4	48	0	0	0	47 (97.9%)	0	0	1 (2.1%)
Alignment 5	92	0	2 (2.2%)	0	0	90 (97.8%)	0	0
Alignment 6	58	0	0	0	0	0	58 (100%)	0
Alignment 7	90	0	2 (2.2%)	0	0	0	0	88 (97.8%)

98.6% of original grouped cases correctly classified
98.2% of cross-validated grouped cases correctly classified

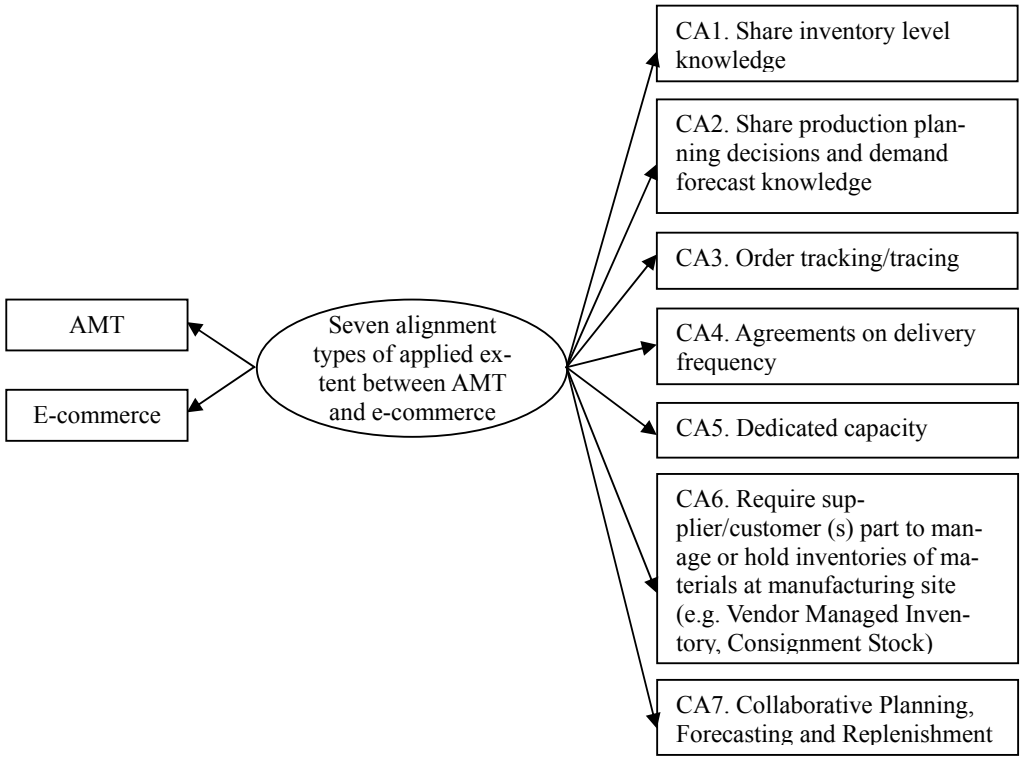


Figure 3. Research model

The sixth type alignment was in the upper quartiles with adoption level of AMT and the middle quartile adoption level with e-commerce technology. 24 (4.83%) samples are sorted into the seventh type alignment. The seventh type alignment was in the middle quartiles with adoption level of AMT and upper quartile adoption level with e-commerce technology.

To ensure the classified results, this study also used the discriminant analysis as a check. As seen in Table 4, the results of discriminant analysis confirmed that strategy No.1 (100%), strategy No.2 (70.7%), strategy No.3 (100%), strategy No.4 (82.8%), strategy No.5 (93.2%), strategy No.6 (86.7%) and strategy No.7 (95.8%). However, the constituent of strategy No.2 result only is 70.7% of the samples, the results of original grouped cases correctly classified is 80.1, and cross-validated grouped cases correctly classified is 79.5%, these results means the classified results should be adjusted and revised. For adjusted and revised classified results, we further adopt k-mean to adjust and revise. Revision results has shown in the table 5, results indicated that 69 (13.88%) samples are into strategy 1, correct rate of classified is 100%; 97 (19.52%) samples are into strategy 2, correct rate of classified is 97.9%; 43 (8.65%) samples are into strategy 3, correct rate of classified is 100%; 48 (9.66%) samples are into strategy 4, correct rate of classified is 97.9%; 92 (18.51%) samples are into strategy 5, correct rate of classified is 97.8%; 58 (11.67%) samples are into strategy 6, correct rate of classified is 100%; 90 (18.11%) samples are into strategy 7, correct rate of classified is 97.8%. The result of original grouped cases correctly classified is 98.6%, and cross-validated of grouped cases correctly classified is 98.2%. Revision results can be accepted. After revision, all new classified results will be further test.

Based on the above, we define seven alignment strategies. In the next section, we further test the research objective through supply-chain coordination activities and seven alignment strategies.

3.4 Methodology and test framework

As for methodology, this study uses Structural Equation Modeling (SEM) to test influence of seven alignments strategies between AMT and e-commerce for seven kinds of coordination activities. The SEM is a very general, chiefly linear, chiefly cross-sectional statistical modeling technique. It is a largely confirmatory, rather than exploratory, technique. Through SEM, we can ensure whether a certain model is valid, and

further explore and test for research question.

In the test framework, as research objective, definition of coordination activities, and operationalization variables, this study will develop seven types of test frameworks to explore research hypothesis. In next section, we will use SEM to test seven frameworks. Test framework has shown in Figure 3.

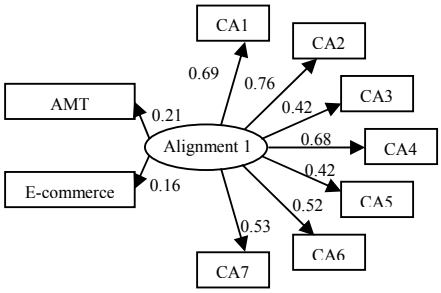
4. RESULTS AND DISCUSSION

In this section, we test seven kinds of alignment strategies by SEM, the results are presented in Figure 4. In the fit indices, all results of indices include Incremental Fit Index (IFI), Tucker-Lewis Index (TLI), Comparative Fit Index (CFI), and Root Mean Square Error of Approximation (RMSEA) they all can be accepted. Results of fit indices indicated that IFI of model 1 is 0.944, model 2 is 0.940, model 3 is 0.997, model 4 is 0.965, model 5 is 0.964, model 6 is 0.955, and model 7 is 0.952. TLI of model 1 is 0.908, model 2 is 0.909, model 3 is 0.995, model 4 is 0.943, model 5 is 0.942, model 6 is 0.928, and model 7 is 0.919. CFI of model 1 is 0.938, model 2 is 0.937, model 3 is 0.996, model 4 is 0.962, model 5 is 0.962, model 6 is 0.948, and model 7 is 0.948. RMSEA of model 1 is 0.067, model 2 is 0.071, model 3 is 0.022, model 4 is 0.065, model 5 is 0.057, model 6 is 0.047, and model 7 is 0.068.These results confirm the evidence of convergent validity in all models.

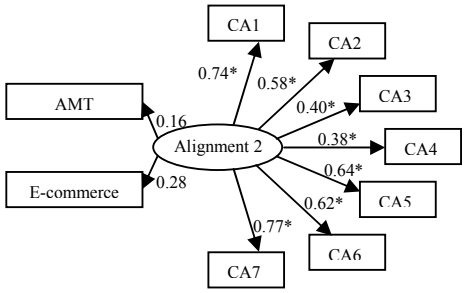
Regarding the test results, we found that alignment strategy 3 has a direct influence on all the coordination activities. Test result of alignment strategy 3 also supports the hypothesis in this study. However, in addition to alignment strategy 3, we also found the alignment strategy 2 and 7 can influence on all the coordination activities. Otherwise, we also found the alignment strategy 5 can influence few coordination activities. Finally, test results indicated that alignment strategy 1, 4, and 6 cannot influence any coordination activity.

This study first explores the effect of alignment strategies of different adoption level between AMT and e-commerce for supply chain coordination. Based on the test result of alignment strategy 3 against the hypothesis, we can understand when firms pursues the improvement of coordination between partner firms, taking the alignment of broad adoption level between AMT and e-commerce does influence partner firms to readily carry out the necessary coordination activities, thus significantly improve the supply chain coordination outcomes. On the other hand, supply chain operational environment also involves partner firms of upstream and downstream. That's the reason why in case that a company wants to influence and further guide partner firms to do coordination via AMT applications, the adoption level of AMT must be equivalently throughout partner firms of upstream and downstream in the entire supply chain. However, information flow also plays an important role to reinforce the influence on coordination outcomes that AMT has contributed. Given the equivalent adoption level of AMT has already diffused through partner firms of upstream and downstream, but not so for the diffusion of information technology/e-business, then the globalization for overall coordination could be impeded. Test results of alignment strategy 3, 4, and 6 can evidence the above inference. In the alignment strategy 3, it showed the adoption level of AMT and e-commerce complements each other in the diffusion process, therefore, makes effective improvement for mutual coordination. In the alignment strategy 4 and 6, test results of alignment strategy 4 and 6 showed the adoption level of e-commerce is lower than that of AMT, test results indicated that alignment 4 and 6 are difficult to improve coordination between partner firms.

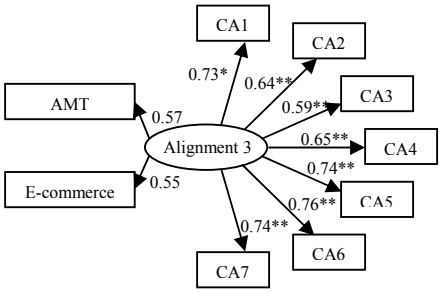
Although equivalent adoption level for both AMT and e-commerce that completely diffuses in the supply chain partners can effectively influence coordination, however, by the test result of alignment strategy 2, incomplete diffused but equivalent adoption level of AMT and e-commerce can still influence the coordination between partner firms. Definition of alignment strategy 2 is "in the middle quartiles with both adoption level of AMT and e-commerce technology". The definition of alignment strategy 2 means although the diffusion of AMT and e-commerce is not complete in the chain, but alignment strategy 2 still can influence partner firms for coordination. As this result, we presume that it is the information flow under e-business setting that makes the contribution, and this implies the crucial position e-business lies in the coordination. Test results of alignment strategy 5 and 7 can support this statement. Alignment strategy 5 means the adoption level of e-commerce has diffused to partner firms of upstream and downstream but is not complete, and adoption level AMT is only to focus on manufacturing. However, alignment strategy 5 still imposes a little influence for coordination. Alignment strategy 7 means the adoption level of e-commerce has completely diffused within partner firms, but adoption level of AMT is incomplete in diffusion. However, test result of



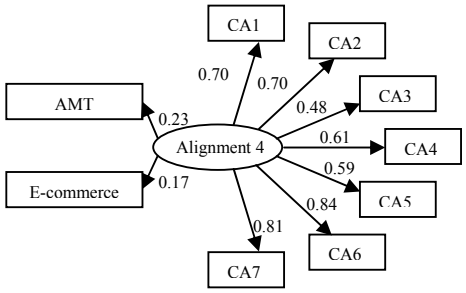
CMIN=31.399, df=24, CFI=0.938
IFI=0.944, TLI=0.908, RMSEA=0.067



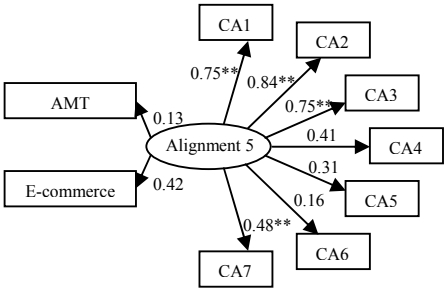
CMIN=37.203, df=25, CFI=0.937
IFI=0.940, TLI=0.909, RMSEA=0.071



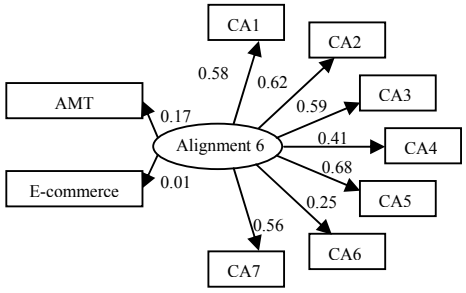
CMIN=26.505, df=26, CFI=0.996
IFI=0.997, TLI=0.995, RMSEA=0.022



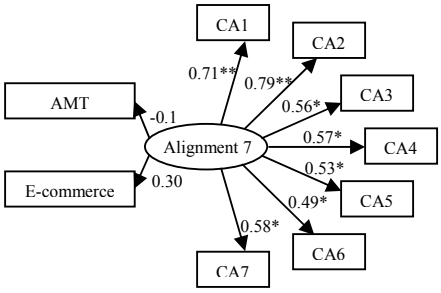
CMIN=28.761, df=24, CFI=0.962
IFI=0.965, TLI=0.943, RMSEA=0.065



CMIN=30.990, df=24, CFI=0.962
IFI=0.964, TLI=0.942, RMSEA=0.057



CMIN=29.237, df=26, CFI=0.948
IFI=0.955, TLI=0.928, RMSEA=0.047



CMIN=32.458, df=23, CFI=0.948
IFI=0.952, TLI=0.919, RMSEA=0.068

Figure 4. Results of SEM

alignment strategy 7 tells us that the alignment strategy 7 can influence significantly coordination between partner firms. These test results evidence that although AMT adoption diffusion is not so complete, however, underpinned by information via e-business setting the coordination still can be improved.

However, if adoption level of AMT and e-commerce has not completely diffused, or that of e-commerce is higher than AMT, the influence on coordination will be lower than that of complete diffusion cases. Comparison between the result alignment strategy 2 and 3, or between alignment strategy 7 and 3 can justify the above viewpoint. According to comparison result between alignment 2 and 3, we found the significance of coordination improvement of alignment strategy 2 is lower than that of alignment strategy 3; otherwise, the significance of coordination of alignment strategy 7 is lower than that of alignment strategy 3. Therefore, when firms want to improve coordination between partner firms, taking alignment strategy of broad adoption level between AMT and e-commerce to influence coordination of partner firms, enables a significantly improved coordination outcomes.

5. CONCLUSION

The objective of this study is to empirically identify various alignments in the context of different applied of AMT and e-commerce, and test whether these alignments strategy can impose influence upon supply-chain coordination outcomes. Through the test result we can infer which alignments strategy makes more significant contribution. Using the data set based on large samples from the International Manufacturing Strategy Survey (IMSS) database, we have justified the proposition.

In this study, we classified seven types of alignments strategies of utilizing AMT and e-commerce for supply chain coordination and then using SEM to test how influential each strategy can be. The conclusion is made here:

First, Applied of AMT must completely diffuse to partner firms of upstream and downstream if a company wants to influence and further guide supply chain partner firms for effective coordination by AMT. By the test results, complete diffusion of AMT under the constraint of incomplete diffusion of e-business adoption, however, the premise is that that adoption level of e-business should be compatible among partner firms. To pursue the optimal results, company must develop and build competent information technology infrastructure to empower the advantage of AMT in the supply chain operational environment as firms can use e-commerce setting to connect partners firms to streamline the information flow. Therefore, it is evident that the adoption level of AMT must be equivalent to the adoption level of e-commerce to support the significant influence and improvement in supply chain coordination outcomes.

Second, information flow plays an important role when firms adopt AMT to influence and guide partner firms for coordination. Test results indicated that the adoption level of e-commerce must equate that of AMT if AMT applications are expected to effectively influence partner firms for coordination, or else it could be difficult to significant improve the coordination outcomes between partner firms by AMT. Test results also indicated, if applied extent of e-commerce is higher than applied extent of AMT, coordination between partner firms still can be influenced and improved by AMT; however, if adoption level of e-commerce is lower than that of AMT, effective coordination between partner firms will be hardly to be achieved. Therefore, this study has deliberately identified the critical role of e-commerce setting plays in the coordination of supply chain activities.

Based on the findings in this study, we recognize the fact that e-business/information technology indeed plays a critical role in the supply chain integration. Therefore, we suggest that an in-depth exploration into the relationship between e-business/information flow and coordination outcomes, and the direct or interaction effect of AMT and e-business on coordination outcomes as the direction for further research.

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探討先進製造技術與電子商務對供應鏈協調與競爭績效連結關係之影響

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摘要

本研究之目的在於根據不同使用程度的先進製造技術與電子商務，定義在供應鏈作業環境中的形成各的種連結策略，並驗證各種連結策略對供應鏈協調的影響結果。基於驗證結果，我們可以證明能夠增進供應鏈協調的最佳連結策略。樣本方面，本研究使用國際製造策略調查資料庫 (International Manufacturing Strategy Survey, IMSS)之資料進行驗證。我們由 IMSS 中選出 497 個樣本來進行分析，並根據不同使用程度的先進製造技術與電子商務去歸類出七種連結策略。驗證結果指出若先進製造技術與電子商務的使用程度高且完全擴散於供應鏈作業環境中其能有效影響夥伴廠商之間的協調，並增進供應鏈作業績效。此外，我們也發現電子商務在連結策略中扮演相當重要的角色。

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