E-Logistics: A Strategy for Gaining Competitive Advantage *

N.VISWANADHAM
The Logistics Institute–Asia Pacific & Mechanical and Production Engineering
NATIONAL UNIVERSITY OF SINGAPORE
SINGAPORE-119260
E-mail:mpenv@nus.edu.sg

Abstract

E-Logistics is the management of logistical resources using the Internet. Logistics has become the primary subsystem and the key factor for gaining competitive advantage in manufacturing supply chains. Traditionally logistics is relegated to the purchasing and transport divisions and did not have much visibility in organizations. Now it is the key factor for the success of any business and companies with core competence in logistics are playing a key role in supply chain management and Internet fulfillment.

1 Introduction

Logistics is defined as the broad range of activities concerned with effective movement of semi-finished or finished goods from one business to another or from retailer to the end user. The main goal of a logistics organization is to ensure the availability of the right product at the right place, in the right quantities and the right condition at the right time and the right cost for the right customer. The activities include freight transportation, warehousing, material handling, protective packaging, inventory control, warehousing, order processing, marketing, forecasting, and customer service. E-logistics is the management of logistical resources using the Internet. It involves automated coordination of a chain of material and information flows across different organizations and functions. Locating freight agents and courier services, tracking internal inventory flows, speeding up the process of procurement and invoicing, and harmonising the flow of customs and shipping documents in ports and other transportation hubs can all be facilitated by well-designed E-logistics solutions.

Over the years, the logistics industry had witnessed significant changes. It started off as a labor-intensive industry in the sixties. In the seventies and eighties, computers and material handling equipment were brought into the warehouse to improve efficiency and enhance productivity. Now the logistics industry has evolved to one which provides a comprehensive range of value-added services in integrated supply chain networks.

Because of fierce global competition and rapid technological advances, the pace of change in logistics has been even faster in the nineties. They have become an integral part of the Integrated Supply Chain Network(ISN). Instead of acting as transporters of semi-finished and finished goods, they provide value added services such as managing customer inventories, just-in-time delivery, customization in the warehouses, labeling, and many others. This has helped to reduce inventory and storage costs all along the supply chain. The seamless integration of manufacturing and logistics has strengthened the ISNs, a development that augurs well for the future of logistics industry.

The outlook of logistics in the Internet-based economy is promising because time-to-market and product delivery times will get shorter. The fight for market share will no longer be simply between product features and pricing, but between the supply chains. Third-party logistics providers will have the opportunity to play an expanded role because manufacturers will outsource more, and the market will become more global due to influence of Internet commerce. They will take on more value-added services such as inventory management, financing, sub-assembly, delivery, installation, returns and repairs. They will also be challenged to offer new capabilities such as mass customization of products and services, speedy fulfillment of e-commerce transactions in the regional and global markets, and timely logistics information through Internet and Web-EDI (electronic data interchange). Also the infomediaries [1], who bring the buyers and sellers together and enable fast trading on the net, need agile third party logistics providers for

*Logistics 99: Second Intl. Conf. on Supply Chain & Logistics Management

fulfillment of their transactions.

The electronic logistics model discussed here can make possible innovations that produce measurable savings throughout the integrated supply chain. For example, logistics information system can track availability of supplier's inventories, match these against sales data gathered from end-user transactions and determine the most economical point of fulfillment, whether it is re-directed from another distributor or shipped directly from the manufacturer to the end-user. Using the shared forecast information, the manufacturer can better plan production cycles, the distributor can better manage the inventory asset and the customer benefits from the accumulated efficiencies derived from the new model, both in terms of better price and improved availability. In other words, the logistic industry will be increasingly driven by the creative exploitation of knowledge, bright ideas and technology. It is certain to transform itself into a knowledge-based industry in the 21st century.

1.1 Third-party logistics

Logistics could be provided by either the seller or the buyer or by a third party. More specifically, a tier I supplier may have a contract to deliver components directly to the factory floor of the manufacturer, or a manufacturer may have a contract to have a batch of parts ready for pickup. Alternatively, a third-party logistics(3PLs) provider may supply the interface and transport the parts from suppliers to the manufacturer. In international logistics, they provide services for freight forwarding, packaging, shipping, customs clearance, and a host of other things.

Thus, third-party logistics is the use of an outside company, a transportation carrier, a warehouse, or a third-party freight manager to perform all or part of a company's material management or product distribution functions [2]. There are several reasons for this trend, the principal ones being

- globalization of sourcing, manufacturing, and distribution leading to global manufacturing and the consequent increase in the complexity of material movement

- competition that forced companies towards more product offerings, more responsiveness, a reduction in inventories and safety stock, and the increased need for small but frequent shipments with 100% reliability, requiring core competence in logistics management

- resource constraints that enable companies to concentrate only on their core manufacturing or new product development activities.

Many firms are now entering into alliance with logistics providers. This change has led many firms to greatly reduce the number of carriers they do business with and to increase the involvement of the carriers in planning shipments by sharing information.

A new breed of logistics providers called 4PLs (Fourth party logistics) with the expertise to manage the resources, the technology, and the value delivery processes have sprung up. The 4PLs agree that the 3PLs have superior expertise in transportation and warehousing, but argue that these operational tasks only provide one-time cost reductions but cannot sustain them over time.

In this paper, we first identify the reasons for the rapid growth of logistics and the the emergence of third party logistics providers as key players in providing competitive advantage to supply chain networks. We identify the logistics facilities and the IT infrastruture in logistic networks. We deal with decison making and performance modeling in the logistics world in section 5. We briefly survey the Indian scenario on logistics and related IT infrastructure and conclude with some comments for future action.

2 Drivers for Integrated Logistics

Globalization, global manufacturing , the advances in Internet technologies and growth orientation of manufacturing companies are the four key drivers of E-logistics. Also, companies are focusing more and more on growth which means, new products, new customers and innovative order fulfillment. We describe below the growth of ISNs which includes other key drivers as well.

2.1 Growth of Integrated Supply Chain Networks

An integrated supply chain network is a group of independent companies, often located in different countries, forming a strategic alliance with the common goal of designing, manufacturing, and delivering right-quality products to customer groups faster than other alliance groups and vertically integrated firms[3]. Such networks are common in all industrial sectors including the automobile, pharmaceutical, aerospace, electronics, computer, food, and apparel industries. The

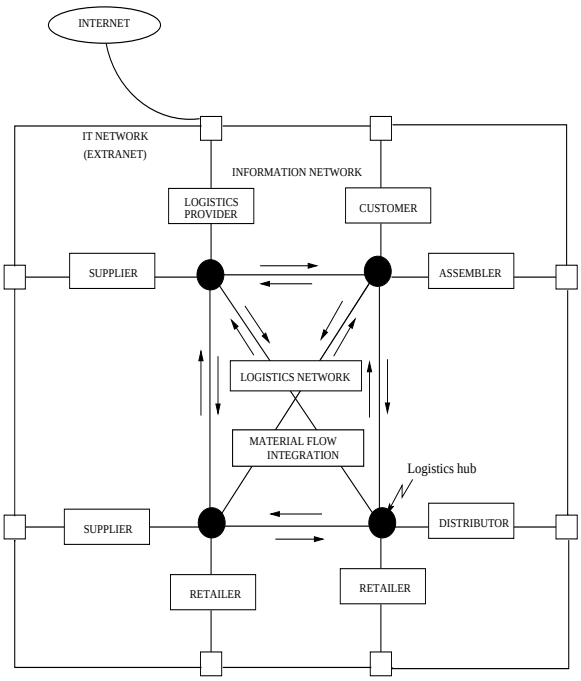

Figure 1: Integrated Supply Chain Network

lowering of trade barriers by various countries, combined with rapid advances in logistics and information technology, has led to the proliferation of global manufacturing networks.

Figure 1 shows the schematic of an integrated manufacturing supply chain. A well-designed logistics network provides a streamlined material flow between all parties, cutting down the lead time and cost of moving the raw materials, subassemblies, and finished goods to their destinations. The extranet, a secure and reliable communications network linking all the companies of the enterprise, provides the information integration. This architecture allows broadcasting of relevant information to all partners not just the adjacent ones. By providing the right information at the right time to all the stakeholders, the extranet enables efficient logistics and effective decision making. This integration will reduce the inventory levels and also the cost of delivery. Essentially information substitutes inventory [4]. In other words if one knows when his or her order is scheduled on the assembly plant and on the transport carrier, then the need for inventory and safety stock is reduced.

In global manufacturing of the kind described above, components may be sourced from several countries, assembled in yet another country, and distributed to the customers all over the world. These networks are not generally under single ownership but are group formations of independent companies in alliance for a specific and special purpose. They compete with similar cooperating networks. Each company in the alliance group specializes in what it does best, and the membership covers all competencies that are critical to the mission of value delivery to the customers. For a manufacturing supply chain to succeed, the critical competencies include product design and development, process design, production, distribution, logistics, product maintenance, information systems and processing, etc. No single company can have world-class competencies in all these areas but a well formed network can. A strategically formed integrated network can provide a formidable competitive advantage.

The new standard for the supply chain is value delivered, not cost eliminated [5]. Instead of merely striving to implement cost-reduction targets, managers at leading companies are repositioning the supply chain as an enabler of growth. They are speeding the flow of generations of new products; reaching new markets across the globe; developing electronic channels of distribution; customizing services to customer segments; and forging new value-added relationships with suppliers and customers. Frequent and rapid introduction of new products would be impractical without agile supply chains. Some companies have grown by creatively using alternative distribution channels, and in many instances developing multichannel strategies. Gateway 2000 and Dell Computer, for example, experienced double-digit growth by selling personal computers through the mail.

3 Logistics Facility Location

The location, size, and organization of various facilities, such as warehouses, distribution centers, and procurement and service offices are important strategic issues(see Figure 2) . The manufacturing facilities are located in various countries, to take advantage of cheap labor and infrastructure facilities, government subsidies, tax relief, etc., and also to gain access to local markets and technologies. Consequently, the logistics provider also has to have international presence. Location of facilities in several countries will certainly increase the complexity of coordination, scheduling, transportation, and in-transit inventory.

3.1 Infrastructure

The cargo handling facilities at the Airports and Ports are vital for attaining supply chain efficiencies. The

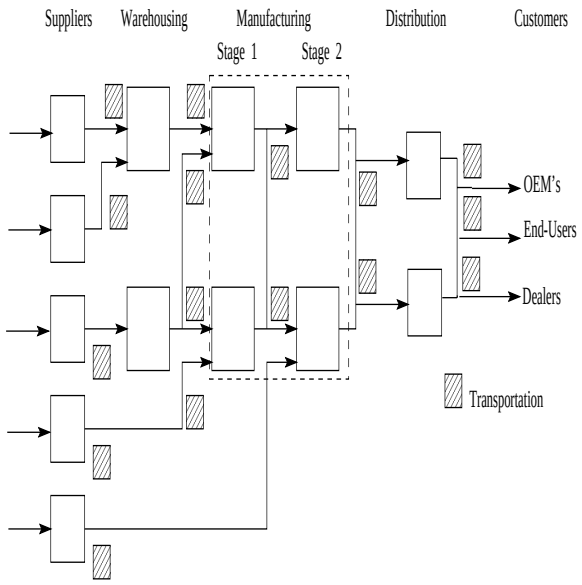

Figure 2: Supply chain facilities

varieties of technologies and the level of automation in best ports such as Singapore are world class. India has to identify and develop ports and airports of excellence to be able to compete globally. Intermodal rail and road transport is also becoming competitive because of improvements in load and unload operations during transshipment. Containerization has improved the efficiencies in both shipping and intermodal transport. Important issues that need attention in aircargo, seacargo and in trucking are yield management and pricing policies.

3.2 Staged manufacturing

Manufacturing could be done in a single stage from raw materials to components to subassemblies to assemblies. It could also be done in multiple stages by locating factories for different stages in various countries. This is because, sometimes it is cheaper to ship components and subassemblies over long distances than to ship finished products. Decisions regarding the number of stages of the manufacturing activity and the customization stage at which the product is earmarked for the customer (at the labeling stage, packaging stage, assembly stage, subassembly stage, etc.) can profoundly influence the logistics architecture. Such decisions can be analyzed by building cost and cycle time models [6, 3].

3.3 Distribution

Distribution often implies inventories of finished or semi-finished products delivered from a factory to the distribution center and then to the customers. Some distribution centers act as final customization points where the final assembly of such things as power supplies and power cards is done, thus efficiently managing the product variety. Third party logistics providers such as Fedex have dozens of distribution centers around the world, where customers store fast moving merchandise at the transportation hubs to serve the customers more quickly and easily and at less cost. In recent years, distribution has been a beneficiary of advances in information and automation technologies and also innovative practices such as cross-docking.

Warehouses are used for stockholding and product customization. The conventional warehousing involves receiving goods, putaway, order processing and shipping. It is a human intensive process. Current warehouse technology is dominated by forklift and pallet technology. ASRSs are also popular but are very capital intensive. Warehouse control systems(WCS) are software packages that assist in the work flow management and also handle the order processing, packing, checking, sorting,labeling and loading. It also generates the bill of lading and packing lists where necessary. Certainly use of automation in warehouses improves the accuracy of shipments and documents.Also, with the growth of Internet commerce, there is a need for picking and packing smaller order sizes.

3.4 Transportation

Air, rail, truck, water, and pipeline are different modes of transport with different economic characteristics. Loading and unloading facilities; communication facilities onboard vehicles to receive telephone, fax, Internet, and EDI messages; and alliances between transport, distribution, and production partners are important issues. Delivery within the window of time specified by the customer is rated as the most important service quality. Transit time determines pipeline inventory, and its variability determines the buffer or safety stock necessary. Large transit times also reduce the ability to respond quickly to the market and thus the effectiveness of the ISN. Choice of the mode or the optimal modal mix are interesting issues and are determined taking into account the transit and warehousing costs and the premium the customers are willing to pay for freshness of products (flowers, beer).

4 Information Systems in Logistics

In order to make the most of the new electronic logistics models, all the stake holders must integrate their company's infrastructure with that of their partners in the ISN. The integration should facilitate moving information before moving inventory. The higher the accuracy of that information, the more precise the quantity of product moved. A compelling argument for improved information flow among supply chain partners is perhaps the most basic of all; financial. It is far less expensive to move information than it is to move product. Success in logistical operations depends in satisfying the collective informational needs of the logistics provider by integrating data from multiple and disparate origins.

Information is pivotal in a relationship. The logistics contractor needs information about future product flows, capacity and special equipment needed, and likely destinations. The distribution or manufacturer needs information as to how the product is handled, performance measurements such as delivery reliability, process deviations, and root causes. Use of barcode and EDI technologies, computerized order processing, and appropriate data communication methods has made possible information sharing in a secure way.

Logistics companies are using IT to gain competitive advantage. They enhance the quality of service offered through broad applications of several information-based technologies. To succeed and grow, third-party logistics providers will need knowledge workers who are multi-skilled, IT savvy and creative.

1. Barcoding and scanning allow companies to selectively track and report on shipment status 24 hours a day, seven days per week, simply by calling a toll-free number.

2. Truck drivers carry computer clipboards that utilize digital pen-based technology to sequence routes and collect delivery information. The clipboard allows the driver to digitally record the shipment recipient's signature to provide receipt verification. The computerized clipboard coordinates driver information, reduces errors, and speeds up delivery.

3. A national wireless communication network and the cellular phone technology allows drivers to transmit real-time tracking information from their trucks to the company central computers. Wireless mobile technology and system support from company data center enable the company to provide electronic data storage and retrieval to track the company's millions of daily deliveries around the globe.

4.1 Business-to-Business Communications

In electronic logistics models, information is actually the vital commodity for exchange between partners, and it also represents a large percentage of the cost structure. In the health care industry, for example, the patient records, diagnostic test results, physician notes, and insurance claims form 30% of the total health care costs. There is a tremendous amount of information flow between the stakeholders of the supply chain. If one can reduce the information asymmetry between manufacturers and suppliers then substantial cost reductions are possible. This will enable the partners to make decisions based on global information that benefits the entire process. A variety of information-sharing patterns are practiced in the industry. These vary between the two extremes of sharing no information and sharing all relevant information. These patterns are marketed as best practices in the industry circles and include vendor-managed inventories, quick response manufacturing, supplier scheduling, JIT purchasing, JIT II, and efficient consumer response [7]. Basically, these are information-sharing patterns among two or more partners in an ISN. An ISN derives its competitive advantage because of sharing of information with its partners on demand forecasts, point of sale data, production schedules, logistics plans, market trends, etc. Thus the only uncertainty is the market uncertainty, which is mostly beyond the control of the ISN but could be partially influenced through differential pricing.

Electronic point of sale (EPOS) systems have made possible automation of stocktaking and replenishment i.e. sales-based ordering. Sharing of EPOS information among partners, makes possible scheduling of production and logistics activities in relation to the demand. One of the recent trends is to warehouse and mine the EPOS data to determine *which products are sold to whom and in what markets.* This information can be used for forecasting and analyzing the logistics usage patterns and a host of others. Figure 3 illustrates the use of information for joint scheduling of production facilities of supplier and OEM as well as transport services of the logistics provider. Electronic Data Interchange (EDI) is a tool to exchange business

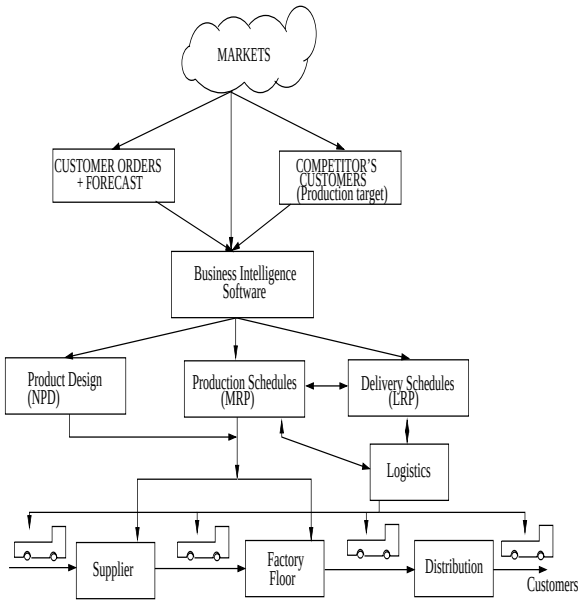

Figure 3: Integrated scheduling

data between organizations in a machine-processable format. EDI standards have evolved over time. The communication is either through dedicated lines or through a third-party valued network (VAN). Encryption and authentication are also provided by the VANs. Internet-based EDI is becoming very popular since it is relatively cheaper than the VAN-based EDI.

Recent developments in the Internet, intranets, extranets, and the World-Wide-Web have immense possibilities for sharing information reliably and securely among partners. It is now possible to transfer funds securely over the network. The Automotive Network exchange (ANX), the most visible of the new wave of business-to-business virtual private networks (VPNs) running over the Internet, promises to provide the network infrastructure to cut costs by billions of dollars and change the way the automotive supply chain does business. ANX provides a common, standards-based global TCP/IP network service to meet the data communications needs of the automotive industry's applications. Using the ANX, each automotive supplier and OEM will need only a single TCP/IP data transport connection to communicate globally with all trading partners. Similarly, grocery companies are trying to form food exchanges, and textile manufacturers have formed AMTEX, the American textile partnership. Instill corporation is a leading provider of e-business services to the food service industry. Oracle has recently announced an open standards exchange for B2B communications.

Whenever information is shared between two parties, the party supplying information is running a risk. When a retailer provides point of sale data to the supplier, then the retailer is running a risk of a shift in bargaining power. In addition, the supplier gains strategically from better forecasts. The retailer has to evaluate the gains of the suppliers and get price advantages through appropriate contracts. Studies are needed to evaluate risk coverage policies in B2B communications.

4.2 Partnership

From Figure 1 we can define interfaces between suppliers and manufacturing, suppliers and logistics, manufacturing and distribution, manufacturing and logistics, and finally between distribution and logistics. Basically, there are two extreme relationships between various organizations: one based on the mass production paradigm and the other based on the lean production model.

The relationships in the mass production model are adversarial, based on mistrust, threats, and counterthreats between the so-called seller and buyer. Also, contracts are awarded for short time spans creating a transitory perception with the result that renegotiations consume time. The results of such a model include procedural delays, frequent reworking and redesign of products, and inventory buildup.

In the lean production model, collaborative partnership among all elements is encouraged, which will lead to long-term contractual arrangements, information sharing, co-design of products based on trust, and an overall relationship focused on effectiveness and improvement. The relationship is established based on the capabilities, infrastructure, people, and practices of the constituent partners.

5 Decision Making In Logistical Systems

Decision making in the Logistic companies is very complex because a large number of organizations are involved and several alternative routes are possible to fulfill an order. A Logistics company has several facilities in different geographic locations, moving different products and serving different customers by supplying them with the required variety and lot sizes at the time and place they specify. Thus the third party logistics providers need to solve a five-dimensional decision problem: *When, Where, What and How much to deliver, and for Whom.* This problem is in contrast

to the one dimensional decision problem of old mass production logistical systems: how to maximize the number of full capacity shipments.

Here, we now identify the strategic, tactical, and operational decisions in integrated supply chain networks.

5.1 Strategic Decisions

The strategic decisions are long-term and are often one-time decisions. They determine the competitiveness of the logistics company. These include strategic alliances, location of facilities, purchase of equipment, technology choices and outsourcing(second-tier subcontractors such as truck providers) decisions. Which products to deliver and for what markets are also strategic issues. The service levels, performance measurements and contingency plans are to be given importance in making the above decisions.

5.2 Tactical Decisions

At the tactical level, the time horizon is weeks or months. Demand forecasting, resource allocation, routing of the orders along the supply chain, subcontracting, scheduling workload onto the facilities, load leveling, and bottleneck scheduling are all issues at this level.

5.3 Operational Decisions

The operational-level decisions include order processing, delivery matters, fleet scheduling, and inspection, to mention a few. These are basically day-to-day decisions. The questions that are addressed at this level include which customer order is to be filled, how to react to breakdown of a truck carrying items to a customer, the disruption of the supply of subassemblies from a supplier due to labor problems, etc.

Effective logistical management involves addressing issues at all the three levels simultaneously.

Basically, all decisions made in the industrial world have to counter some kind of uncertainty. It is known that retail product stock-outs in the industry occur at an average rate of 8%. The traditional answer to customer service problems has been to increase inventories. Unfortunately, inventory bears a high cost in terms of capital consumption and expense: it is known that inventory costs form one third of total sales. Planning and forecasting have made steady and significant improvements over the last several years[8]. The use of collaborative planning, forecasting and replenishment can minimize inventories, and supply chain participants can focus on value-added process activities.

6 Performance Modeling

Performance measures are useful to monitor, evaluate, and improve the value delivery systems. They can also be used to compare similar systems in different companies for benchmarking purposes. The financial indicators are lagging metrics that are a result of past decisions and are too old to be useful in operational performance improvement. Here, we identify the nonfinancial measures that would indicate the health of the entire value delivery system and hence the health of all organizations involved in it. More specifically, we define seven performance measures—lead time, quality, cost, capacity, reliability, asset utilization, and flexibility—and mention methods for their determination and improvement.

6.1 Performance Measures

In this paper, we consider the following seven performance measures for a supply chain process

1. **Lead time:** The lead time of a value delivery process is the interval between the start and end of the process. It is the concept-to-market time in the case of the product development ; the clock time between placing an order to the delivery at the customer site in the case of the procurement process; and the time elapsed from raw material ordering until the final assembly reaching the retailer in the case of the supply chain networks. Lead time reduction by removing nonvalue-adding activities; using information technologies such as EDI, databases, etc.; and effectively managing interfaces with suppliers, manufacturing, logistics, and distributors is an important exercise.

2. **Quality:** Quality is management of all the logistical activities so that they are on design target with low variation. This goal is achieved through monitoring the performance for defects, conducting root-cause analysis of defects, and and eliminating the sources of defects.

3. **Cost:** Like the lead time, cost also provides tremendous insights into system problems and inefficiencies.

4. **Capacity:** The maximum output rate of the logistics network is called the capacity. All the

organizations and their activities must be balanced in capacity, otherwise, there will be bottlenecks and delays. Strategic alliances are common among various facility owners in order to have variable capacity. A little overcapacity to meet rush demands can improve the operational measures.

5. **Asset utilization:** The assets of a logistics provider such as warehouses, communications infrastructure, fleets of vehicles, etc., are worth billions of dollars. Their utilization is an important issue.

6. **Reliability and dependability:** Here we are concerned with the reliability of product delivery as an operational issue. We measure the ability to manage disruptions such as machine failures, worker absenteeism, truck failures, supplier failures, etc. as well as rush orders.

7. **Flexibility:** Flexibility is the ability to meet customer requirements under various environmental uncertainties in various dimensions such as delivery time, schedules, design and demand changes, etc. Logistics for all products is not the same and logistical practices differ from country to country. For a global logistics player flexibility is an important issue.

The above seven measures are very generic and from them the customer satisfaction levels and the operational effectiveness and efficiency of the logistics system can be computed. We may mention that five different modeling methods—simulation, probabilistic networks, queuing networks, Petri nets and dynamical system models— are useful in the analysis of logistical systems. We do not go into details. Interested readers may refer[3].

7 Infrastructure Development

It is very important for India to make strategic investments in the logistics and IT infrastructure. A precursor to this should be a survey the logistics scenario in the country and also assess the country's logistics capabilities. The IT infrastructure development has got lot of attention recently. I am not very sure if these plans include development of state of the art logistics information and communication systems.

The cargo handling within India is done by the railways and road transport companies. A small percentage of the cargo goes through air cargo and shipping companies. International cargo is handled by ship and air routes. Probably, the railways provide the cheapest mode of cargo transport through out the country and has lots of legacy infrastructure. The truck companies on the other hand, could either be state-wide or nation-wide. The level of automation at the cargo facilities at the airports, seaports, railway stations and truck loading stations is minimal. The paper work at these facilities is enormous and procedures are not streamlined. Interstate laws further complicate the paperwork and movement of the cargo from state to state.

The communications between the businesses and the logistics providers and among the constituents of the logistics network is paperbased. The use of IT–e-mail, EDI or EFT–almost does not exist. The technology in warehousing and material handling is primitive. Use of canned software packages for fleet scheduling, warehouse control and management and attempts to integrate the logistics into the supply chain are also minimal. There is a tremendous need to develop infrastructure at key ports and airports.

Elbee Express Service, the Indian service partner of United Parcel Service, plans to launch a Web-based package tracking tool. The deployment of such services across wider sectors of the courier and transportation sectors in India should open up new business opportunities, help our companies become more efficient and competitive.

7.1 IT Infrastructure

Indian banks like HDFC Bank, ICICI Bank, IndusInd Bank Global Trust Bank - along with foreign banks operating in India, like Hongkong Bank and CitiBank - have launched Internet banking and bill payment services. India Internet World '99 also witnessed a spate of launches in areas like corporate Intranet solutions and content aggregation services, by Indian as well as foreign companies such as Ericsson, DelhiNet, Matrix Information Services and Federal Express. India's IT sector is aiming for ambitious growth rates of 80 per cent to achieve a target of US $50 billion worth of software exports by year 2008. Software exports grew by 50 per cent during 1992-97. The growth of the Net will undoubtedly play a key role in creating millions of software and services jobs. Leading ISP Videsh Sanchar Nigam Limited (VSNL) - until last year the sole government monopoly ISP for commercial access—announced plans to increase its international bandwidth capacity from 156 Mbps to 540 Mbps in three months. Bangalore–based Internet services firm WiproNet has tied up with US $8 billion Royal

Dutch Telecom (KPN) for commercial-class Internet services in India and other Asian markets.

E-commerce in India is very much alive, of course, with sites offering books for sale in Bombay, vegetables in Delhi, and movie tickets in Bangalore. IDC (India) estimates that the value of sales over the Net in India will mushroom to Rs.1,200 crore in year 2001. In terms of online assistance, more than a hundred Web solutions companies have sprung up all over India, offering services ranging from basic Web page publishing to international marketing and strategic consulting. Companies like Polaris and NetBase Computing are already working on Web-based solutions for the retail industry.

Despite the above developments, the author believes that the infrastructure growth is not strategy driven and is too little to support large scale business-business activity. It is very important to develop high speed, high bandwidth, secure and reliable global connectivity for businesses to transact their business and financial transactions on the Internet [9]. Such a thing cannot be built overnight and would be prohibitively expensive to completely outsource. A phased approach of building high speed communications backbone between the businesses and their global partners, by attracting foreign communication component and systems manufacturing and service companies to open outfits in the country is vital for future industrial growth of the country. Also, exchanges of the kind we described above for textiles, metals, grocery ,etc. are needed for internal use and international marketing and sourcing.

8 Conclusions

Supply chain management(SCM), Logistics, E-commerce and its variants are very hot research topics. There are lots of white papers, concept papers, and vision papers written by management consultants, ERP vendors, IT companies such as HP, IBM, i2, and Netscape, scheduling software vendors, and market researchers. Logistics is an important back-end of the Internet order fulfillment process, and got lot of attention with the booming of I-commerce. Internet based companies such as amazon.com and e-toys, PC companies like Dell and Gateway are highly successful business ventures with new business models and value propositions. Logistics strategic information systems, and well planned business to business communications are behind their success.

We conclude this paper with suggestions for logistics research and development in India.

1. As of now logistical management is offered as a universal methodology—independent of the markets, products and the supply chain architecture. Different supply chains in different countries require different logistical solutions. Individual industry segments and regional chains may offer sharper logistics solutions. from farmers, warehousing by FCI for rice distribution through fair-price shops offers its own unique features.

2. Most studies on logistics concentrate on PCs, deskjet printers, apparels, grocery and documents. Attention to the sunset industries such as agriculture, iron, steel, paper, chemical, electrical, and petrochemical industries will yield large payoffs.

3. Among infrastructure and service supply chains IT supply chains, health care, and banking dominate. Construction logistics are well developed particularly in UK. India need to concentrate on this sectors as well.

4. Strengthening our basic IT infrastructure and improving access to information is one key steps towards improving industry productivity. A well formulated and well articulated action plan on top of the IT policy already announced is urgently needed.

5. The government should focus on fostering an environment conducive to growth and entrepreneurship among younger population. Internet is what will give Indians a level playing field with the rest of the world, and the chance to get ahead.

6. More importantly, India needs educational and research and development programs in this critical area and none of the Institutions of higher learning are currently giving attention to this issue. Initiatives in this direction are vital for the very survival of the industry

References

[1] John Hagel III and J.F. Rayport. The Infomediaries. *The McKinsey Quarterly*, 4, 1997.

[2] P. V. Laarhoven Shyam Lal and G.Sharman. Current Research: Making logistics alliances work. *The McKinsey Quarterly*, 3, 1995.

[3] Viswanadham N. *Analysis of Manufacturing Enterprises*. Kluwer-Academic, Boston, 1999.

[4] P. Milgrom and J. Roberts. The economics of modern manufacturing: Technology, strategy and organization. *American Economic Review*, 80:11–528, 1990.

[5] Dobbs John H. Competition's new battle ground: The integrated value chain. Technical report, Cambridge Technology Partners, 1999.

[6] Lee H L and Tang C. Modelling the costs and benefits of delayed product differentiation. *Management Science*, 43, 1997.

[7] John E. Schorr. *Purchasing In The 21st Century*. Oliwer Wight, Ezzex Junction VT, 1992.

[8] Fisher M.L and A. Raman. Reducing the cost of demand uncertainty through accurate response to early sales. *Operations Research*, 1996.

[9] Viswanadham N. *E-revolution: The role of OR Scientists*. Keynote address at the 1999 OR society annual meeting, July 1999.

Author's Biography

N.Viswanadham is a Professor in Department of Mechanical and Production Engineering and Associate Director of Research in The Logistics Institute–Asia-Pacific, at the National University of Singapore, Singapore. He was previously Professor of Computer Science and Automation at the Indian Institute of Science, Bangalore, India. He was a Tata Chemicals Chair during 1992–1994. He is the recipient of the 1996 IISc Alumni award for excellence in research. appointments at several North American Universities. He was a GE Research Fellow during 1989.

He is a Fellow of the IEEE, Indian National Science Academy, Indian Academy of Sciences, Indian National Academy of Engineering and Third World Academy of Sciences.

He is the author of several journal articles and conference papers. He is the lead author of two textbooks, the first entitled " Reliability in Computer and Control Systems", published by North-Holland in 1987 and the second entitled "Performance Modelling of Automated Manufacturing Systems", published by Prentice Hall Inc., USA in 1992. His 1999 book "Analysis of Manufacturing Enterprises- An approach to leveraging the value delivery processes for competitive advantage" is a Kluwer Academic publication. He is the editor (or co-editor) of six other edited volumes.

He is currently the Editor of IEEE Transactions On Robotics and Automation and Associate Editor of the Journals: IEEE Trans. Systems, Man and Cybernetics, Journal of Manufacturing Systems, Intelligent and Robotic Systems, and The Journal of Franklin Institute.

His current research interests include Supply Chain Engineering and Business to Business commerce.