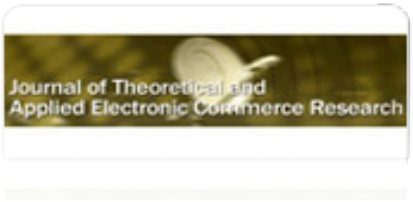

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The Effect of E-Supply Chain Management Systems in the North American Electronic Manufacturing Services Industry

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Abstract

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 electronic manufacturing services firms in order to determine the impact of e-supply chain management on their key supply chain operations. Results of the research revealed that e-supply chain management had a positive effect in the electronic manufacturing services industry as these showed that the profits of the firm increased and internal communications were improved due to the implementation of e-supply chain management. The research also showed that e-supply chain management systems 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.

Keywords: Supply chain management, Electronic manufacturing systems, E-business, Business models, E-SCM

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1 Background and Objective of Study

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. Before the 1980's, EMS were primarily utilized to reduce labour costs and to provide additional manufacturing capabilities. EMS customers provided all board designs, components and testing. In the 1980's, because of the rapid increase in electronic manufacturing, EMS providers stretched their services to not only provide consignment but complete turnkey services such as product design, materials management, final assembly, and in some cases, after-sale services. Close to 60% of all products produced by EMS providers are for the computer or consumer products industries. Other industries utilizing EMS include automotive, communications, medical and office equipment. With the reality that most companies want to reduce labour costs, many turn to outsourcing through EMS to gain advantage. Outsourcing is a management strategy that farms out non-core organizational activities to vendors who specialize in these activities in order to execute them more efficiently.

On the side of the EMS industries, they have utilized the advent of the Internet as an advantage to promote their products well and to have a real time connection with their customers. The changing environment of the business market, with its focus on costs, quality, flexibility and technology to meet the competitive challenges is causing major changes in inter-organizational business relationships and many manufacturers are developing closer relationships with their suppliers the application of E-Supply Chain Management Systems (e-SCM). 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 [21]. Identified information gaps will be documented as open research issues [33].

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.

2 Literature 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.

2.1 Electronic Manufacturing Services Industry

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 [11].

Since then, the EMS industry has grown to an estimated $100 billion-industry worldwide. Today EMS companies offer a full range of services that include design, engineering, manufacturing, test and logistics to original equipment manufacturers (OEMs) like Dell, Ericsson, Motorola and Microsoft. This outsourcing model involves a complex process in which services must be offered across the entire product cycle from product design to system build to logistics. A turnkey approach to manufacturing allows the EMS to take projects from the concept and design phase to industrialization, manufacturing and deployment [11].

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2.2 E-SCM, E-business and the EMS Industry

As the EMS industry is attempting to re-engineer the supply chain system, perhaps a more accurate description of the sector would be supply-chain engineers. We use the term supply-chain engineers with the understanding that it applies to a variety of capabilities well beyond printed circuit assembly and encompasses engineering services, prototyping, testing, system assembly, power, memory, packaging and distribution, and repair and warranty services. Coordinating these activities to run as a smooth-flowing process is the essence of supply chain management (SCM) and the opportunity for the EMS Company.

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. Within the world of technology hardware, the management of the supply chain is emerging as an important strategic factor.

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 of the aforementioned factors are clear and tie in with the essential long-term opportunity for EMS companies as the virtual OEM enabled. It is imperative that companies squeeze every last ounce of efficiency out of their supply chain, starting with new product introduction programs and continuing on through to end-of-life management. To accomplish this, companies have to re-engineer the entire concept of supply-chain management. Two major change agents are impacting the supply chain today. First is the Internet, which has set into motion an unquantifiable number of changes within the supply chain and has forced major shifts in business practices including the opening up of Internet-based exchanges for components, which will be discussed later. Second is the emergence of the EMS industry as a viable and attractive partner in supply-chain management. In many parties' opinion, the EMS industry is quickly developing into the premier source in a new and higher segment of the value chain that is driving the explosive growth of the industry and having repercussions throughout the electronics supply chain [18]. This first agent will be discussed in detail in next part of this section.

The internet and IT have important effects in the modern chain management. The most import according to Simchi-Levi et al. [23], the objectives of e-SCM are:

- Providing information availability and visibility
- Enabling single point of contact of data
- Allowing decisions based on total supply chain information
- Enabling collaboration with supply chain partners

Hua and Cong [10] 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) identify the core features of an e-SCM as:

- Strategy of cooperation among members
- Intelligent of Information Management
- The agility and flexibility of business
- Integration of the network organization

According to Hua and Cong [10], e-SCM puts emphasis on the sharing resources and integration of information systems between the participating entities in the supply chain 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. Mohammadi et al. [17] conducted a study that revealed that the improvement in supply chain capabilities through Information Technology (IT) allows the firm to learn and respond to market changes better and quicker than competitors.

IT has been recognized as an important strategic driver for SCM. Bowersox and Daugherty [4] outlined that IT is key in supporting companies creating strategic advantage by enabling centralized strategic planning with day-to-day centralized operations. A common view held is that IT has a profound impact on managing supply chains. Using

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case studies in six Finnish industrial supply chains as data, Kemppainen and Vepsäläinen [12] argue that IT is, alongside specialization and outsourcing, a key precondition for networking of organizations.

Because of internet technologies, supply chains become more integrated and more market oriented [7], [16], [31]. For example, Williams et al. [31] suggest that e-SCM combines the structural benefits of Supply Change Management with the efficiency benefits of an arm length approach, enabling, for example, lower cost through possibilities of selecting from a larger supplier base. Tai's [29] study revealed that internet based procurement systems enabled firms to improve their intra- and inter-organizational process integration capabilities which, in turn, yield sustained gains in organizational performance

Wieder et al. [30] examined the rationale for IT integration by analyzing the problems of enterprise resource planning (ERP), electronic data interchange (EDI) and presented the solutions of e-SCM. Wider et. al found that firms with ERPs tend to deliver higher overall performance. In the same paper, Wieder et al. [30] found that EDI adopters perceived more operational benefits, more external pressure and mutual understanding, and fewer technical and organizational difficulties than non-adopters of EDI.

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. [26] used discrete-event simulation to examine how a manufacturer can combine traditional order data available from non-VMI customers with sales data available from VMI customers in its production and inventory control and what impact this has on the manufacturer's operational efficiency. Smaros et al. [26] revealed that information sharing could improve production and inventory control efficiency with information sharing due to demand visibility. Kocakulah et al [13] mentioned that one major benefit of e-business is the ability to more efficiently manage the supply chain and that although the process of developing and implementing e-business can consume a large amount of resources and may pose some managerial challenges, the benefits derived from e-business will more than justify the costs expended and will allow a business to remain competitive and sustain a competitive advantage.

The landmark work of Malone et al. [16] proposes that the value offerings through internet are electronic communication (speed of communication), electronic brokerage (by IT providing a lean, automated intermediary for resolving market transactions), and electronic integration (coupling of processes).

IT seems to be particularly important in fast clock speed industries [8] or when flexibility and agility are needed [9], [22]. Without doubt, the Internet is transforming the conventional supply chain. In the pre-Internet era, a product had to travel a long road from the design table to the consumer, passing from manufacturer to supplier to retailer, and even one or more resellers, before reaching its final destination. By processing orders over the Internet, organizations need to rethink the relationship between existing data and applications and how they can benefit from having more tightly integrated communications with a more optimized business process. This will mean a radical departure from the tradition application design and manufacturing development and production of which have been previously somewhat remote to each other.

Sudhindra [28] looks at the concept, history and evolution of internet technology in manufacturing and explains the changes from traditional isolation of the shop floor to an interactive supply chain. By embracing the internet and connecting suppliers and the supply chain has the potential to make huge gains in efficiency. Seamless connectivity to the entire supply chain via the web includes real time connectivity, comprehensive people management, products and processes. Manufacturing strategies and aims have evolved in the last century, in scale and resource against cost and quality, through to the production of large quantities in the 1990's.

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. It is believed the EMS and component distribution industries will be competitors in many ways. The current distribution model has developed to manage logistics and component inventory for both large and small customers so that a single source is available to purchase a wide variety of components, as opposed to dealing with multiple vendors. As the EMS industry gains more control over the supply chain, the need for distributors should diminish as EMS providers move to offer the same services for its customers. It is expected that this competition will grow over the next few years as the EMS industry continues on its rapid growth track. Top-tier EMS companies are expected to rapidly approach revenue levels of over $20 billion each, and serve a large number of companies expanding across every segment of the electronics industry [4].

In aggregate the EMS industry will generate over $654 billion in annual revenue by 2016 alone [20], with further growth opportunities available through second stage outsourcing in Europe and the potential unlocking of Japan. Of this total dollar value estimates that approximately 50% to 60% is generated via component sell-through. With such a large and growing presence in the supply chain [4], the EMS industry will have even better purchasing power across more SKUs, and there is speculation that the larger EMS companies will have a powerful influence over the approved vendor list. These factors combined should give sufficient strength and incentive to continue bypassing intermediate distributors and the associated markup by purchasing directly from component manufacturers. Current statistics estimate that top-tier EMS companies use traditional third party distributor relationships for approximately

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10% to 15% of their component needs today [4]. However, it is believed this percentage is abnormally high due to the tight component market and that as supply improves, a lower quantity (5% to 10%), will be purchased through traditional distributors [4].

Distributor purchases tend to be meaningfully higher (40% to 60% of total need) for smaller EMS companies, which do not have the same logistics expertise, operating economies or diverse component requirements of the largest EMS providers. Current trends would indicate, however, that the largest EMS companies should continue to gain market share, with a portion of the industry revenue concentrated in the top 5 to 10 companies.

The market may also expect that the 100 largest global tech companies will generate a majority of the revenues in the leading EMS companies [11]. 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.

The impact of IT in the SCM has also affected the EMS industry and the traditional component distribution model. As online business and E-business become more common place traditional ways of business are fading. The Internet is transforming the conventional supply chain. In the pre-Internet era, a product had to travel a long road from the design table to the consumer, passing from manufacturer to supplier to retailer, and even one or more resellers, before reaching its final destination. However, nowadays the Internet has changed the way the SCM is managed.

Sudhindra [28] in his white paper on the subject of responsive shop floors, looks at the concept, history and evolution of e-manufacturing and explains the changes from traditional isolation of the shop floor to an interactive supply chain. By embracing the internet and connecting suppliers and the supply chain has the potential to make huge gains in efficiency. Seamless connectivity to the entire supply chain via the web includes real time connectivity, comprehensive people management, products and processes.

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. The one notable exception is ChipCenter.com, a joint venture between Avnet and Arrow Electronics. Following this lead, other high-tech industry leaders are teaming up to sponsor their own online marketplaces [4].

One such endeavor, aptly dubbed The High-Tech Exchange, has received initial backing by twelve companies, including Compaq, Hewlett-Packard, Gateway, Solectron and Sanmina-SCI Systems. Another similar venture, e2open.com, sponsored by IBM, Nortel and Solectron, is also in the works. Others, such as iSuppli, will act as intermediaries and bring together a myriad of component manufacturers and accumulate the flow demand for multiple customers and place large aggregated orders with each supplier. The opportunity is massive, but eventually a few major consortiums may emerge and be the primary online source for most EMS companies and OEMs.

In terms of actual purchases via Internet exchanges, it may be estimated that from 15% to 25% of EMS industry needs could be fulfilled through this medium, with the smaller EMS companies being the largest users. The actual impact of the Internet, however, is severely understated because online communications between the EMS Company and component manufacturer is becoming the status quo. This would include order status, demand schedules, technical specifications, etc. The objective is to have more transparency in the supply chain between the various segments, and integrated e-SCM systems and ERP platforms will be the standard.

Looking ahead, the small and medium OEMs and EMS companies will represent the most significant opportunity for the traditional distribution companies. Although large OEMs and EMS companies will continue to use distributors in specific instances, these customers will continue the practice of direct procurement from suppliers and/or e-based exchanges. With that said, very few small OEMs and EMS companies have the E-SCM, logistics, and supply-chain management expertise that their larger peers have developed. It is within this market that the distribution companies have the best opportunity to prosper. The larger, dominant distributors are able to provide their medium and small customers with service offerings and cost savings that are unrealizable on a stand-alone basis. A leading electronics distributor brings supplier relationships, global infrastructure, and broad product offerings, E-SCM and logistics expertise to the table. By no means should anyone believe that the distributor will become extinct; rather, the distributor will be forced to focus more attention on the small- to mid-size customer base or face direct challenges from top-tier EMS companies.

The conflict between the EMS and component distribution industries will be expected to grow. The EMS industry will continue to expand its services in design, inventory management (both raw material and finished goods) and logistics, which is crossing over into the value-added content of component distributors. Furthermore, the fast-developing market for e-based exchanges represents a challenge for distributors, and although they have been somewhat slow on this initiative, progress is being made. The larger, top-tier EMS companies will not enter the distribution business to serve the merchant market, but rather to fulfill internal needs, capture the mark-up, and extend control over their supply chain. Again, 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

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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.

2.3 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 [15].

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 [15], 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. (Another debate concerns the EMS industry revenue figures and the total available market, both of which some experts believe are overstated.) 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. Using the analogy of Levi's blue jeans will help to understand the changes that may occur in the EMS industry.

Blue jeans were specifically designed for the rigors of mining and other rugged outdoor activities and sold incredibly well during the gold rush period. Other purveyors of goods also benefited from the gold rush phenomenon, yet are not household names any longer. After the gold rush was over, Levi Strauss became a household name by finding markets for blue jeans other than miners or laborers [15].

Many experts predict that the first decade of the millennium will be called the *gold rush in outsourced electronics manufacturing.* Who in the EMS industry will find new markets and perhaps become a household name? And how will this occur? How will the EMS industry maintain shareholder expectations in a market whose margins are declining and moreover, where growth is expected to saturate the industry?

Consolidation has been an effective way to keep the shareholders of the declining margin electronics distribution business happy. (Declining margins are due primarily to the EMS sector becoming distribution's fastest growing customer base.) Yet consolidation in distribution is a mixed bag for mid-tier OEM/EMS [11] 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.

Consolidation presents problems for the EMS sector and its customers in particular. Mass consolidation is against the fundamental objective of the EMS paradigm, which is a limited customer set with a focused profile, whereas the acquisition of companies means an unwieldy, over-large customer base. Historically, EMS acquirer's cherry-pick the customer base of its acquisition, which leaves many orphans in its wake. Consolidation can only be effective when tier-one EMSs devise a strategy to service mid-tier OEMs. This is meaningful precisely because these OEMs represent the largest revenue opportunity in the total available market [11].

Recent moves by semiconductor manufacturers indicate that they will not participate in the eroding margin game. They expect to avoid a collision with customers by separating commodity business from value-added business. In time, this will mean that both OEM and EMS suppliers will be told where to buy and at what price for high-ASP components. This could have a significant impact on component procurement and margin structure.

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; they are farther in the E-SCM implementation cycle; and they understand how to support a larger number of customers without being a competitor to their EMS customer base. Owning a distributor and

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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.

Last January, L. M. Ericsson, the Swedish mobile phone maker, announced that it was discontinuing its manufacturing operation. It was turning six factories, along with their employees, over to Flextronics, the contract manufacturer. In doing this, Ericsson was joining Motorola, which, only a short time before, said that it would outsource much of its mobile phone production. Recently, Solectron acquired manufacturing facilities from Sony, IBM, and Nortel. These companies will now rely on Solectron to supply the products formerly made in their own plants [6].

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. There is now a greater willingness to entertain suggestions from line workers that would improve production processes, cut costs, and sometimes, even change the nature of the product itself. When production is turned over to a contract manufacturer, especially one that is offshore, the opportunities for such feedback are greatly diminished.

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. We know that co-location is an important consideration for an R & D team. Research has found that having members of such teams separated by even relatively small distances within the same building can make a difference in product team coordination and performance

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. Here the opportunity cost in terms of product design and improvement may be substantial. In that sense, the decision is similar to the one to cut back on product development when times are tight. This is done because the impact on costs and profits of the foregone opportunities of new products are difficult to calculate. 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. The more product innovation and improvement a company does, the more it keeps its fingers on the pulse of changing process and design technology. When these functions and responsibilities are turned over to an outside contractor, the level of skill, experience, and judgment with regard to product innovation may be affected decisively [32].

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. EMS providers are waging an informal campaign to persuade their customers to take full advantage of new-product-introduction (NPI) services, a move that ultimately may demand that the contract manufacturing industry surmount its biggest challenge yet [1].

In her article, Serant [25] proposes that by tapping NPI services at the conceptual stage, EMS providers claim they can help their OEM customers cut costs, improve time-to-market, and streamline new designs to optimize manufacturing efficiencies. That would represent a marked change, given that OEMs historically have embraced such services primarily to aid them with product redesign. Serant [25] also claims that getting involved at the midpoint of the development process is too late to have significant product-cost impact.

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3 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.

3.1 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. Questionnaires were chosen as they appeared to be the most effective and practical strategy given the time and monetary constraints imposed. A questionnaire is defined as "a pre-formulated written set of questions to which respondents record their answers, usually within rather closely defined alternatives" [24].

Questionnaires have a number of inherent advantages in regard to conducting research. The most of significant of these are that they can be sent to a sample population that is dispersed over a wide geographical and they can be answered by respondents at their own convenience [19]. Furthermore, as the participants are assured complete anonymity, self-administered questionnaires overcome the problems of *interviewer bias* as well as reducing the respondent's likely reluctance to convey negative or controversial information [2].

Reliability is another advantage of questionnaires and refers to "the repeatability or replicability of findings" [27]. 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.

As stated above, this research will partially base its findings through quantitative research methods because this permits a flexible and iterative approach. The data collected from the questionnaires may be used to answer the questions on the profitability of e-SCM on these EMS companies. During data gathering the choice and design of methods are constantly reviewed, based on ongoing analysis and the new issues that will emerge about the topic. This allows for unproductive areas of research to be dropped from the original research plan.

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.

3.2 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. To assess the effectiveness of e-SCM as a strategy of enhancing the productivity of electronic manufacturing services firms and commitment that ensured from the literature review, 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

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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. A Likert Scale is a rating scale that requires the subject to indicate his or her degree of agreement or disagreement with a statement. It was named after Rensis Likert, the American professor who designed a scale survey in 1932 to measure the attitudes towards certain products and services.

It attempts to quantify subjective information, and respondents indicate along a continuum where their particular attitude resides.

For example, a question on how much a housewife prefers a certain household product would be answered this way:

- 5 4 3 2 1

Where 5 means strongly agree, 4 agree, 3 neutral, 2 disagree, and 1 strongly disagree.

For the first phase of the research, convenience sampling was used. This sampling technique refers to obtaining sample units or people who are most convenient available [34]. Since participation in the study will be voluntary, it is impossible to anticipate the number of participants in the sample, however, the population of EMS facilities in North America is known and estimated in 1669 in 2009 according to Digikey Corporation [5], according to Bartlett et al. [3], the sample size required for a survey can be estimated by using the Cochran's sample size formula. The formula requires an alpha level that indicates the level of risk the researcher is willing to take that the true margin of error may exceed the acceptable margin of error. The study of this research assumes an alpha of 0.10 that according to Bartlett et al [3] is an acceptable level for studies in identifying relationships. The formula also requires a marginal error that the researcher is willing to accept, a 5% marginal error was selected for this study as it is the recommended for categorical data [3]. The calculated sample size by using the Cochran's sample size formula for a survey of 5 points scale, alpha of 0.1, population size of 1669 and margin error of 5% was 30. 56 questionnaires were emailed to employees at managerial level involved in E-business applications in the North American region but only 36 were returned, however, this number respondents is enough to satisfy our target goal of at least 30 returns Participants were emailed out a consent form and participation in the study was strictly voluntary.

To immediately establish the academic nature of the study, the questionnaires were accompanied by a covering letter incorporating the University letterhead. The covering letter clearly indicated the time it would take to complete the questionnaire (approximately 15-20 minutes) and offered the respondents a summary of the aggregate results of the study, at their request. This was intended to convey the researcher's appreciation for their investment in time, and the courtesy shown by responding to the questionnaire [14]. The length of "email questionnaires should not exceed six pages" [34]. The respondents were first selected through inquiries with the companies. The proponent of this study ascertained that the position of the respondent was well within the requirements for answering the survey; meaning that all respondents were, in one way or another, in positions related to the E-business applications of their respective firms. The respondents, in turn, were given 2 weeks to complete the survey and return to the surveyor. After two weeks, if the form was not yet returned, follow-ups were made either through telephone or through e-mail. The proponent of this study made sure though, that all the survey forms were in his possession at the end of one month from the date the said forms were received by the respondents.

If there were any seemingly contradicting replies within the form, follow-up face-to-face interviews were then done with the respondent themselves.

3.2.1 Statistical Methods in Descriptive Research

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.

In order to find the central location or *middle figure* or average values per question in the survey, ordinarily, one would have to use the mode for ordinal or positional values like the ones in our survey. The mode then may be interpreted to the most frequently occurring reply to each survey question. However, the mode does not necessarily lie in the middle of all the results.

However, for further testing, we can give weights to the answers and look for the mean answers of every question. The mean is a measure of central tendency. It is a value that tends to lie in the middle of a set of data and can be

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viewed as an average. Likert scales were used in questionnaires in order to measure attitudes ranging from very Strong (5) to weak (1) [34]. 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

Again the means of each question shall be presented in tabular form also in the next section to facilitate analysis. Among the groups of similar questions, the mean of each group was taken and will also be presented in tabular form for comparison with the individual means and will be used for further analysis. The *means of the means* could be said to be truly the middle values for the main groups of questions in the survey.

To determine the range of values or the variance of values, we then took the standard deviation per question. The standard deviation is a measure of how far in terms or units are all the responses located on both sides of the mean. To illustrate, a standard deviation of 4.1 with a normal distribution means that 99% of the responses' scores are found within 3 times 4.1 units of each side of the mean. The lower the standard deviation is, the closer to the mean the respondent's scores are, and thus, the answers are more consistent among the respondents for a certain position.

When the means of the responses per group of questions in the survey have been taken, it is possible to test whether the results are comparable or consistent enough. This means it is possible to find out if there are inconsistencies in the replies, or whether it is safe to say that the results appear to be uniform in nature. This was done using what is called a two-tailed test. This test is used in statistics to determine if there are inconsistencies or the results obtained earlier.

For instance, we would like to know if there is a significant difference between the answers of respondents on the questions regarding the usefulness of e-SCM in the working needs of employees vs. the increase (or decrease) in revenues e-SCM has brought to the company. We first ought to formulate our hypotheses regarding the topic. See hypotheses Ho and H1 below:

Ho = There is no significant difference in the responses; that is, any difference could only be due to chance; and

H1 = There is a significant difference between the two groups of responses.

The Z value that we then will get must be found to be within the range – 1.96 to + 1.96 so that there will be consistency in the replies to within 95% accuracy. The range came from the area under a normal curve representing 95% of the total population under it.

We then apply these two tailed tests to certain pairs of groups of similar questions to determine if there were any significant differences, or if the groups of replies were consistent with one another. The results of these two-tailed tests will be presented in the next chapter.

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.

3.3 Causal Research

The main goal of causal research is identification of cause-and-effect relationships between variables [34]. 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.

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4 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.

4.1 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. The question in efficiency of information flow intended to measure the effect of e-SCM in the distribution of the information in the SCM. The Reduced Cost in Documentation Preparation question was used to measure the effect of e-SCM in the cost reduction due to paperless operations. The Productivity question was asked to measure the effect of e-SCM in the sales of the industry researched. Finally, the last question intended to measure the effect of e-SCM in the productivity of the industry in terms of sales for employee used.

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 questions were intended o measure the reduction of lead time to customer, stockouts, inventory carrying costs, stockouts of production, reduced distribution costs for customers, distribution costs for suppliers and increase in capital, sales and revenue.

The group mean of 3.9 reveals a considerable effect of the e-SCM in making more efficient the SCM. None of the respondents considered e-SCM as a weak contributor to the effectiveness of the SCM and most considered that is affected positively the effectiveness of the SCM.

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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. The questions measured how satisfied were the users in terms of information needs for transacting with suppliers, information needs for transacting with customers, internal communication, communications needs for transaction-interaction with suppliers, communications needs for transaction-interaction with customers and a relation of e-SCM to the EMS industry.

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.

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The variable identified to measure the efficiency of operations are internal communications, Inventory, purchasing, procurement, sharing, integration with existing systems, training and communication to external parties.

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. However, there were some respondents that evaluated e-SCM with as a low or weak contributor to the facilitation of operations in 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. The respondents have considered that e-SCM had a considerable impact in their integration with suppliers by evaluating e-SCM as a tool that allows them to connect remotely to suppliers and that has considerably contributed to shorter response times and better information flow and as result a perception of being of benefit to the EMS industry. 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. This reflects that although e-SCM has been in the industry for long time, there are still some technical issues that need to be resolved to make it fully accepted as an effective tool. The table also reflects a productivity issue of sales, it seems that some respondents were expecting e-SCM to increase sales due to faster response rates but for some reason this is not being translated as higher sales.

The standard deviations per group, could give an insight as to the consistency of the responses across all the firms surveyed. A higher standard deviation indicates less consistency in the responses; meaning the responses are quite varied; and a small standard deviation indicates more consistency in the responses; meaning the responses of the

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employees across the firms were more or less similar. Below is a summary of the standard deviations per group (See table 8):

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. However, the impact of e-SCM on the SCM has the lowest level of consistency, this tells us that opinions about the impact are diverse and this could be related to personal experiences with the system and to possible technical issues that might cause e-SCM being perceived as of being of little impact to 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. Thus we will compute for the z-values of both pairs of groups of means to validate our hypothesis. Thus, at a level of 95% accuracy, we designate as the borderline z-values -1.96 to + 1.96. This means that if we arrive at a z-value outside this range, we can say that there are clear differences in the means of both pairs of groups. 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.

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4.2 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. R^2*	*σ*
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; σ: 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.

5 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.

Descriptive statistics revealed to us that in the 5 categories of questions, the average was around 4 indicating that there was a relatively strong agreement on eSCM influencing in some way operations. Looking into the survey at the questions level we find that there are 4 primary concepts that were investigated: Quality, information, communication, cost, sales, usability and access. These concepts are cross-cutting and can be found in all 5 categories. What is interesting is that there seems to be a strong agreement on the importance of information, communications and access and to a much lesser extent on the quality of the eSCM. All these issues are eSCM system enterprise related which draws attention on the system's implementation instead of the supply chain operations. This begs the question (which is outside the scope of this study) – is there a confusion between the actual advantages of eSCM and benefits as perceived through the lens of its implementation and integration. We certainly believe that this is the case.

Moreover, the regression analysis was performed in order to investigate any relationships between the categories in the survey. Out of 10 regressions 4 were significant to <0.01, three of which are related to the influence of the *perceived impact of eSCM on SCM* on *efficiency, system quality, system usage*, and the influence of *perceived system quality* on *perceived system usage*. Results show that respondents who agree on eSCM impact on 4 key

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indicative areas also believe that this impact negatively influenced effectiveness of SCM tasks (standardized beta coefficient of -0.22). Similarly, this influence is also negative on system quality (standardized beta coefficient of -0.31) and system usage (standardized beta coefficient of -0.30). Regression analysis also seemed to indicate that the influence of perceived system quality on perceived system usage is negative (standardized beta coefficient of -0.29). These results suggest that although there is a belief of *advantageous* impact of eSCM on the SCM, there impact on operations is not felt and some sort of discomfort exists.

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 might need 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.

6 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. The questionnaire used in the present study was a *snap-shot* of perception of senior management who understood at both operational and tactical level the concepts of eSCM. 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. This also applies here due to the fact that a database providing a list of the companies of interest with senior management contact names was used. This indeed may be problematic due to the quality of the information in the database. 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. The survey used here may not necessarily be appropriate and apply to other manufacturing segments. In other words we can say that this study is based on a single distinct manufacturing segment namely the North

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American Electronic Manufacturing Services Industry. This therefore, may not generalize across a wide set of industries.

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?

Q1. Efficiency in flow of information and documents
Q2. Reduced costs in preparation of documents
Q3. Productivity-Increases in Sales/Total assets ratio
Q4. Increases in Sales/Employee ratio

GROUP 2: E-SCM Effectiveness

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

Q1. Reduced lead-time to customer
Q2. Reduced stock outs of finished products
Q3. Reduced inventory carrying costs
Q4. Reduced stock outs of production materials
Q5. Reduced distribution costs to customers
Q6. Reduced distribution costs from suppliers
Q7. Performance-Increase in income/capital ratio
Q8. Increase in return on sales
Q9. Increase revenues

GROUP 3: Satisfaction of the E-SCM

To what extent, users of eSCM are satisfied?

Q1. Information needs internally
Q2. Information needs for transacting/interaction with suppliers
Q3. Information needs for transacting/interaction with customers
Q4. Communication needs internally
Q5. Communication needs for transacting/interacting with suppliers
Q6. Communication needs for transacting/interacting with customers
Q7. To what extent, eSCM is related to EMS industry?

GROUP 4: E-SCM Quality

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

Q1. Internal access convenience
Q2. Accuracy
Q3. Shorter response time
Q4. Useful functions/features
Q5. Ease of learning to use
Q6. User friendliness of system
Q7. Remote access capability

GROUP 5: E-SCM Performance

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

Q1. Effective Intranet for internal communication
Q2. System monitors inventory and purchasing situation
Q3. Effective electronic system for product distribution
Q4. Effective electronic system for procurement

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Q5. Automated transmitting and processing of data
Q6. Internet enabled system for information sharing
Q7. eSCM system fully integrated with existing systems
Q8. To what extent eSCM is beneficial to EMS industry?
Q9. Adequate training provided for users
Q10. Extranet exists for communication to external parties