Empirical Investigation of e-Supply Chain Management Experience in North American Electronic Manufacturing Services

Raul Valverde

*Concordia University, Canada*

Raafat George Saadé

*Concordia University, Canada*

Sherif Barrad

*Concordia University, Canada*

**introduction**

The paper examines the effect of E-Supply Chain Management Systems in the North American electronics manufacturing services industry. A causal and descriptive research study was conducted based on a survey applied to thirty six individuals in EMS firms in order to determine the impact of e-SCM on their key supply chain operations. Results of the research revealed that e-SCM had a positive effect in the EMS industry as these showed that the profits of the firm increased and internal communications were improved due to the implementation of e-SCM. The research also showed that e-SCMs have many technical issues such as problems with process automation and transmission of supply chain data, e-procurement effectiveness, integration with existing systems and the monitoring of inventory systems and purchasing process. Several recommendations are made to overcome these challenges including employee training and re-engineering of business processes for better system integration.

Key words: Supply chain management, Electronic manufacturing systems, E-business, Business models, E-SCM.

**Background**

The Electronic Manufacturing Services (EMS) suppliers are used by many companies as a strategic way to reduce time to market, decrease costs, improve quality, and improve overall customer satisfaction. Many manufacturers are developing closer relationships with their suppliers by using E-Supply Chain Management Systems (e-SCM) (Valverde & Talla 2012). This business-to-business approach not only provides the lenience of exchange in information, but also allows industries such as EMS to increase the accuracy and efficiency of business transactions processing.

The main purpose of this research is to investigate the following research question: Did e-SCM impact positively efficiency, satisfaction, quality and performance of North American EMS industry? This study is of significance to the EMS industry as it would provide a different view on the positive effects of e-SCM to its supply chain.

In the first stage of the study, a comprehensive literature review will isolate the body of knowledge available in E-business for EMS and identify any additional information gaps (Perry, 1998). Identified information gaps will be documented as open research issues (Yin, 1994).

After a literature review, the research methodology will be justified and explained. The results of the study will presented and analyzed in order to address the research objective. Finally, recommendations for improvement to the implementation of e-SCM strategies in the EMS industry will be documented.

This study is only limited to North American manufacturing industries in the EMS. This study will only conduct its research within those concerned in the industries. The outcome of this study will be from the primary data gathered from the result of the questionnaire survey and interview that will be conducted by the researcher. The conclusion and recommendation will only apply to EMS manufacturing industries that engage in e-SCM and those industries, which plan to engage in the online field sometime in the near future.

**Litterature review**

The literature review will start with an overview of the EMS industry, later the effect of Information Technology (IT) in the Supply Change Management will be examined and its impact in the EMS business model will be discussed. The literature review will end by outlining some key considerations with regards to platform security.

The Electronic Manufacturing Services (EMS) industry started over 30 years ago when companies were formed to manufacture designs created by governmental agencies such as the Department of Defense (DOD) and NASA. During the 1980s, a handful of contract manufacturing companies or *board stuffers* were formed each year. Many of these companies started with one or two Surface Mount Technology or SMT lines, accepting contracts from companies that had an overflow of work (ILO 2000, 2011).

To this end, SCM has emerged as a key competitive factor and companies such as Dell and Cisco have shown the economic power of a well-run supply chain. The pursuit of supply chain prowess has created a window of opportunity for EMS companies to move up the value-chain and beyond a simple manufacturing arm for customers.

We would argue, however, that many of the required supply-chain optimization skills are outside the realm of expertise of most high-tech companies and many of their supply-chain management results in shorter time-to-market cycles, reduced manufacturing cost, more competitive pricing power, and optimal use of capital. The competitive advantages are tied in with the essential long-term opportunity for EMS companies. Two major change agents are impacting the supply chain today. First is the Internet and second is the emergence of the EMS industry as a viable and attractive partner in supply-chain management.

The internet and IT have important effects in the modern supply chain management. The most import according to Simchi-Levi et al. (Simchi et al, 2003), the objectives of e-SCM are:

* + 1. Providing information availability and visibility
    2. Enabling single point of contact of data
    3. Allowing decisions based on total supply chain information
    4. Enabling collaboration with supply chain partners

Hua and Cong, 2011) define e-SCM as the management in all the processes in the entire supply chain, such as planning and forecasting, procurement, inventory, production, logistics, sales and information and other resources and customer satisfaction, which is achieved by the means of e-commerce of information technology. Hua and Cong (2011) indentify the core features of an e-SCM as:

* + 1. Strategy of cooperation among members
    2. Intelligent of Information Management
    3. The agility and flexibility of business
    4. Integration of the network organization

With the rapid rise of Business to Business (B2B) transactions over the internet, there is an increasing use of e-SCM solutions by large organizations for purchasing (Stephans & Valverde 2013). RFID technology has also transformed the supply chain management by providing real time intelligence for tracking enterprise assets (Khan & Valverde 2014) and for inventory management (Adoga and Valverde 2014).

According to Hua and Cong (Hua and Cong, 2011), e-SCM puts emphasis on the sharing resources and integration of information systems between the participating entities in the supply chain. Hua and Cong also mentioned that with the use of the information technology, it is possible to collect and analyse various information in the supply chain and with this the business can manage full range of information on the purchase of raw materials, production, distribution, marketing, customer relationship and react fast to business changes in demand and trends.

Integration of supply chains involve information sharing practices such as vendor-managed inventory (VMI) that give manufacturers access to more accurate demand information. (Småros et al., 2003) revealed that information sharing could improve production and inventory control efficiency with information sharing due to demand visibility.

IT is expected to have a pivotal role in managing supply chains, now and in the future. In fact it seems that the use of IT is crucial, especially in the fast moving industries: particularly for managing contemporary supply networks. The second major change agent that is impacting the supply chain today is the emergence of the EMS industry as a viable and attractive partner in supply-chain management.

The market may also expect that the 100 largest global tech companies will generate a majority of the revenues in the leading EMS companies (ILO 2000, 2011). This will carve out a large piece of the technology pie for those EMS companies and the resulting power shift will have implications on both the component manufacturers and distributors.

Internet technology has helped the EMS industry to control the supply change management. The EMS strategy of direct component purchases has been supported with the recent development of internet-based online marketplaces and although most EMS companies have not yet fully adopted this medium, they will become part of the EMS supply chain in the near future. The B2B market for components is still in its infancy, but nonetheless making its presence known. Today most of the B2B sites for electronic components online tend to be smaller in size.

Because of the rapid growth of the EMS industry, a sea change is taking place in how the supply chain will look, and component manufacturers and distributors are being forced to rethink their business models. It is a very interesting and challenging time for component distributors, as the impacts of the EMS industry and e-based exchanges have yet to be fully realized or understood.

**Changing EMS Business Models**

OEMs are now dictating margins to EMS companies, and margins are going down. This may make OEM shareholders happy, but in time, this trend could significantly weaken their own supply chain. What Ralph Kenton of Ralph Kenton and Associates refers to as the *hollowing-out* of the OEM is their increasing urge to outsource everything in order to focus on their core competencies (Lyell, 2000).

This trend is expected to result in OEMs' complete dependence on their suppliers-the same ones whose margins they are driving down. The disparity in perceived value for the design and marketing functions (OEM) versus the manufacturing and logistics functions (EMS), creates potential conflict between the two. This is because the margin equation is weighted heavily in OEMs' favor, due not only to inherently high margins (55-65 percent) dictated by their business models, but also because they control their suppliers' margins (in the four- to seven-percent range for the typical EMS focused on PCB assembly).

The only force that offsets a potential collision between OEMs and EMS is industry growth, and the single greatest source of EMS growth is OEM divestitures. Sixty-five percent of all EMS growth, as reported by Technology Forecasters (Lyell, 2000), is through the acquisition of OEM facilities. As long as this growth-by-acquisition trend continues, the two independent industries will continue to prosper, albeit in delicate balance.

The current rate of growth will eventually lead to a saturation of the total available market. There are currently many debates regarding the amount of time this process will take. However, if the trend stays constant, major penetration will be noticed in five years and complete in less than ten. Should this happen, it could have a profound impact on the delicate balance between OEM and EMS.

Consolidation has been an effective way to keep the shareholders of the declining margin electronics distribution business happy. Yet consolidation in distribution is a mixed bag for mid-tier OEM/EMS (ILO 2000, 2011) customers. Procurement of many component lines from a single supplier helps enormously to lower material logistics costs, but service is much worse than from smaller suppliers competing for the business. A significant part of distributor consolidation success-never easy-is due to a business model that allows the convergence of customer bases, and the ability to support thousands of purchasers.

Recent moves by semiconductor manufacturers indicate that they will not participate in the eroding margin game.

What was once two separate supply chains (EMS/electronic distribution) with margins for both has collapsed into one. EMS suppliers currently have an upper hand because of lower transaction costs and higher return on assets, but this advantage could change with the commitment to a *demand creation* model by the component manufacturers.

Yet there are several reasons an EMS might think of acquiring a distributor. Distributors understand material logistics far better than an EMS. Owning a distributor and eliminating double mark-up could increase EMS margins. The problem is that there are probably very few worthwhile distribution acquisitions left and a lot of competition for them.

More recently, with the increased emphasis on globalization, the practice of shedding functions previously thought to be integral to the company's success is becoming widespread, with companies switching all, or a substantial proportion, of their manufacturing from in house to external contract manufacturers. Such developments have caused the growth of contract manufacturers such as Flextronics and Solectron, who run large offshore manufacturing operations.

This is particularly true in the electronics field where recent years have seen spectacular growth in the electronics manufacturing services (EMS) industry. In 1998 the estimated value of EMS was $90 billion. One forecaster projected this value to grow 26% a year, which means, if this projection is correct, that the value of EMS will exceed $2880 billion by the year 2013.

Clearly, there are efficiencies to be realized in terms of lower labour costs and knowledge of basic production techniques and processes applicable across the products of several manufacturers. The result, at least in the short term, is lower costs, higher profits, an enhanced competitive position, and perhaps lower prices to the consumer.

Yet from the point of view of new product development and product improvement, it seems that there is an important hidden cost here. For years, spurred on by Japanese practice, it has been heard about product improvements having their roots in the factory floor.

Then there is the impact on designers and engineers responsible for product development. While the lack of factory floor suggestions is likely to have its greatest effect on incremental improvements in the product, it may also have an influence on the development of new products.

It is not only production that is at issue. Large contractors such as Solectron, Celestica, and Flextronics undertake to provide expanded functions such as new product design and development, and even new product launch services. Product innovation and improvement are skills that are honed by use and used as key elements in product differentiation and as points of competitive advantage.

One will never know exactly how the large-scale contracting out of manufacturing and other functions has affected the development of new products and the improvement of existing products. It is well to bear in mind, however, that with disuse, abilities decay and functions atrophy. It pays to bear that in mind when evaluating decisions on large-scale outsourcing.

**methodology**

The methodology chapter will start with an overview of the research methodology for the study, later descriptive research methods used are covered and in the last part of this chapter the causal research method used for the study is discussed.

**Overview**

For this study, descriptive and causal research will be used. Descriptive research will be used in order to determine the characteristics of the population used for the study while causal research will be used to determine the cause-effect relationships between e-SCM and the variables identified in the research questions.

Survey questionnaires will be used for data collection in the descriptive research.

Reliability is another advantage of questionnaires and refers to "the repeatability or replicability of findings" (Sommer & Sommer, 1997). That is, as respondents simply nominate a particular box to answer questions, no value judgements are required. On the other hand, it is likely that responses gathered by qualitative means such as interviews, would be interpreted differently depending on the personal bias of the researchers.

Questionnaires were distributed among the respondents who were named among the top ten known EMS companies with global reach headquartered in the North American/American region. Further, this research will also use interview questionnaires. The questionnaires will be used to collect quantitative data and the interviews will be used to provide qualitative insights into the data collected.

This study will also employ causal research because it will attempt to find and build the relationships that will explain how one variable relates to another variable through qualitative analysis. Through this type of analysis, qualitative elements that do not have standard measures such as behaviour, attitudes, opinions, and beliefs within the industry will be analyzed.

**Descriptive Research Methods**

The research project was based on primary investigations from the EMS industry conducted between January and April 2010. The settings for the research were a number of North American /American EMS firms. The justification for the present research design was to discover the impact, which e-SCM has placed on the Electronic Manufacturing Service Industry. The research utilized a multi-method approach combining qualitative and quantitative methods.

A survey instrument was designed with questions covering the different areas (See Appendix A)

1. E-SCM impact on SCM.
2. E-SCM’ effectiveness on SCM tasks.
3. Satisfaction of the e-SCM’s users when dealing with customers with respect to the addressing of information and communication needs;
4. E-SCM Quality
5. E-SCM Performance in the Different Supply Chain Task Areas.

The Likert Scale will be applied as the data collection instrument, with A having the highest score and E the lowest.

**Statistical Methods**

Statistical methods were then applied to be able to:

1. Get the range of data or deviation from the standard representative data from sample;
2. Get the range of data or deviation from the standard representative value;
3. To test if the obtained standard data from the sample of 36 respondents does indeed represent the entire group;
4. To test slight differences in representative data between groups of questions.

However, for further testing, we can give weights to the answers and look for the mean answers of every question. We therefore assigned values to the letter responses in the questions as follows:

• S(Strong) = 5, C(Considerable) = 4, M(Medium) = 3, L(Low) = 2, W(Weak) = 1

To summarize the statistical analyses made on the results of the primary research, the following shall be presented in tabular form:

1. The modes of each question in the survey;
2. The means of each question in the survey;
3. The standard deviations of each question in the survey;
4. The means of the groups of similar questions in the survey;
5. The results of the two-tailed tests to determine consistencies in the results per group.

The impact of e-SCM on the sample group of EMS firms will clearly be seen in the results mentioned above, as seen from the viewpoint of the people working in these EMS companies themselves.

The main goal of causal research is identification of cause-and-effect relationships between variables (Zikmund, 2000). In order to do causal analysis, we followed a simplified cognitive mapping approach that will allow us to investigate the influences between the set of constructs studied. Cognitive mapping represents causal relationships between subjective variables that are suspected to be important in a specific context. A cognitive map entails factors/variables, arrows that represent the relationship between any two factors and causality indicating negative/positive strength. The cognitive mapping technique involves the creation of an influence matrix generated by a number of simulations. The simulation matrix is then used to understand the relationships network between the factors in consideration.

**analysis of results**

The analysis of results chapter will start with an overview of the descriptive portion of the research and its interpretation and it will be followed by a causal research analysis.

**Descriptive Research & Interpretation**

In the survey used for this research, the value of 5 was given to *S(Strong)*, 4 to *C(Considerable)* 3 to *M(Medium)*, 2 to *L(Low)*, and 1 to *W(Weak)*. Therefore it became possible to calculate the value of the mean and standard deviation per question in the survey.

The questions in the survey were divided into 5 groups as indicated below:

1. E-SCM impact on SCM – which defined the positive effect e-SCM has on information flow, document preparation, company productivity in terms of increases in sales and total assets
2. E-SCM’ effectiveness on SCM tasks; which attempts to measure the perception of the employee himself with regards to the fact whether or not improvements have been made in the many aspects of his job;
3. Satisfaction of the e-SCM’s users when dealing with customers with respect to the addressing of information and communication needs;
4. E-SCM Quality – which attempts to measure the technical aspect of the e-SCM in use in the firm;
5. E-SCM Performance in the Different Task Areas – which measures the efficiency of E-SCM in different workplaces in the firm, especially procurement, product distribution, and purchasing.

Below are the tables with the means per question in the survey, as well as the means of each group with their corresponding standard deviations.

In the first group (table 1), questions were prepared in order to determine the level of impact of e-SCM in the productivity, efficiency and cost of operation in the industry researched.

*Table 1: Group 1: E-SCM’s impact on supply chain*

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
|  | **S** | **C** | **M** | **L** | **W** | **Mean** |
| Efficiency in Information Flow | 12 | 16 | 8 | 0 | 0 | 4.10 |
| Reduced Cost in Document Preparation | 7 | 22 | 5 | 2 | 0 | 3.94 |
| Productivity: Increase in Sales/Total Assets | 4 | 21 | 9 | 2 | 0 | 3.75 |
| Increase in Sales/Employee Ratio | 6 | 14 | 15 | 0 | 1 | 3.67 |
| **Group Mean** | | | | | | **3.90** |
| **Group Standard Deviation** | | | | | | **0.17** |

The group mean of 3.9 tells us that there is a considerable impact of the e-SCM in the SCM. Most respondents considered e-SCM as being a technology that impacts positively the SCM.

The second group of questions were used in order to measure the effect of e-SCM in the cost, productivity and profitability of the industry researched in terms of the SCM tasks (see table 2).

The group mean of 3.9 reveals a considerable effect of the e-SCM in making more efficient the SCM.

*Table 2: Group 2: E-SCM’s effectiveness on SCM tasks*

|  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  |  |  |  | **S** | **C** | **M** | **L** | **W** | **Mean** |
| Reduced Leadtime to Customer | | |  | 8 | 21 | 6 | 1 | 0 | 4.00 |
| Reduced Stockouts of finished products | | |  | 8 | 22 | 5 | 1 | 0 | 4.03 |
| Reduced Inventory Carrying Costs | | |  | 8 | 18 | 8 | 2 | 0 | 3.90 |
| Reduced Stockouts of Production | | |  | 5 | 22 | 6 | 3 | 0 | 3.80 |
| Reduced Distribution Costs to Customers | | |  | 9 | 14 | 12 | 1 | 0 | 3.86 |
| Reduced Distribution Costs from Suppliers | | |  | 5 | 20 | 10 | 1 | 0 | 3.80 |
| Performance Increase in Income to Capital ratio | | |  | 2 | 24 | 10 | 0 | 0 | 3.80 |
| Increased Return on Sales | |  |  | 5 | 21 | 10 | 0 | 0 | 3.86 |
| Increase in Revenues | |  |  | 4 | 20 | 12 | 0 | 0 | 3.80 |
| **Group Mean** | | | | | | | | | **3.90** |
| **Group Standard Deviation** | | | | | | | | | **0.05** |

The third group of questions (see table 3) were intended to measure the level of satisfaction that e-SCM causes to its users of electronics SCM Systems.

*Table 3: Group 3: Satisfaction of e-SCM’s users*

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  |  |  | **S** | **C** | **M** | **L** | **W** | **Mean** |
| Overall satisfaction | | | 6 | 19 | 11 | 0 | 0 | 3.86 |
| Info needs for transacting w/suppliers | | | 9 | 17 | 10 | 0 | 0 | 3.97 |
| Info needs for transacting w/customers | | | 9 | 19 | 7 | 1 | 0 | 4 |
| Internal Communication Needs for transacting/interacting w/suppliers | | | 11 | 20 | 5 | 0 | 0 | 4.2 |
| Internal Communication Needs for transacting/interacting w/customers | | | 12 | 15 | 6 | 3 | 0 | 4 |
| Communication needs for transacting w/ customers | | | 6 | 22 | 7 | 1 | 0 | 3.94 |
| Relation of E-SCM to EMS Industry | | | 9 | 20 | 7 | 0 | 0 | 4.05 |
| **Group Mean** | | | | | | | | **4.00** |
| **Group Standard Deviation** | | | | | | | | **0.04** |

Based on the results, it is possible to deduct that most respondents were considerably satisfied with e-SCM although there were few respondents that had low satisfaction with the use of e-SCM.

Questions in the fourth group (Table 4) intended to measure the quality of the e-SCM. The quality variables identified in the survey were: internal access convenience, accuracy, response time, usability, ease of learning and user friendliness.

*Table 4: Group 4: E-SCM quality*

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  |  |  | **S** | **C** | **M** | **L** | **W** | **Mean** |
| Internal Access Convenience | | | 9 | 19 | 7 | 0 | 1 | 3.97 |
| Accuracy | | | 5 | 23 | 8 |  |  | 3.92 |
| Shorter Response Time | | | 11 | 21 | 3 | 1 | 0 | 4.12 |
| Useful functions and features | | | 6 | 26 | 4 | 0 | 0 | 4.05 |
| Ease of Learning to Use | | | 4 | 23 | 9 | 0 | 0 | 3.86 |
| User Friendliness | | | 5 | 25 | 6 | 0 | 0 | 3.97 |
| Remote Access Capability | | | 13 | 22 | 1 | 0 | 0 | 4.33 |
| **Group Mean** | | | | | | | | **4.03** |
| **Group Study Deviation** | | | | | | | | **0.06** |

Most respondents considered e-SCM of being of high quality; this indicates that the current technology for e-SCM is robust and stable enough to satisfy quality expectation of users. Questions in the fifth group (see table 5) were used to measure the effect of the e-SCM in the efficiency of tasks performed in the operations in the researched industry.

*Table 5: Group 5: e-SCM in different task areas*

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  |  |  | **S** | **C** | **M** | **L** | **W** | **Mean** |
| Effective intranet for internal communication | | | 7 | 21 | 7 | 0 | 1 | 3.92 |
| e-SCM monitors Inventory system & purchasing situation | | | 7 | 17 | 8 | 3 | 1 | 3.72 |
| Effective e-SCM for product distribution | | | 9 | 18 | 7 | 2 | 0 | 3.94 |
| Effective e-SCM for procurement | | | 4 | 19 | 11 | 1 | 1 | 3.67 |
| Automated Transmitting and Processing of Data | | | 5 | 14 | 16 | 0 | 1 | 3.61 |
| Internet Enabled System for Sharing | | | 7 | 19 | 9 | 0 | 1 | 3.86 |
| e-SCM system Fully Integrated with existing systems | | | 4 | 19 | 12 | 1 | 0 | 3.72 |
| E-SCM beneficial to EMS industry | | | 14 | 19 | 3 | 0 | 0 | 4.30 |
| Adequate Training for Users | | | 3 | 21 | 12 | 0 | 0 | 3.75 |
| Extranet Exists for Communication to External Parties | | | 2 | 24 | 10 | 0 | 0 | 3.80 |
| **Group Mean** | | | | | | | | **3.80** |
| **Group Study Deviation** |  | | | | | | | **0.10** |

The group mean of 3.8 reveals that most respondents evaluate e-SCM as a tool that considerably facilitates the operations of the SCM.

Based on the computation of the mean, below (see table 6) are the five highest-ranked questions, meaning these five questions were found out to have the most positive response from the survey respondents:

*Table 6: Five highest-ranked questions*

|  |  |  |
| --- | --- | --- |
| **Question** | **Group** | **Mean** |
| Remote Access Capability | 4 | 4.33 |
| E-SCM beneficial to EMS industry | 5 | 4.30 |
| Internal Communication Needs for transacting with Suppliers | 3 | 4.20 |
| Shorter Response Time | 4 | 4.12 |
| Efficiency in Information Flow | 1 | 4.10 |

From table 6, we can deduct that e-SCM has affected the way the EMS integrates with their suppliers.

Below (see table 7) are the five questions with the lowest means, meaning, these five questions were found out to have elicited the most negative responses from the survey respondents:

*Table 7: Five lowest-ranked questions*

|  |  |  |
| --- | --- | --- |
| **Question** | **Group** | **Mean** |
| Automated Processing &Transmitting of Data | 4 | 3.61 |
| Increase in Sales to Employee Ratio | 2 | 3.67 |
| Effective e-SCM for procurement | 4 | 3.67 |
| E-SCM Fully Integrated with existing systems | 4 | 3.72 |
| E-SCM monitors Inventory system & purchasing situation | 4 | 3.72 |

Although these 5 questions still have an average mean that reflects a positive view of e-SCM, they reflect areas of opportunities for improvement. It seems that the common ground of for four of these questions is technical related to data transmission, integration, e-procurement and monitoring of inventory and purchasing..

The standard deviations per group, could give an insight as to the consistency of the responses across all the firms surveyed.

*Table 8: Summary of Standard Deviations per Group*

|  |  |
| --- | --- |
| **Group** | **Standard Deviation** |
| E-SCM’ Impact on SCM | 0.17 |
| E-SCMs effectiveness on SCM tasks | 0.04 |
| Satisfaction of e-SCM’s users | 0.04 |
| E-SCM Quality | 0.06 |
| E-SCM in the different task areas | 0.10 |

As one can see, the most consistent scoring was found in the satisfaction e-SCM’s users. This shows that the most respondents were satisfied as users of e-SCM.

Also, some of the other comments added by the respondents collected from the open question *Do you have any additional comments on the impact of E-SCM on the EMS industry?* were:

1. Employee training for the use of e-SCM in the firm is necessary. E-SCM in all EMS industries is necessary for the firm to be able to adapt to the changing needs of the industry itself.
2. Purchasing becomes more cost-effective and efficient with the use of e-SCM.
3. E-SCM minimizes errors and promotes productivity for all levels in the firm.
4. E-SCM in all EMS industries is necessary for the firm to be able to adapt to the changing needs of the industry itself.
5. The information generated by E-SCM is equivalent to money for the firm.

The first comment is of high interest to the researcher as this could be a possible explanation of some of the problems indicated by some of the respondents as e-SCM integration and data transmission. If firms are not investing enough money on technical training, technical staff might not be able to make e-SCM fully functional and some might perceive this as a short come of e-SCM systems. The other comments indicate that e-SCM has the SCM in the EMS industry in terms of efficiency of operation. A second set of tests, namely, the two-tailed tests, will be performed on pairs of groups of similar questions to determine if there are inconsistencies in the responses thereto. The two tailed tests are done therefore to find out if indeed there are any differences between the replies of two groups of questions, and if the differences are only due to chance or are actual differences themselves.

For the two-tailed tests, our main hypothesis is that there are no significant differences between the means of the pairs of groups of questions. The first pairing of groups of questions selected was the pair of groups two and three. They were selected because they both deal with the efficiency of certain tasks in the e-SCM in dealing with both their customers and suppliers. The second pairing of questions was the pair of groups three and four. This pair was selected for the reason that both groups of questions deal with satisfaction on both the employee involved in e-SCM. The last pairing of questions was the pair of groups one and three since they both deal with the flow of information in the e-SCM in the firms. Below are the results of the two tailed tests (See table 9):

*Table 9: Results of the two tailed tests*

|  |  |
| --- | --- |
| Between Groups 2 & 3 – z | -2.23 |
| Between Groups 3 & 4 – z | -7.75 |
| Between Groups 1 & 3 – z | - 3.31 |

Since all values are beyond the range -1.96 to +1.96, it is evident that there are marked differences in the means of the said groups. This can be interpreted to mean that the respondents answered each of the questions independent of one another, thinking rather per question alone.

**Causal Research Analysis**

In the cognitive mapping approach, the influence matrix is composed of row scenarios and column factors. Row scenarios (or *run* as shown in table 10) are viewed as causal and column factors are viewed as the resulting effect. The usefulness of the matrix (table 10) becomes clear when we introduce a different stimulus to a factor and see how the response changes. The objective is reveal significant influences on the outcome factors by which reasonable recommendations can be made for the context being considered.

In order to achieve that, a simulation matrix needs to be constructed as shown in table 10. The simulation matrix can be used effectively to perform what-if simulations (Runs) to investigate influences and predictive abilities.

Table 10: Results of the cognitive mapping simulations

|  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| ***Run*** | ***eSCM*** | ***EFF*** | ***S*** | ***SQ*** | ***SU*** | ***U-B*** | ***S-B***  *Pearson*  *Coefficient* | ***t-score*** | ***Adj. R2*** | ***ϭ*** |
| 1 | 1 | 1 | 0 | 0 | 0 | -0.34 | -0.22 | -2.70 | 0.04 | <0.01 |
| 2 | 1 | 0 | 1 | 0 | 0 | 0.29 | 0.18 | 2.24 | 0.03 | <0.05 |
| 3 | 1 | 0 | 0 | 1 | 0 | -0.55 | -0.31 | -3.89 | 0.09 | <0.001 |
| 4 | 1 | 0 | 0 | 0 | 1 | -0.33 | -0.30 | -3.74 | 0.08 | <0.001 |
| 5 | 0 | 1 | 1 | 0 | 0 | -0.02 | -0.04 | -0.28 | -0.01 | NS |
| 6 | 0 | 1 | 0 | 1 | 0 | -0.01 | -0.01 | -0.10 | -0.01 | NS |
| 7 | 0 | 1 | 0 | 0 | 1 | -0.11 | -0.16 | -1.94 | -0.02 | <0.05 |
| 8 | 0 | 0 | 1 | 1 | 0 | -0.00 | -0.002 | -0.82 | -0.01 | NS |
| 9 | 0 | 0 | 1 | 0 | 1 | -0.03 | -0.04 | -0.46 | -0.07 | NS |
| 10 | 0 | 0 | 0 | 1 | 1 | -0.18 | -0.29 | -3.59 | -0.08 | <0.001 |

**U-B**: Unstandardized Beta Coefficient; **S-B**: Standardized Beta Coefficient; ***ϭ***: Significance.

Table 10 (simulations matrix) presents the results of the simulations which totalled 10 linear regression runs. The first column to the left identifies the run number. The following 5 columns identify the use of the factor for regression by 0=not used and 1=used. Therefore each run will constitute two 1s and three 0s. Unstandardized, and standardized beta coefficients are then provided followed by the t-score, r-squared and significance level.

Table 10 shows that 6 (1 to 4, 7, and 10) out of the 10 runs are significant relationships with sigma values less than 0.05. The strongest relationships are for runs 3 (eSCM to SQ), 4 (eSCM to SU), and 10 (SQ to SU). This is a clear indication that there is strong correlation between eSCM, SQ and SU. Interestingly and further supporting the correlation between these three factors, the standardized beta coefficients for all 3 relationships are practically equal at 0.3. It is evident therefore from the latter that the impact of eSCM is strongly related to quality and performance.

**Discussion & conclusions**

# *Did e-SCM impact positively efficiency, satisfaction, quality and performance of North American EMS industry?* is the primary research question of this study. To investigate this, we created a number of questions related to 5 impact categories: eSCM impact on SCM, eSCM impact on effectiveness, eSCM satisfaction, eSCM system quality and eSCM performance. This subjective assessment was emailed to over 800 North American companies and then followed up by email and telephone reminders for completion. A database of these companies was used. Around 40% of the emails were bounced back. Other emails were replied to saying that the person in charge is not available or not in the company any more. In the end a total of 36 usable responses were obtained over a period of around 8 months of data collection. The 36 responses were analysed in two different ways, namely via descriptive statistics and regression analysis.

# The results of the study, shows that most respondents believe that E-SCM has a considerable positive impact in the SCM of the EMS industry as it promotes better communication between the firm and its suppliers, facilitates document preparation and provides for better remote access capability thereto. The survey revealed that the use of e-SCM in the firm for SCM will lead to fewer errors by employees and thus cost savings.

# Shorter response times and better information flow has been seen as one of the most important positive effects of the e-SCM on the EMS industry. This is critical for a low cost strategy that requires the implementation of just in time and other lean strategies that require quick response times and high level of integration with suppliers for inventory information systems.

However, the study revealed certain areas of opportunity. Employee training is a necessity at this point in time such that the e-SCM in place in the firm operates smoothly. Employees clearly see this activity as a long-term investment, which will ultimately benefit both the firm and its employees.

The research also revealed that e-SCM have many technical issues such as automated processing and transmission of supply chain data, e-procurement effectiveness, integration with existing systems and monitoring of inventory systems and purchasing process. These technical challenges are related to the complexity of integrating e-SCM with existing Enterprise Resource Planning systems that might be from different vendors or follow different standards. E-SCMs are normally used to integrate business functions and business processes within and across companies, into a cohesive and high-performing business model. Existing Enterprise Resource Planning systems mightneed to be re-engineered to better support modern e-SCMs.

# Many businesses have invested an enormous amount of resources and effort in the development of e-SCMs. In general, they contend that this saves them a considerable amount of time and money and, perhaps more importantly, provides them with an opportunity to be more competitive and profitable. A lot of anecdotal evidence in the literature supports their contention but there is no hardcore empirical evidence to back their claims. This research fills this gap by providing empirical evidence of the much anticipated relationships between e-SCMs and business value. To the best of our knowledge, this is the first such attempt in this area. The results of the study should, however, be viewed with caution due to small sample size.

# Much of the data gathering are from literature and limited responses from individuals surveyed. Future research related to this topic should be continued. A suggestion would be to make the same survey more technical oriented and involve technical staff as many of the issues seem to come from the technical perspective. Many of these issues could be avoided in the causes are discovered and aid in the selection and adoption of e-SCMs.

# In closing, the study has been able to dissect the impact of e-SCM in the EMS industry; that is, it has been able to pinpoint the specific areas where e-SCM has the greatest impact. The research has also identified areas of improvements for the industry in particular the need for employee training in the use of e-SCM and the need for better integration of these with Enterprise Resource Planning systems.

**limitations and further research**

The findings of this study must be considered in light of the limitations of our approach. First, the questionnaire approach in general as a method of study is not free of the subjectivity of the respondents. Second, while the respondents are expected to be senior management (and all efforts were made to ensure that they are), and that the subject matter is appropriate to the respondents’ context; caution needs to be taken in generalizing the results. Therefore, generalizing the respondents’ perceptions to a broader workforce may be limited. Criticism about using email for surveying senior management in large corporations for research purposes has been made to the point where they may not necessarily represent the target population. The influence of the quality of information in listing databases may vary drastically and needs further research.

Conclusions drawn in this study are based on the concept of eSCM impact on SCM in a specific manufacturing segment in the North American Electronic Manufacturing Services Industry. The survey used here may not necessarily be appropriate and apply to other manufacturing segments.

Finally, the regression used in this study predicts causal relationships between the variables studied. Measures of the variables were gathered at one point in time. Therefore, causality cannot be inferred from the results and conclusive statements about causality cannot be made since alternative explanations cannot be ruled out.

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# APPENDIX A: QUESTIONNAIRE

***Personal Information***

Name (optional):

E-Mail (optional):

What is your professional field?

***For the rest of the questions (S=Strong, C=Considerable, M=Medium, L=Low, W=Weak)***

**GROUP 1: E-SCM IMPACT on SCM**

**To what extent does eSCM impact SCM in the key indicative areas below?**

1. Efficiency in flow of information and documents
2. Reduced costs in preparation of documents
3. Productivity-Increases in Sales/Total assets ratio
4. Increases in Sales/Employee ratio

**GROUP 2: E-SCM Effectiveness**

**To what extent does eSCM impact the effectiveness of SCM tasks?**

1. Reduced lead-time to customer
2. Reduced stock outs of finished products
3. Reduced inventory carrying costs
4. Reduced stock outs of production materials
5. Reduced distribution costs to customers
6. Reduced distribution costs from suppliers
7. Performance-Increase in income/capital ratio
8. Increase in return on sales
9. Increase revenues

**GROUP 3: Satisfaction of the E-SCM**

**To what extent, users of eSCM are satisfied?**

1. Information needs internally
2. Information needs for transacting/interaction with suppliers
3. Information needs for transacting/interaction with customers
4. Communication needs internally
5. Communication needs for transacting/interacting with suppliers
6. Communication needs for transacting/interacting with customers
7. To what extent, eSCM is related to EMS industry?

**GROUP 4: E-SCM Quality**

**With respect to eSCM, how will you rate system quality?**

1. Internal access convenience
2. Accuracy
3. Shorter response time
4. Useful functions/features
5. Ease of learning to use
6. User friendliness of system
7. Remote access capability

**GROUP 5: E-SCM Performance**

**On system usage, how will you rate your current eSCM in the following areas?**

1. Effective Intranet for internal communication
2. System monitors inventory and purchasing situation
3. Effective electronic system for product distribution
4. Effective electronic system for procurement
5. Automated transmitting and processing of data
6. Internet enabled system for information sharing
7. eSCM system fully integrated with existing systems
8. To what extent eSCM is beneficial to EMS industry?
9. Adequate training provided for users
10. Extranet exists for communication to external parties