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Performance measures and metrics for e-supply chains

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Abstract

Purpose – e-Supply chains are fast becoming a reality. In order to manage such supply chains efficiently and effectively, traditional measures of supply chain performance are not adequate. The literature search revealed lack of measures and metrics for e-supply chains. The purpose of this paper is to develop new measures and metrics for monitoring the performance of e-supply chains.

Design/methodology/approach – A framework based on the benefits of e-supply chains has been used to develop the metrics and measures. The study makes use of focus group discussion by assembling eight experts and practitioners in the field of e-supply chain to come up with the measures and metrics. A questionnaire is designed with these measures and metrics and is sent to about 300 electronic component manufacturing companies in Malaysia to obtain feedback from the industry practitioners. Appropriate reliability and validity tests are conducted to measure the reliability of the instrument and validity of the constructs.

Findings – Through the focus group discussion, this study identifies six metrics and 21 measures. Further validation through the industry practitioners, reveals that these measures are important and some are in use by the industries. The six metrics are: web-enabled service, data reliability, time and cost, e-response, invoice presentation and payment and e-document management metrics.

Originality/value – The study uses a simple framework and a sound methodology to develop new measures and metrics that are relevant for e-supply chains.

Keywords Supply chain management, Performance measures, Focus groups, Electronic commerce, Malaysia, Singapore

Paper type Research paper

1. Introduction

e-Supply chains are supply chains in which the supply chain members are connected/integrated by the internet technologies at technical, application and business management levels (Caputo *et al.*, 2004). Technology has become a core component of every supply chain innovation. For example, the internet brings immediacy to almost any supply chain event by enabling companies to capture real-time customer demand and by maximizing visibility. The internet has resulted in entire networks of e-supply chain processes across various organizations (Kirchmer, 2004). Simple investments in technology are not the whole story of improved performance. By investing in a combination of supply chain capabilities, companies like Dell and Scholastic have brought their business models to life and have created market differentiation (Mulani and Lee, 2001). The world wide web has caused a paradigm shift

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in the way businesses are conducted by allowing companies to explore new and virgin markets and by facilitating electronic transactions that adds value to the buyer and the supplier. For example, General Electric saved about US$500 million in the year 2001, when it used e-auction in its transportation systems transactions (Mulani and Lee, 2001).

With the evolution of the web, even traditional business functions have evolved and the internet has become an integral part of the core business activities and processes for many companies. For example, many companies have e-planning, e-logistics, and e-sourcing. In order to ensure that the e-supply chains are managed effectively, the metrics that are used to measure the supply chain performance must reflect these initiatives. The widespread use of the technologies requires the development of sophisticated measurement tools to assess the performance of the supply chains (Mondragon *et al.*, 2006). According to Gunasekaran *et al.* (2001), very little attention has been given to the measures and metrics of supply chains. In this study, we treat the terms measure and metric differently. We define measure as a more objective or concrete attribute that is observed and measured and metric as an abstract, higher-level latent attribute that can have many measures.

The literature is replete with articles on various aspects of supply chain management (SCM), but not rich in measures and metrics to measure the performance of SCM. Dearth of metrics for e-supply chains after analyzing the literature is palpable. The opportunity to improve metrics for e-supply chains is extensive (Gartner, 2001). Of the 206 companies surveyed by Gartner, less than 25 per cent of the companies had implemented new metrics for e-supply chains and more than 30 per cent were not measuring the e-supply chain initiatives at all. Many of them were depending only on the traditional supply chain metrics. There is a shortage of metrics for e-supply chains and this paper attempts to fill the gap in this area by developing appropriate measures and metrics. The measures and metrics developed in this paper for e-supply chains must be used in conjunction with the traditional supply chain metrics. Few researchers have developed measures for traditional supply chains (Beamon, 1999; Dixon *et al.*, 1990; Gunasekaran *et al.*, 2001). Since supply chain is a network of firms that includes material suppliers, production facilities, distribution services and customers linked together via the flows of materials, information and funds (Gunasekaran *et al.*, 2001), the measures have been classified as follows: fund flow (cost and profitability), internal process flow (production level flexibility, order fulfillment and quality), material flow (inventory and internal time performance), sales and services flow (delivery performance, customer responsiveness and customer satisfaction), information flow and partner relationship process flow (supplier evaluation and sharing of information with suppliers and customers). The organization of this paper is as follows. Section 2 describes the framework for developing e-supply chain metrics. Section 3 describes the research methodology. Section 4 discusses the findings of the survey. Section 5 presents the conclusions and limitations. Section 6 lists the lessons learnt from this study.

2. Toward a framework for developing e-supply chain metrics

The internet has drastically changed the nature of supply chain relationships and activities. It offers a variety of benefits to supply chain partners that include better, faster and easier cooperation among different partners, improved roles of customers

in product developments and improved customer interaction (Hausman, 2002). According to Jonsson and Gunnarsson (2005), the internet can be used to:

- manage strategic alliances;
- increase supply chain efficiency and shift toward customer-perceived value; and
- continually refine current operations and add economic value to the processes.

The internet also facilitates supply chain improvement initiatives such as vendor-managed inventory and allows increased and more efficient information sharing opportunities across the supply chain. According to a global business management consultancy firm specializing in supply chain performance measurement and benchmarking analysis (PTRM), companies have already started realizing benefits of adopting e-supply chain initiatives in their supply chains. Some of the benefits of e-supply chain initiatives are: higher performance, greater interconnection and cooperation between members of the supply chain (suppliers, manufacturers and customers).

e-Supply chain facilitates organisations to reduce costs, increase demand and create new business models. It has the potential to benefit all consumers through reduced prices and improved products and information (Singh and Byrne, 2005). e-Supply chain initiatives are designed to bring in the following benefits: efficiency, effectiveness and strategic benefits (Riggins and Mitra, 2001; van Hooft and Stegwee, 2001). According to Vidgen *et al.* (2004), web services have the potential to help organizations achieve efficiency, operational gains and strategic benefits. Improving efficiency has traditionally been the primary use of information technology. Even before the internet, companies engaged in electronic commerce using electronic data interchange (EDI) to improve the efficiency of coordinating with external trading partners (Riggins *et al.*, 1994). Therefore, at the minimum e-supply chain initiatives must improve the efficiency of processes. According to Riggins and Mitra (2001, p. 8):

> [...] the opportunity to improve the effectiveness of decision-makers by getting the right information, to the right person, in the right format, at the right time forms the basis for management information systems, decision support systems, and e-supply chains.

The e-supply chain initiatives can result in strategic benefits such as increased revenues by opening up new markets, new products and services, or by allowing firms to gain an advantage over competitors by developing customer loyalty. Bremser and Chung (2005) have suggested a strategy-focused framework, based on balanced scorecard (BSC) system, for developing performance measures for e-supply chains/e-businesses. They have expanded BSC framework on two dimensions: in the scope of external constituencies (stakeholders) and in the domain of business models (e-businesses). Bremser and Chung (2005) have proposed 11 key implementation issues for metrics that must be examined by the companies using or planning to use metrics. They have discussed the framework but have not discussed about the specific metrics. Caputo *et al.* (2004) have proposed a model for the analysis and performance evaluation of e-supply chains. They have assumed that the performances of e-supply chains are influenced by three factors: network organizational structures, criteria adopted to manage relationships among involved actors and the critical activities the leading company performs. Through case studies, Caputo *et al.* (2004) have demonstrated the ways to restructure the e-supply chains by using the proposed model. We propose a benefit-focused framework, based on Riggins and Mitra (2001), to develop e-supply

chain metrics because it addresses the important characteristics of e-business metrics. Our framework includes three benefits:

(1) efficiency benefits;

(2) effectiveness benefits; and

(3) strategic benefits.

3. Research methodology

Earlier studies on e-supply chains have not adequately addressed the development of relevant measures and metrics that are generic. The main contribution of this paper, therefore, is the development of metrics and measures for e-supply chains. Since this study is more of an exploratory nature, we used the framework as shown in Figure 1 to identify the measures and metrics. A focus group discussion was adopted to identify an initial list of measures and metrics for e-supply chains. A focus group is defined as a panel of experts that meets for 90-120 minutes. A facilitator or moderator guides the group in an exchange of ideas, feelings, and experiences on a specific topic (Cooper and Schindler, 2000). The focus group members for the present study were selected from various industries in Malaysia and Singapore from companies like Acer Computers, Hitachi Corporation, SCM Consulting, Compaq Computers, HP Computers, SAP Consulting, and Sony Corporation. The eight members selected were managers in logistics and supply chain activities in their respective organizations. The members, two weeks before the group discussion, were informed about the objective of the whole process and the specific topic that would be discussed. This was done to ensure that the discussion members were better prepared. A ten-step approach recommended by Simon (2003) was followed in conducting the focus group discussion. In the first part of the discussion that took place for two hours, the members came up with a list of measures and metrics, focusing on the benefits and for e-supply chains. In the second part of the discussion that took place for 30 minutes, the members reviewed the list and came up with six metrics and 22 measures under these metrics. After consolidating the outcome of the focus group discussion, a questionnaire was constructed with these six metrics and 22 measures. The basic purpose of the questionnaire was to obtain feedback from a larger number of industry practitioners about the importance and use of measures and metrics pertaining to e-supply chains.

The target group for the questionnaire was supply chain managers from electronic components manufacturing companies in Malaysia. The sampling frame consisted of 2,000 companies listed in:

- Federation of Malaysian manufacturers' directory;
- a list of Japanese businesses in Malaysia; and
- a list of e-business hosting companies.

We approached all the companies in the sampling frame and questionnaires were sent to the companies that agreed to participate in the study.

The "items" of the questionnaire were numerical values or perceptual Likert scales. For each of the measure, the respondents were asked to rate the importance of the measures on a five-point scale, ranging from "not very important" to "very important" and the frequency of use of the measures on a five-point scale, ranging from "don't know" to "annually". The reliability of the measures was assessed using Cronbach alpha and

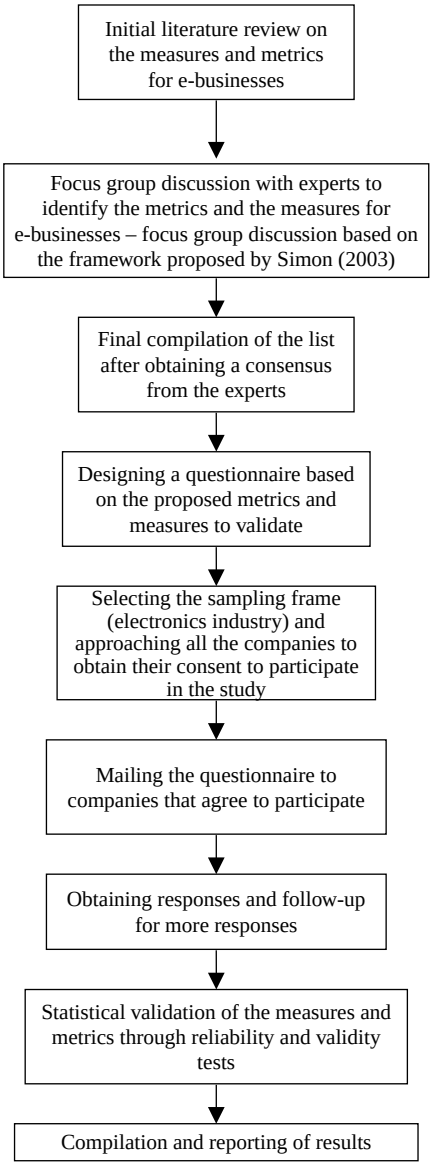

Figure 1.
Framework for the methodology

the validity of the measures was assessed using confirmatory factor analysis – CFA (Cooper and Schindler, 2000).

3.1 Measures and metrics

Many authors have criticized the measures and metrics used by the members in the supply chains. These authors contend that the measures and metrics do not capture the performance of the entire supply chain, rather the performance of an individual

firm (Gunasekaran *et al.*, 2001; Neely *et al.*, 2005; Sachan and Datta, 2005). The measures and metrics developed in this study capture the performance of the entire e-supply chain and its members. The six metrics that came out the focus group discussion are:

(1) web-enabled service metric;
(2) data reliability metric;
(3) time and cost metric;
(4) e-response metric;
(5) invoice presentation and payment metric; and
(6) e-document management metric.

In the following paragraphs, we explain the six metrics and the measures that come under each of these metrics.

3.1.1 Web-enabled service metric. This dimension measures the speed and the security of information retrieval by the supply chain members. In a web-enabled environment, it is important that the supply chain members are able to retrieve information faster and under secured conditions. The benefits that are addressed by this metric are effectiveness and efficiency benefits. The measures that come under this metric are:

- *Global visibility through near real-time data.* Companies share information through their organization's intranet/extranet with the other members in the supply chain to have visibility of the data entered through a transaction (for example – goods movement status). This measure represents the time taken to reflect the changes due to the transaction and this includes time to capture data, time to verify the data, time for any approvals and time to update the database.
- *System response time.* This measure indicates the time required by the user to retrieve information from the system. System response time gives the average time taken from the start of enquiry to the actual display of requested information. The focus group members recommended a target of five to seven seconds as system response time.
- *Data transmission speed between B2B application.* This measures the time taken for the data to be transmitted from the source back-end system to receiver system. The mode of data transmission can typically be through FTP, e-mail, direct upload/download and EDI and the network speed is determined by whether lease line, ISDN or broadband is used.
- *Security of data (at data access level).* This measures the number of verification steps required by the end-user to access any data/information. If the number of verification steps is more, the system is considered to be secure. The security steps are required to ensure that the data are retrieved and used by the right person.
- *Traffic by page and site.* This measure indicates the time taken or the number of "clicks" required before the user gets the required information. It is essential that the user accesses the correct information quickly and easily without going through many web pages or site visits.

3.1.2 Data reliability metric. This dimension measures the reliability of the data of e-supply chain applications. These applications process the data and provide a log of the "processed" and "exception" data to the initiators of the data/end-users in order to track and fix the problems immediately, if there are any. This step is vital to maintain the reliability of the data entered into the system. This metric can be used to measure the effectiveness benefits of e-supply chains. The measures that come under this metric are:

- *Transaction error rate.* The e-supply chain application should be able to handle any incorrect transaction from updating the database. The system must reject the transaction errors from corrupting the database and must trigger appropriate alert messages for corrective actions. This measure is calculated as the average number of error transactions per transmission.
- *Number of backlog transactions.* This measure allows the supply chain partners to track the number of backlog transactions within their control and scope so that they can resolve issues and take quick actions. This is measured in terms of total number of backlog transactions relative to the number of total transactions.
- *Transaction cost.* This measures the cost per kilobyte of information published/data transmitted. This cost is typically based on the volume of transaction. For example, between 1 and 50,000 kilobytes transaction cost is ¢45 and between 50,001 and 100,000 kilobytes transaction cost is ¢50.
- *User utilization.* This measures the application utilization by the supply chain partners and the type of information that is utilized most. The measure is given in terms of number of visits to retrieve/download information from the system.
- *Time taken to fix any interface enterprise resource planning (ERP) problem.* This measures the time taken to resolve any interface problem with ERP or any other application. This is to ensure that there is a high degree of availability of e-supply chain applications. The supply chain partners' confidence with the system improves with availability.

3.1.3 Time and cost metric. The basic objective of implementing e-supply chain initiatives is to improve the efficiency and effectiveness of operations. These are achieved by ensuring global visibility (transparency) of data, reduced transaction cost, reduced administrative time, reduced error of transactions, and reduced lead time. The supply chain partners can use this metric to check if they have achieved their strategic objectives in implementing the e-supply chain initiatives. This metric can be used to measure strategic, efficiency and effectiveness benefits. The measures that come under this metric are:

- *Administration time and cost (for example, purchasing activity).* Some of the routine tasks can be automated by having automatic data transmission to web-based application. The supply chain partners can later access the information and acknowledge the receipt of the information. For example, automatic processing of purchase orders and availability of purchase order information on the system. Traditionally, these activities were done manually. This measure is calculated as the savings in the administration time and cost because of automation.
- *Number of steps in procurement cycle.* Standardizing and simplifying the sequence of steps in the procurement cycle keep the e-supply chain activities between the

supply chain partners simple. This allows easy troubleshooting, training, and easy exchange of information even if the number of supply chain partners is large. This measure tracks the number of steps in the procurement cycle before and after the implementation of e-supply chain initiatives.

- *Procurement cycle time.* This measure gives the time taken from the issue of purchase requisition to the acknowledgement of receipt of purchase order by the supplier and can be tracked before and after the implementation of e-supply chain initiatives.
- *Supplier-buyer response time in procurement operation.* The industry practitioners call this measure as "Retrieval aging time". This measures the time taken by the suppliers to respond to the "request for procurement" transaction and can be tracked before and after the implementation of e-supply chain initiatives.
- *Purchase lead time.* This measures the total time taken from requisition of material to receipt of material. Any reduction in this time has direct impact on the inventory, production schedules, and response time and this result in benefits to all the supply chain members.

3.1.4 e-Response metric. This metric is used to monitor response activities by using electronic response such as workflow tool or application retrieval status to ensure that all the members in the supply chain are able to respond to the data or transaction in an effective manner. This metric addresses the effectiveness and efficiency benefits. The measures that come under this metric are:

- *Mail service reliability.* This measures the mail service down time during the business hours besides the scheduled down time for upgrade and planned maintenance work. This measure is measured in terms of hours per month or hours per year.
- *Response time to trigger alarm.* After a business transaction is entered into the system, an alert message (alarm) is triggered to all the relevant members in the supply chain. This measure represents the time taken by the receiver to acknowledge the transaction from the time the system triggers the alarm. The alarm is triggered through mail or e-supply chain dashboard (e-dashboard) or helpdesk application.
- *Daily completed and outstanding number of transactions to respond.* Supply chain partners must quickly respond to the urgency of information. For example, the suppliers must quickly respond to shorter delivery time than the one agreed earlier. The quick response can enable the manufacturer to take appropriate actions. This measure is measured in terms of number of transactions completed and outstanding relative to number of transactions published in the e-dashboard.

3.1.5 Invoice presentation and payment metric. Each supply chain member has different modes and terms of payment, for example, e-banking. Suppliers require that the steps to handle invoice and process payments are simplified and automated. This dimension measures the number of steps in invoice presentation process and time taken to process payments. This metric measure the efficiency benefits. The measures that come under this metric are:

- *Number of steps in invoice presentation process.* This measures the number of steps that are involved in invoice presentation process. Many suppliers in the e-supply chain have migrated to e-invoice. This ensures that the invoices are validated electronically and errors corrected immediately. The invoices can then be integrated with the payment process.
- *Dispute resolution time.* Disputes may arise between supply chain members regarding any transaction. The strength of relationship between the members is dependent upon the speed at which the disputes are resolved. This measure measures the time taken to resolve any dispute that may arise.
- *Payment and reconciliation time.* This measures the time taken for the payment process through e-payment after reconciling with any differences in the payment that may arise.

3.1.6 e-Document management metric. This dimension measures the reliability of the data transmitted through the electronic tools against the physical document attached with the goods. Any difference between the physical document and electronic data must be corrected immediately to ensure error-free data. This metric measure the effectiveness benefits. The measure that comes under this metric is:

- *Document accuracy.* This measure is calculated as the percentage of transactions pending closure due to the discrepancy between the electronic data and document. The discrepancy may be because of document error or transaction updated with wrong information.

4. Findings and discussions

A total of 300 questionnaires were sent to electronic component manufacturing companies in Malaysia. Even though 300 companies agreed to participate in the study, only 150 companies filled and returned the questionnaire and out of these, only 120 questionnaires were usable. The respondents were senior managers and managers of supply chain in their respective organizations and these organizations were practicing many aspects of e-supply chain. More than 65 per cent of the respondents had more than ten years of experience in their field and about 75 per cent of the companies responded had more than 500 employees. The questionnaire captured the importance of each measure and the extent of use by the companies surveyed. Table I gives the summary of the results of the survey.

The table indicates that the metrics and the corresponding measures that came out of the focus group discussion are relevant and important for measuring the performance of e-supply chains. Only four of the 22 measures have been rated important by less than 50 per cent of the respondents. Some of the measures were measured by few in spite of being declared as important by the majority of respondents. When the respondents were questioned, through e-mail/phone by the researcher, many agreed that they had started using e-supply chain measures recently and indicated that they would be using more of these measures in the future.

The metrics were checked for internal consistency and validated using reliability and validity analysis. The reliability and validation procedures were conducted using the "importance" of the measures and the metrics. Cronbach alpha values were used to measure reliability. An alpha value of 0.7 was used as a threshold to indicate acceptable level of reliability (Nunnally, 1970). CFA was used to measure the validity of

Metric	Measure	Survey results
Web-enabled service	Global visibility through near real-time data	61 per cent rated this measure as important (only 25 per cent measured)
	System response time	77 per cent rated this measure as important (about 55 per cent measured)
	Data transmission speed	77 per cent rated this measure as important (about 56 per cent measured)
	Security of data	85 per cent rated this measure as important (only 37 per cent measured)
	Traffic by page and site	52 per cent rated this measure as important (only 31 per cent measured)
Data reliability	Transaction error rate	80 per cent measured this measure (about 63 per cent measured)
	Number of backlog transactions	48 per cent rated this measure as important (only 32 per cent measured)
	User utilization	60 per cent rated this measure as important (only 45 per cent measured)
	Transaction cost	79.7 per cent rated this measure as important (only 24 per cent measured)
	Time taken to fix any interface problem	44 per cent rated this measure as important (only 5 per cent measured)
Time and cost	Administration time and cost	59 per cent rated this measure as important (only 33 per cent measured)
	Number of steps in procurement cycle	67 per cent rated this measure as important (only 43 per cent measured)
	Procurement cycle time	65 per cent rated this measure as important (about 50 per cent measured)
	Supplier-buyer response time	49 per cent rated this measure as important (only 44 per cent measured)
	Purchase lead time	60 per cent rated this measure as important (only 49 per cent measured)
e-Response	Mail service reliability	90 per cent rated this measure as important (about 75 per cent measured)
	Response time to trigger alarm	79 per cent rated this measure as important (about 70 per cent measured)
	Daily completed and outstanding number of transactions to respond	64 per cent rated this measure as important (about 60 per cent measured)
Invoice presentation and payment	Number of steps to process invoice	62 per cent rated this measure as important (only 48 per cent measured)
	Dispute resolution time	48 per cent rated this measure as important (only 38 per cent measured)
	Payment and reconciliation time	78 per cent rated this measure as important (about 67 per cent measured)
e-Document management	Document accuracy	100 per cent rated this measure as important (about 100 per cent measured)

Table I.
Results of the survey

the metrics (Hair *et al.*, 1998). This was done to verify if the measures measured the intended performance metric. Cronbach alpha values for various metrics are given in Table II. From the table, it can be inferred that all the metrics had high-reliability values. e-Document management metric was not tested for reliability since it had only

one measure. As a next step, CFA was performed on all the metrics using LISREL 8.52. The results of the test are given in Table III. The results of the validity tests indicate that the measures do measure the intended performance metric.

According to Singh and Byrne (2005), quantifiable and non-quantifiable benefits of e-supply chains are many. Some important benefits are: increased revenue from enhanced sales, reduced time in customer service, supply chain cost reductions, accuracy of data and an improved competitive position, improved customer service,

Table II.
Results of the reliability tests

Metric	Cronbach alpha
Web-enabled service	0.8899
Data reliability	0.8969
Time and cost	0.8938
e-Response	0.8634
Invoice presentation and payment	0.8517

Table III.
Results of validity tests

Metrics	Measures	CFA results
Web-enabled service (benefits: efficiency and effectiveness)	Global visibility through near real-time data System response time Data transmission speed Security of data Traffic by page and site	$\chi^2 = 16.72$ df = 9 p-value = 0.05331 RMSEA = 0.084 GFI = 0.96 RMR = 0.047
Data reliability (benefits: effectiveness)	Transaction error rate Number of backlog transactions User utilization Transaction cost Time taken to fix any interface problem	$\chi^2 = 18.11$ df = 9 p-value = 0.03390 RMSEA = 0.091 GFI = 0.95 RMR = 0.056
Time and cost (benefits: efficiency, effectiveness and strategic)	Administration time and cost Number of steps in procurement cycle Procurement cycle time Supplier-buyer response time Purchase lead time	$\chi^2 = 18.11$ df = 7 p-value = 0.0400 RMSEA = 0.075 GFI = 0.96 RMR = 0.047
e-Response (benefits: efficiency and effectiveness)	Mail service reliability Response time to trigger alarm Daily completed and outstanding number of transactions to respond	$\chi^2 = 14.35$ df = 5 p-value = 0.065 RMSEA = 0.057 GFI = 0.95 RMR = 0.039
Invoice presentation and payment (benefits: efficiency)	Number of steps to process Dispute resolution time Payment and reconciliation time	$\chi^2 = 15.00$ df = 5 p-value = 0.08 RMSEA = 0.04 GFI = 0.97 RMR = 0.02
e-Document management (benefits: effectiveness)	Document accuracy	NA

and applications of intelligent software for data mining and forecasting trends and demands. How do managers know if they have achieved these benefits?

Business managers depend upon metrics and measures to judge the results of managerial practices (Riggins and Mitra, 2001). There is a discernible trend of traditional supply chains either migrating to e-supply chains or expanding to incorporate e-supply chains (Bremser and Chung, 2005). According to Barnes and Hinton (2007), the unique characteristics of e-supply chains necessitate the need for new metrics to facilitate the development of innovative solution to emerging problems. A detailed literature review has exposed the dearth of metrics and measures appropriate to e-supply chains. Our validation survey with the practitioners in the electronics industry indicates that more than 50 per cent of the companies do not use metrics specific to e-business applications. This result is not surprising in a developing economy like Malaysia where the companies are still grappling with the implementation of e-supply chain initiatives and the companies that have implemented are struggling to identify the appropriate metrics to measure.

Our validation survey has revealed some interesting results. First, more than 50 per cent of the (important) measures are measured by less than 50 per cent of the respondents. Our informal discussions with a few companies revealed the following plausible reasons for this phenomenon, the:

- management does not effectively convey the need and the benefits of appropriate measures to the employees and therefore, the employees do not see their relevance;
- employees are not trained properly to capture the measures; and
- measures are captured but are not used by the managers for decision making and after some time the measures loose their significance.

These shortcomings must be overcome by the managers managing the e-supply chain initiatives to achieve the organizational goals.

Second, some important measures such as global visibility through real-time data, security of data, user utilization, number of backlog transactions, transaction cost, and administration time and cost that reflect the efficiency and effectiveness of e-supply chain initiatives are measured by a few companies. These measures help to justify the costly implementation of e-supply chain initiatives such e-procurement, e-payment, and other electronic transactions/processes. According to Sammon and Hanley (2007), the important measures of success of e-supply chain initiatives are the user utilization and the transactions processed.

To measure the performance of the e-supply chains, traditional metrics and measures do not suffice. Therefore, we have developed a set a metrics and measures that can be used by e-supply chains. The metrics and measures have been developed from the perspective of following benefits: efficiency, effectiveness and strategic benefits. A closer look at the metrics reveal that they address the following aspects of e-business: data transmission speed, security, data reliability, transaction cost and time, speed of response, electronic payments, and document management. These metrics can be applicable for any e-supply chain without regard to industry. Therefore, the metrics developed are generic.

5. Conclusions and limitations

e-Supply chains are fast becoming a reality. In order to manage such supply chains efficiently and effectively, traditional measures of performance are not adequate.

The main focus of this paper was to develop measures and metrics for e-supply chains. We developed six metrics and they were:

(1) web-enabled service metric;
(2) data reliability metric;
(3) time and cost metric;
(4) e-response metric;
(5) invoice presentation and payment metric; and
(6) e-document management metric.

Our study revealed that the development of measures and metrics for e-supply chains were important and the major challenge for the companies was to measure them. The managers have to educate the employees about the relevance of each measure and develop systems/procedures to capture the performance measures. Unless the measures are captured and used regularly for decision making, the targeted process improvements through e-supply chains may be difficult to achieve. To assess the success of e-supply chain initiatives, the managers must, at least, capture information on user utilization and transaction statistics (Sammon and Hanley, 2007).

For the supply chains to be successful its members must shift their focus from individual-member performance to supply chain performance and this requires integration (Smart, 2008). According to Kwon and Suh (2005), trust, commitment and communication between the supply chain members (managers) are critical to achieve integration. However, building and managing these factors is not an easy task since this process takes time to happen. The internet technologies have enabled supply chain members to be more integrated than ever before. The performance measures and metrics must reflect these initiatives. We believe that the measures and metrics discussed in this study can enable the supply chains to capture and improve their performance.

Our study has some limitations. First, we have developed the framework from a narrow perspective: benefits. The future studies can develop a framework from different perspectives. Second, we have validated the measures using the companies in the electronic industry. The future studies must validate these metrics and measures from other industries. This can guarantee the robustness of the measures used. Third, even though the metrics and measures developed in this paper are generic there can be other metrics and measures that can be of relevance and importance. An interesting future direction of this research is to study how the internet and other technologies, supply chain processes, and appropriate measures and metrics help to achieve supply chain integration.

6. Lessons learnt

There are many lessons that have been learnt from this study:

(1) Traditional performance measures do not suffice to measure the performance of e-supply chains.
(2) The performance measures and metrics must reflect the efficiency, effectiveness, and strategic benefits of e-supply chain initiatives.

(3) The companies involved in e-supply chain activities do realize the importance of the measures and metrics but do not measure them because:
   - the employees do not understand the relevance of measures;
   - of insufficient training given to employees to capture; and
   - of infrequent use of measures and metrics for decision-making purposes.

(4) The management responsibility is enormous in implementing the performance measures and metrics for e-supply chains.

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