Applications of e-commerce across the manufacturing supply chain to achieve the promise of e-manufacturing

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This thesis is dedicated to my parents:

Xu Hui Qin

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GLOSSARY

Agile manufacturing: *i*s defined as the capability of surviving and prospering in a competitive environment of continuous and unpredictable change by reacting quickly and effectively to changing markets, driven by customer-designed products and services (Gunasekaran, ed. 2001).

Application Software: is a subclass of computer software that employs the capabilities of a computer directly and thoroughly to a task that the user wishes to perform (Wikipedia 13, 2008).

Automated Guided Vehicle (AVG): A computer controlled device used to ferry parts around a manufacturing plant (Toncich, 1995).

Application: A piece of software that runs on a computer system. (Toncich D J, 1992)

Bandwidth: The difference in frequency between the highest and lowest frequency in a transmission channel (Toncich, 1992)

Broadband: Use of multiple channels over the same media via frequency division of the bandwidth (Toncich, 1992).

Business-to-business (B2B): businesses buy and sell among themselves (Milutinovic and Patricelli, 2002).

Business-to-consumer (B2C): consumers purchase products and services from businesses (Milutinovic and Patricelli, 2002).

Capacity Management: the function of establishing, measuring, monitoring, and adjusting limits or levels of capacity in order to execute all manufacturing schedules. (Sheikh, 424, APICS dictionary)

Computer Integrated Manufacturing (CIM): is to provide computer assistance, control and high level integrated automation at all levels of the manufacturing industries, by linking islands of automation into a distributed processing system (Ranky, 1986).

Computer-aided Design (CAD): is the use of computers to aid in the construction, modification and evaluation of design, includes hardware such as processors, graphics display terminals, keyboards and other ancillary equipment, and software namely computer programs for modelling, draughting, manipulating and creating the appropriate data base for the different designs (Meguid, 1987).

Computer-aided Manufacturing (CAM): use of computers to control production processes; in particular, the control of machine tools and robots in factories. In some factories, the whole design and production system is automated by linking CAD to CAM (Helicon, 2005). The development of CAM technology to automate and manage machining, tooling, and mold creation with greater speed and accuracy is intimately linked to the development of CAD technology (Geng, 2004)

Computer Numerical Control (CNC): A specialised computer control systemd used to co-ordinate the operation of a machine tool such as a lathe or mill. CNC is also used for surface-mount technology in electronics and for sewing machine control in textiles industries (Toncich, 1995).

Content Access Software: is used primarily to access content without editing, but may include software to allow content editing. Such software addresses the needs of individuals and groups to consume digital entertainment and published digital content. Examples include Media players, web browsers, help browsers, and games (Wikipedia 13, 2008).

Continuous Replenishment Program (CRP): is an EDI-based ordering system, aims to match the flow of products to the consumer's actual demand yielding improvements in manufacturing and warehousing activities, enables product flow prediction and inventory management (Monteiro et al., 2003).

Customer-to-business (C2B): individuals sell goods and services to companies (Jackson, Harris and Eckersley, 2003).

Customer-to-customers (C2C): the sale of goods and services between individuals, often via auction sites such as Amazon, eBay (Jackson, Harris and Eckersley, 2003).

Customer Value: is the customers' perception of what they want to have happen in a specific use situation, with the help of a product and service offering, in order to accomplish desired purpose or goal (Woodruff and Gardial, 1996).

Customer satisfaction: is a customer's positive or negative feeling about the value that was received as a result of using a particular organisation's offering in specific use situations. This feeling can be a reaction to an immediate use situation or an "overall" reaction to a series of use situation experiences (Woodruff and Gardial, 1996).

Departmental software: is a sub-type of Enterprise software with a focus on smaller organisations or groups within a large organisation, such as Travel Expense Management, and IT Helpdesk (Wikipedia 13, 2008).

Distributed Control System (DCS): is a control system that is used in complex manufacturing industries, it is an integrated system based on the concept of decentralization. The DCS controls and monitors inputs and outputs to and from remote terminal units (RTUs). It handles both sequential and analog control, implements it and performs operations, e.g. data gathering, data processing, data storing, monitoring of operational conditions to the operator, trend and analysis of data, historical record keeping (product/batch tracking), system maintenance from a single console, reporting of production status and information (Girdhar, 2004).

Digital/Distributed Network Architecture: The networking architecture of the Digital Equipment Corporation (Toncich, 1995)

Distributed or Direct Numerical Control (DNC): can simply refer to a CNC that can be linked to a host computer for unchecked file transfers. DNC can also infer that a Computer Numerical Control can be remotely controlled by a host computer, through a communications protocol. (Toncich,1995)

Electronic business (e-business): is the use of electronic communications networks to allow organisations to send and receive information, and this transfer of information can be entirely internal, unlike e-commerce, which typically crosses organisational boundaries (Slyke and Belanger, 2003).

Electronic commerce (e-commerce): is broadly defined as an electronic transaction, the sale or purchase of goods or services, whether between businesses, households, individuals, governments, and other public or private organisations, is conducted over computer-mediated networks. The goods and services are ordered over those networks, but the payment and the ultimate delivery of the goods or service may be conducted on or off line (Vickery, 2002).

E-manufacturing: is the vertical (business) and horizontal (supply-chain) integration of systems to ensure the correct dissemination of information throughout the value-chain of a business, making use of appropriate technology like the internet to ensure that real-time accurate information is available at all decision points throughout an organisation and supply chain (Greeff G and Ghoshal R, 2004).

Economic order quantity (EOQ): Ford Harris published in 1915 the first formula to calculate an EOQ to minimize the total of ordering-related and inventory carrying costs.

Electronic Data Interchange (EDI): is the electronic exchange of business documents between the computer systems of business partners such as banks, customers, and suppliers, using a mutually agreed standard format over a communication network (Pitlak, 2002).

Electronic Whiteboard: There are two very different types of interactive whiteboards: the first is a "virtual" electronic version of a dry-wipe board on a computer, that enables users to view, write or draws, can be found in conferencing and data sharing systems such as Microsoft NetMeeting. The second is a large physical display panel that can function as an ordinary whiteboard, a projector screen, an electronic copy board or as a computer projector screen on which the computer image can be controlled by touching or writing on the surface of the panel instead of using a mouse or keyboard. This technology allows users to write or draw on the surface, print the image off, save it to computer, or distribute it over a network. It also users to project a computer screen image onto the surface and then either control the application by touching the board directly or by using a special pen. The computer image can be annotated or drawn over and the annotations saved to disc or emailed to others (TechLearn Briefing, 2001).

Enterprise Software: addresses the needs of organisation processes and data flow, often in a large distributed environment. Examples include Financial, Customer Relationship Management, and Supply Chain Management (Wikipedia 13, 2008).

Enterprise Infrastructure Software: provides common capabilities needed to support Enterprise Software systems, such as Databases, Email servers, and Network and Security Management (Wikipedia 13, 2008).

Enterprise Resource Planning (ERP): ERP are software systems for business management, encompassing modules supporting functional areas such as planning, manufacturing, sales, marketing, distribution, accounting, financial, human resource management, project management, inventory management, service and maintenance, transportation and e-business (Hossain, Ed. 2002).

Extensible Markup Language (XML): is an open standard for describing data. It allows information to be encoded in a meaningful and yet human-interpretable manner.

Extranets: are business-to-business networks shard by two or more organisations, which accelerates the pace of business and movement toward an extra information economy. This extranet connection provides security to its business partners, suppliers or customers. The connection is typically made outside of the internet backbone (Girdha et al, 2004).

Hardware: is used to create, communicate, compute, modify, or display information (OTP, 1985).

Industrial Robot (IR): IR is a programmable machine that is used to transport objects around the manufacturing workspace. An automatic servo-controlled reprogrammable multifunction manipulator having multiple axes, capable of handling materials, parts, tools or specialised devices through variable programmed operations for the performance of a variety of tasks. (international standards organisation ISO. Cited Williams)

Information Worker Software: addresses the needs of individuals to create and management information, often for individual projects within a department, in contrast to enterprise management. Examples include time management, resource management, documentation tools, analytical and collaborative. Word processors, spreadsheets, email and blog clients, personal information system, and individual media editors may aid in multiple information worker tasks (Wikipedia 13, 2008).

Information Technology (IT): is the study, design, development, implementation, support or management of computer-based information systems, particularly software applications and computer hardware. IT deals with the use of electronic computers and computer software to convert, store, protect, process, transmit and retrieve information, securely. IT has ballooned to encompass many aspects of computing and technology, in general, IT describes any technology that helps to produce, manipulate, store, communicate, and/or disseminate information (Wikipedia 14, 2008).

Information System (IS): uses data to create information and knowledge to assist in operational, management, and strategic organizational decision making. It is also an umbrella term for computer information systems, management information systems, and information technology. (Scime, 2005a)

Intranets: a self-contained, internal network within an organisation. Internets offer the means to be used as a business or organisational tool using the standard protocols of the internet (TCP/IP) and applying it to individual organisational requirements (Girdhar, 2004).

Local Area Network (LAN): A privately owned network, offering reliable high-speed communications channels for connecting information processing equipment over a limited region (Toncich, 1995).

Legacy Application: inherited application, usually an old one that runs on a large minicomputer or mainframe, and that may be too important to scrap or too expensive to change. 'Legacy' implies that such applications are valuable and should be looked after (helicon, 2005).

Legacy System: old, in-house, back-room, pre-internet, corporate computing systems. Legacy systems have to be overhauled so that a company's front- and back-room operations can integrate seamlessly with the internet and internet applications (Helicon, 2005).

Local Area Networks (LANs): LAN is the smallest network, which is usually contained in one office or building or small group of buildings. LANs have high speed, low error rates and they are inexpensive (Karris, 2004).

Metropolitan Area Network (MAN): MAN is a large network that can include one or more LANs to interconnection organisations spread over a town or city.

Minitel: is a Videotext online service accessible through the telephone lines, and is considered one of the world's most successful pre-World Wide Web online services. Users could make online purchases, make train reservations, check stock prices, search the telephone directory, and chat in a similar way to that now made possible by the internet (Wikipedia 15, 2008).

Numerical Controller (NC): it contains an operating system, program editing and storage facilities (Toncich, 1995).

Operational Flexibility: is the ability of the organisation/business network to change the volume, mix and kind of activities based on its current structures (Monteiro et al., 2003)

Podcasting: is method of publishing audio programs via the internet, allowing users to subscribe to a feed of new files, a series of digital-media files which are distributed over the internet using syndication feeds for playback on portable media players and computers (Wikipedia 16, 2008).

Product Engineering Software: is used in developing hardware and software products. This includes computer aided design (CAD), computer aided engineering

(CAE), computer language editing and compiling tools, integrated development environments, and application programmer interfaces (wikipedia 13, 2008).

Programmable Logic Controller (PLC): is a digitally operating electronic apparatus which uses a programmable memory for the internal storage of instructions by implementing specific functions such as logic sequencing, timing, counting and arithmetic to control, through digital or analog input/ouput modules, various types of machines or processes national electrical manufacturing association (NEMA). The PLC is a computer used in process industries for controlling electromagnetic devices (Girdhar, 2004).

Qualitative Research: is based on phenomenological position to generally examine people's words and actions in narrative or descriptive ways more closely representing the situation as experienced by the participants (Maykut and Morehouse, 1994).

Software: is to provide data, knowledge, or programs which are sets of instructions for directing or controlling that hardware in its tasks to make the hardware do useful things (OTP, 1985).

Six Sigma: is a statistical measure of the performance of a process or a product, a goal that reaches near perfection for performance improvement, a system of management to achieve lasting business leadership and world-class performance (Pande, 2001).

Structural Flexibility: is the capability to adapt or transform the current structure or workflow of activities. At the interorganisational level, the structure of a network refers to the overall pattern of relationships. Transforming current structure could thus mean, creating new partnerships or dismantling old ones (Monteiro et al., 2003).

Strategic Flexibility: the most radical type of flexibility and could involve fundamental renovation of activities, products, and organisational structures. It also revolves around the ability to identify market trends before competitors and to make appropriate changes to synchronise production with demand (Monteiro et al., 2003).

Telecommunications: is the science and technology of communications at a distance by electronic transmission of impulses, such as by telegraph, telephone, radio or television. It is the foundation for the Internet and all of the emerging activities surrounding the Internet's activities (ISD).

Total Quality Management (TQM): is the integration of all functions and processes within an organisation in order to achieve continuous improvement of the quality of goods and services. The goal is customer satisfaction (Ross, 1999).

Vendor Managed Inventory (VMI): is a collaborative strategy between a customer and supplier to optimise the availability of products at a minimal cost to the two companies. The supplier takes the responsibility for the operational management of the inventory within a mutually agreed framework of performance targets which are constantly monitored and updated to create an environment of continuous improvement (Researchers at Cardiff Business school, Baily, 2005).

Webcasting: is a live video or audio broadcast over the internet, a user can receive a webcast without any specialist software (CCS, 2008).

Wide Area Network (WAN): WAN is interconnections of any number of LANs and MANs that connects geographically separated areas, with low speed when compared with LANs and MANs. The internet can be thought of as the largest WAN, it covers the entire globe (Karris, 2004).

Web Accessibility: Any person, regardless of disabilities, is able to use web technology without encountering any barriers (Becker, 2005a).

Web Advertising: Advertising through banners, sponsorships, interstitials, hyperlinks, and pop-up and pop-under windows in the internet media (Gao et al., 2006)

Web Application: An application that presents the characteristics and the issues of both hypermedia applications and traditional applications, has the navigational issues of websites joint to the traditional operation issues (Paiano, 2005)

Web Client: A software program (browser) that is used to contact and obtain data from a server software program on another computer (the server). (Nasraoui, 2005)

Web Collaboration: A particular use of a virtual space where people can connect together in a certain number and perform synchronous activities such as communication (text, audio, and video), polling/surveying, and share or work together on any kind of digital content displayed on a common interface. (Agosti, 2005)

Web Enabled: Business systems that are supported by internet technologies. (Braun, 2006)

Web Server: is a 24-hour, 7 days a week communication application that works something like an automated telephone switchboard. It waits for requests placed by people using web browsers asking for web pages. Once a request is made by a browser, the server returns to the client—if it can find it—the requested page (Darlington, 2005).

ABSTRACT

New approaches to the development of manufacturing strategies based on improved supply chain performance have made great progress. This research is undertaken to investigate the use of the internet and web technologies to enhance supply chain agility so the manufacturer is able to cope with make-to-order processing without facing a panic of late delivery.

E-manufacturing is a recent concept developed to achieve higher levels of supply chain integration and agility with the help of the internet. Its scope is greater than e-business and the supply chain. The use of the internet to optimise the customer-oriented supply chain, the use of the website for more than e-commerce known as buying and selling, these developments are immature.

As a result of a review of the literature and eight case studies, this research develops close-up views on the following three aspects that lead to the successful implementation of e-manufacturing in Business to Business (B2B) and Business to Customers (B2C): (1) Requirement specification; (2) Modules development; (3) Implementation methodology. The implementation of e-manufacturing enables the manufacturer to tie up with its supply chain existing partners and potential partners as an entity toward the same objectives, and brings maximum benefits to each participant. The fulfilment of web technologies creates web surroundings which provide the small company with an opportunity to be involved with the large enterprise's e-commerce systems.

THESIS STRUCTURE

Based on the manufacturing perspective, this thesis was written in an effort to outline basic approaches to developing e-manufacturing in B2B and B2C. This thesis comprises eight chapters which specify the whole process of this research and address the research issues. Each chapter contains several subdivisions.

Chapter One, E-manufacturing Era, introduces the background of this research, provides the definition of e-manufacturing and clarifies the problems that this research is going to address. It also sets out the aims and objectives of the research, and finally outlines an overview of the research methodology which will be adopted to complete this project.

Chapter Two, Manufacturing Development, tracks the history of the evolvement of the manufacturing industry since the late of 19^{th} century, which covers the development of manufacturing systems and strategies over the past decades. This chapter delivers a comprehensive review of how the manufacturing industry has been developed.

Chapter Three, Literature Review, discusses the use of the internet in business and the strategies of the implementation of e-manufacturing that have been suggested by other researchers.

Chapter Four, Methodology, introduces the fitting strategies and approaches that led to the successful achievement of this research. It emphasises the importance of setting up right research questions at the early stages which helped the researcher focusing on the objectives.

Chapter Five, Collecting Primary Data, describes what the major techniques were used to collect data. Questionnaire design was mentioned. The brief background of eight case companies was provided separately. Data was collected via site visits, interviews and observation of these eight companies.

Chapter Six, Finding and Analysis, reports on the extracts of findings of the case studies and the survey, provides the analysis relating to the research questions. The discussion recaps how manufacturers have applied the internet to the aspects of manufacturing and business processes. The experience and knowledge acquired through the case studies and the survey indicate the requirements needed for the successful implementation of e-manufacturing.

Chapter Seven, Novel Avenues to E-manufacturing, develops close-up views on the following three aspects that lead to the successful implementation of e-manufacturing: (1) Requirement specification; (2) Modules development; (3) Implementation methodology.

Chapter Eight, Conclusions and Recommendations, denotes the end of this thesis with the final conclusion of the research and a brief discussion of limitations and future research. The conclusion summarizes what the research objectives have been achieved and what the research has contributed to the knowledge.

CHAPTER ONE: E-MANUFACTURING ERA

Chapter One Objectives:

- *The background of this research*
- *The objectives of this research*
- *The deliverables of this research*

This chapter begins with a description of the major pressures that have been weighing on the 21st century's manufacturers. It goes on to introduce e-manufacturing, the needs and opportunities of the implementation of e-manufacturing, and how this research is going to address problems. The chapter then goes on to identify several research questions and to set out the aim and objectives of the research programme and its scope. The methodology for the research is drawn at the end.

1.1 Manufacturing in the 21st Century

"The value age is creating a new set of expectations. With nearly everyone used to getting more for less, price pressures, better service and improved value propositions are beginning to impact nearly every industry?"

-- William Belgard (2004)

The manufacturing industry continues to change and develop the ways it conducts businesses and the technologies it implements. The constant stream of innovations in technologies, new products and services has resulted in the product life cycle getting shorter, as well as higher levels of customer expectation. For instance, the combination of automated ordering systems (telephone, fax, and, most important, the internet) allows companies to serve customers in new ways that add convenience, quality, customization and service against time (Blegard, 2004). Demand for specialised products started to take hold at the beginning of 1950s. Not only are products more specialised, but they also have limited product life cycles (Hobbs, 2003). As companies become larger and international, the number of worldwide products and services has been increasingly growing; more and more products integrate components originating from different countries for the best price (Cunha and Cruz, 2006). Nowadays, competition is not only limited to product quality and price, it also encompasses delivery, product differentiation and great services. Manufacturing has been moving away from a conventional "make to stock" situation toward a "make to order" ethos, where customization is replacing standardization to fit in with the customer-oriented market (Adam, Ed. 2004). Under such circumstances, there are three concerns which manufacturers need to keep in mind: (1) Broader Perspective; (2) Win-Win Strategy; (3) Information Is the Key.

1.1.1 Broader Perspective

Carreira (2005) asserts there are certain steps required to make a particular product, and everyone does them the same way: purchasing identical equipment and facilities, hiring and training qualified people, and purchasing the raw materials required to make a product, but might not necessarily achieve the same result. According to Carreira (2005), the difference appears to be in the manufacturing technique – how to manage and balance people, materials, and machines. This thought was based on the improvement of internal relationships and activities. Is it good enough for manufacturers to be able to survive today and in the future? In fact, manufacturers do not exist in a vacuum. Every manufacturer has to deal with the internal pressures from day-to-day operations, and also those outside pressures including micro-external environments like suppliers, distributors, customers, competitors and other fellowships, and macro- external environments such as political, economic and socio-cultural factors. These external factors are not controlled by manufacturers, but they could inhibit manufacturers growing successfully. Therefore, manufacturers should endeavour to develop relationships with all tiers of suppliers and customers, and enlarge their capabilities to be able to anticipate the external uncertain surrounding. The decision-making processes should take into consideration both internal and external impacts as shown in figure 1.0.

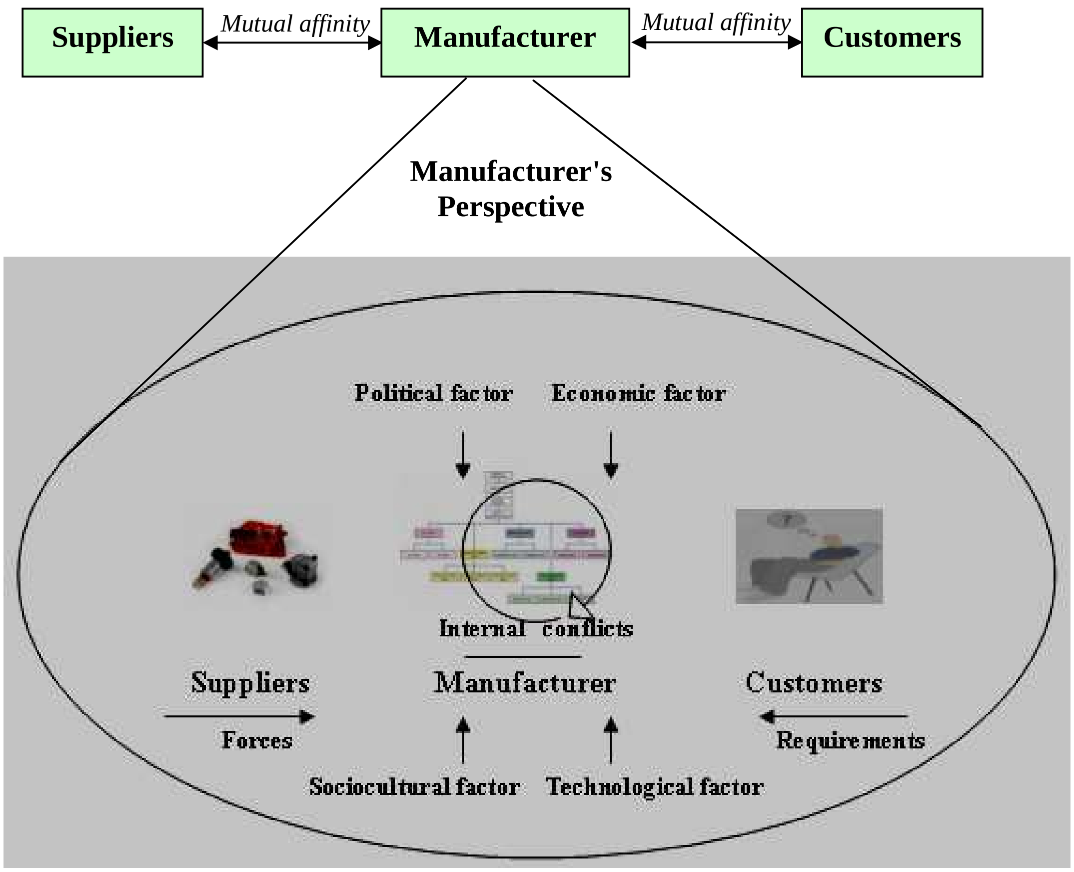

Figure 1.0 Manufacturers' broader perspective

Manufacturer broader perspective fits into the concept of extended enterprise which brings together all members of a value network working toward a common goal or opportunity by integration of the organisation's external networks into internal value chains to yield new value configuration (Ranganathan et.al., 2004).

1.1.2 Win-Win Strategy

The growth of the international market gives buyers more choice and brings domestic manufacturing under more pressure. The widely accepted internet also threatens to introduce new competitors and new products into the domestic market. Buyer awareness of marketing activities and expectations of better value have escalated dramatically. They know more, want more, get more and then will ask for more next time. As the customer becomes sophisticated and indurate, the market is getting volatile and unpredictable (Woodruff and Gardial, 1996). There has been a fundamental shift in power between sellers and buyers. It is worse than just customers with higher expectations though (Piercy, 2002). To guard against a buyer turning away to other competitors, it should be one of the priorities for managers to have a clear understanding of the value on which buyers count (New and Westbrook, 2004). There may well be a range of definitions of 'customer value' as the customers' expectations for value vary from one market segment to another (Gattorna and Walters, 1996). If a company understands individual value, ways usually are found to deliver that value to customers' satisfaction (Woodruff and Gardial, 1996).

From the customer's perspective, their satisfaction may be based on whether manufacturers fit in with their preferences for products' quality, design, function, brand name, price and service. If a manufacturer tailors individual customer's needs to their satisfaction, it creates the foundation of customer loyalty. The more customers experience surprise, delight, and other positive emotions, the higher they are satisfied (Oliver, 1997). Customers total experience with the manufacturer will determine their loyalty, thus, everything that touches the customer must work together to produce customer value (Gattorna, Ed. 2003). There is always a need for a new buyer to spend time on searching products and corporations' information. Facilities for capturing enough information and knowledge will assist customers to search out the right manufacturer over the comparisons. When they approach the manufacturer, if the manufacturer is responsive, customers will be able to explain their need and expect a solution, if the manufacturer is not responsive, the customer has to keep searching until an appropriate solution is found (Davis and Manrodt, 1996).

From the manufacturer's perspective, their satisfaction may build upon a ratio of profits to investment. The more profits they obtain from transactions, the more cost they save from operations, the more margins they may gain from the investment, and then increased satisfaction would be gained. Tactical strategies, flexible management and advanced technologies support manufacturers to perform well leading to gain the maximal profits.

However, there are often conflicts between a manufacturer and its buyers. Figure 1.1 was drawn to illustrate the leverage of a manufacturer and its customers. The balance point is where these two parties can both benefit best from the transaction based on their own merits and trust relationships.

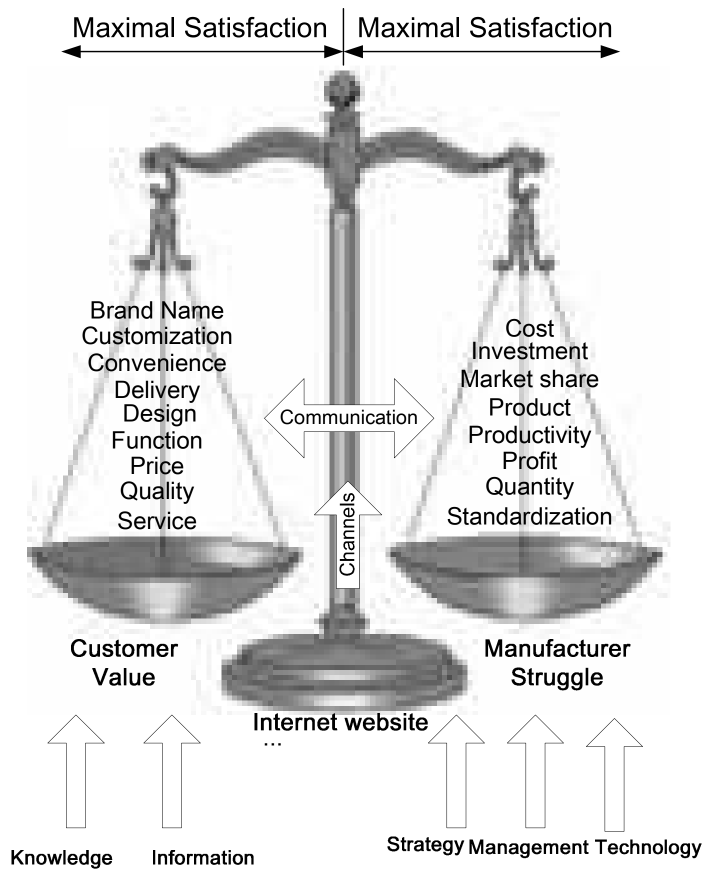

Figure 1.1 Conflicts between Buyer's satisfaction and Seller's satisfaction

1.1.3 Information Is the Key

Obviously, figure 1.1 is a sensitive swinging lever where balance is not always stable. Once elements that make up of both satisfactions are not met, the balance will be destroyed. Usually, the buyer and the seller have different interests, and most of all have conflicting objectives. When the manufacturer acts as a seller, an understanding of how customers define value becomes the guiding force for the manufacturer to determine what should be improved and delivered. In other words, a manufacturers' superior value delivery starts with information from customers (Woodruff and Gardial, 1996).

In the fast changing world, what we all have to compete is rich in information—but information owned by the customer (Piercy, 2002). The degree of imperfect information sharing between the buyer and seller threatens to create barriers for future business (Heinrich and Betts, 2003). It is necessary to create information networks for clear and unambiguous communication to allow suppliers and customers to realise the maximum amount of synergy from their relationship (New & Westbrook, 2004). Efficient communication networks must allow direct and two-way communication to avoid information from being missed out and misinterpretation. Direct two-way communication allows manufacturers to clearly understand how customers define their value real time and then to provide a set of services to precisely satisfy customers and solve customers problems; On the other hand, it also gives customers opportunities to tell manufacturers what they are desired for, this will help in new product development. In addition, if a manufacturer is customer- responsive and effectively meeting customers' needs, it will increase customers' trust and reliance on the manufacturer. When they have a need, they will come back to that manufacturer first. By creating customers' expectations of value for each individual customer, the manufacturer has given rise to increase strong relationships with customers that is more than a one-time business (Davis and Manrodt, 1996).

Incidentally, customer-responsive activities started in the 1960s as customisation was increasingly asked for by customers for their individual needs and solutions (Fleming, 2004). A customer-responsive manufacturer develops a process which allows interaction with each individual customer one-to-one to define their individual needs and coordinate deliveries of customized solutions to each of them (Davis and Manrodt, 1996; Fleming, 2004). This philosophy is market-driven which creates value for customers through listening to them and making what they need. It is different from a product-driven philosophy which aims to maximize company profit via value-added and cost saving. The concept of product-driven focuses on the best way to deliver their offering to customers based on their perspectives rather than on customers perspectives (Davis and Manrodt, 1996).

In conclusion, to be customer-oriented, it is critically important to build upon open communication networks that are powerful and capable to enable rapid direct communication among trading partners so as to enable timely customer-response (Raisch, 2000). When such networking is enabled to respond to each individual customer needs, the greater the value created, the more delighted the customer, and the more delighted the customer, the greater the bonding between customer and manufacturer (Davis and Manrodt, 1996). Fluent communication channels both within the manufacturing organisation and toward suppliers and customers appear to be the lifeblood of successful manufacturers. Especially, when more products and services become commodities, it will force manufacturers to focus competitive differentiations on the effectiveness of customer interactions and the depth of customer intimacy (Aberdeen Group, 2000). Better communication will result in better understanding so the conflicts between a manufacturer and a customer can be quickly eliminated, and their satisfaction can be maintained and a trusting relationship can be developed.

1.2 Promising Strategy E-manufacturing

Fundamentally, there are two ways to compete in business: offer low prices or unique product/service. Offering low prices it has an attraction to customers, but, it is a bit more challenging for a manufacturer to do so to gain the profit (Boyer et al, 2004).

Over the past decades, various approaches to reduce costs have been undertaken. Figure 1.2 illustrates the outstanding manufacturing strategies and systems that have been applied to reduce costs in manufacturing.

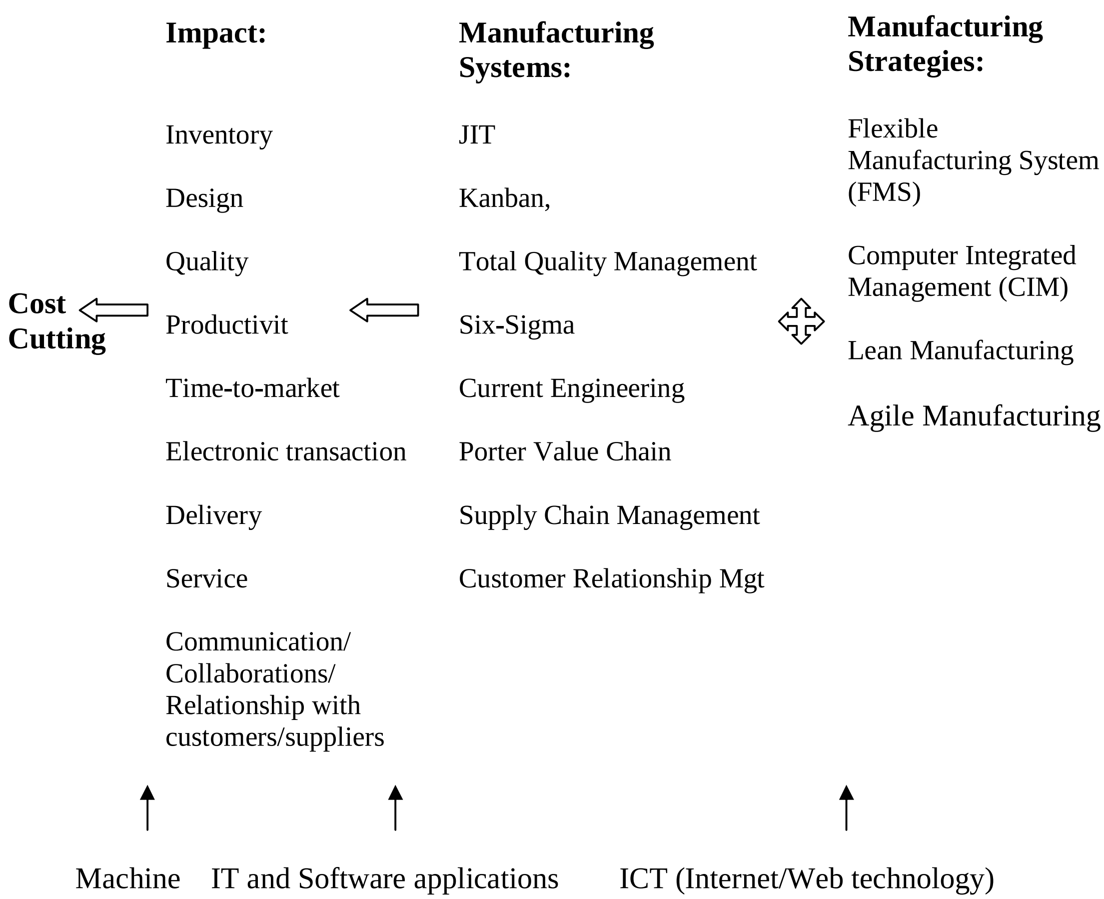

Figure 1.2 Practical applications for manufacturing cost leadership

It was not hard to find savings from better purchasing and sourcing, logistics, storage, product delivery, and management of inventory, but when manufacturers tried to find more saving, when there is not much left to cut from operating costs, most efforts began to deliver fewer returns (Poirier, 2003). When the environment changes, opportunities and impacts will force manufacturing to modernise, the strategies and techniques that performed well in the past might not be able to solve the problems of the modern era. It is always a right question to ask what strategy should be abandoned, what should be still used and what should be developed. Contemporary manufacturing is looking for methods of handling information instead of the outworn methods of driving machinery to move forward businesses (Schurr, 1990). E-manufacturing appears to be an novel means for this challenge by the use of the internet and e-business technologies to carry out the range of online manufacturing activities which cover all aspects of manufacturing including sales, marketing, customer service, new product development, procurement, supplier relationships, logistics, manufacturing, and strategy development (Cheshire Henbury's manufacturing, 2005).

1.2.1 What is E-manufacturing?

There are several perspectives of the e-manufacturing concept have been adopted. One of the popular definitions is provided by Greeff G and Ghoshal R (2004) implies e-manufacturing is a transformation system that enables manufacturers to achieve information flows seamless:

E-manufacturing is the vertical (business) and horizontal (supply-chain) integration of systems to ensure the correct dissemination of information throughout the value-chain of a business, making use of appropriate technology like the internet to ensure that real-time accurate information is available at all decision points throughout an organisation and supply chain.

This definition of e-manufacturing emphasises two "I" elements:

(1) Internet: is embedded into the company's IT systems for the achievement of interconnection, openness and transparency of information sharing across functional boundaries and geographical boundaries. The internet provides users with an easy instant access to a wide range of information. It generates and disseminates a wealth of real-time information throughout the manufacturing supply chains.

(2) Integration: is the essential strategy which is not new to manufacturers. With the help of the internet, e-manufacturing reemphasises the integration of the disparate IT systems to meet the challenge of cross-functional coordination and cross-enterprise coordination for creating the well-integrated supply chain.

E-manufacturing is more than just e-business. AMR Research (2005) clarifies that the core of an e-manufacturing strategy is about the technology roadmap for information transparency between the customer, manufacturing operations and suppliers; an e-manufacturing strategy takes e-business processes such as build-to-order and reliability centred maintenance, associated with the e-business and manufacturing strategies to create a roadmap for systems development and implementation in the plant.

The use of the internet in businesses creates great marketing opportunities for manufacturers, but also enables value-added and value-created benefits to customers with advantages. It provides Small and Medium Enterprises (SMEs) with the opportunity to be involved in larger enterprises' e-commerce systems. Manufacturing production realization encompasses a wide range of activities, from materials sourcing, purchasing and handling, to production planning, controlling and producing, and then to warehousing, distribution and the end users. E-manufacturing is to accomplish a complete integration of all the elements and all the activities of a business, with connectivity and intelligence brought by the web-enabled and tether-free (wireless, web, etc.) technologies and intelligent application software to meet the demands of e-business/e-commerce practices (Zurawski, ed. 2005). For further details of e-business and e-commerce refer to Chapter Two.

E-manufacturing can be understood as a kind of online-manufacturing which is visible to suppliers, manufacturers themselves, customers and transportation so that they can take part in manufacturing activities by way of collaboration (Jiang, ed. 2007). Apparently, e-manufacturing is to use the internet to reshape manufacturing supply chains and create a highly integrated and highly flexible system that provides a holistic view of the entire enterprise, up, down, and sideways (Rockwell Automation, 2000). The successful implementation of e-manufacturing will result in the elimination of any isolating mechanism to ensure manufacturing supply chains and information flow networks seamless connections, and that will lead to materials and goods, data and information, and transactions being handled efficiently and effectively without any unnecessary stop.

The following subsections will separately supply a brief introduction to the internet, telecommunication, and information and communication technology (ICT). The internet**,** telecommunication and ICT are interdependent and interactional. They make concerted effort for fast and easy communication and data sharing world wide.

Communication and information transfer barriers of time, distance and cost have been overcome. The result advances the accomplishment of e-manufacturing.

1.2.1.1 Internet, Web and Computer Network

The internet is *a worldwide computer network, in which any computers in the world can be connected together, ready to communicate with each other within a second; in which end users are permitted to access to any and other connected devices such as a printer, etc.* (Griffiths, R. T., 2002). A computer network is perceived by Bocij et al (1999) as '*a communications system that links two or more computers and peripheral devices and enables transfer of data between the components*'. According to their scale, computer networks are widely categorized to three main types: local-area networks (LANs), metropolitan area network (MAN) and wide area network (WAN) (Karris, 2004).

Computers enable people to do complicated calculations, accumulate and retrieve data, and do many other things effectively and efficiently, but they are limited without a media network. Since the 1990s, when the World Wide Web (the web) and the web browser were released, this revolution of computer networks has brought remarkable achievements in communications of the enhancement of speed and capabilities with lower cost or without cost. Web technologies use a new set of standards and technologies that allow organisations to locate and disseminate information in a standard, user-friendly manner across a variety of incompatible technical platforms and across geographical boundaries, enabling other applications to communicate through its interface regardless of programming language, hardware platform, or operating system (Bussler et al. Eds., 2002, Scheepers and Rose, 2001, citing by Castells, 1996). In practice, web technologies brought network technologies to a further advanced stage where video, sound, documents and almost any other type of data can be transferred and stored over computer networks, and are available to all sizes of organisation, irrespective of whether they intend to possess their own website (Stroud, 1999). Because of the flexibility of the medium and ease of use, the web has quickly become the most popular part of the internet (Nelson, 2000). Web-based applications and the content and services provided by them are sometimes viewed as synonymous with the internet; however, the internet is a more general-purpose network over which the web is layered (NRC, 2001). To be simplified, this thesis considers the internet and the web as interchangeable.

Because of the functionality, easy use and low cost, the use of the internet has expanded from first applying to military sites, then to education, and now to being extensively used in both the corporate and the private world, especially being used in almost every aspect of business. How the internet is used in the manufacturing industry will be discussed in Chapter two. However, the internet can not be so popular without counting on telecommunication and ICT. The integration of telecommunication and the internet deliver a prime method of communications.

1.2.1.2 Telecommunication

The term telecommunication, according to the Information Services Board (ISD), *is the science and technology of communications at a distance by electronic transmission of impulses, such as by telegraph, telephone, radio or television. It is the foundation for the internet and all of the emerging activities surrounding the internet's activities.*

Since the famous "first message"--“What Hath God Wrought?" was sent over the 40-mile line from Washington to Baltimore on May 24, 1844, the electric telegraph enabled early telecommunication technologies to conquer distance based on electronic signals (Pool, 1990). The invention of the telephone allowed interactive voice conversations instantly over great distances and made two-way communication over distances possible for the first time. A nation’s telecommunications infrastructure is vital in maintaining a good business climate, the ability of telecommunications provides an efficient, internationally competitive network for transferring information has significant implications for trade and economic growth (Maddock, 1995). Orders can be made immediately over the phone, and the invoice can be faxed to the overseas company in just couple minutes regardless of the expensive international call.

1.2.1.3 Information and Communication Technology (ICT)

Since the first freely programmable computer Z1 was created by Konrad Zuse in 1936, the powerful computer had been developed to be used in telecommunications (Urs, V.B, 2000). In 1960, Bell Laboratories installed the world's first telephone exchange based on a stored program computer, in Morris, Illinois, USA (Aronsson, 2005). ICT is the fusion of computers and telecommunications. Advances in ICT have progressively reduced the cost and time of managing information, but also is a means of obtaining education, information, and working creatively with others irrespective of geographical barriers (Mobbs P 2002), and brought innovations in products design and operation processes. Today, telecommunications are firmly based on computer technology, fundamentally dependent on the internet (Stroud, 1999). International telephone calls are increasingly made through the internet's network of networks, and television and radio are broadcast via the internet. ICT is a key feature in the explosion of the internet and the web which are explored and exploited to enhance communication and information exchange between organisations and individuals (Morgan, et. al., 2006). The higher the telecommunications bandwidth speed is, the sooner the business user will get the information (Wroblewski, 2002).

The communication industry is committed to develop new technologies for easy access to the internet with high speed, low cost and enlarged capability. The third-generation (3G) wireless networks which use a new radio communication technology have achieved high-speed mobile access to the internet. This 3G technology is all about high-speed, multimedia, intelligence, convenience and it achieves the promise of always-on access internet anytime and anywhere. In the near future, when beyond 4G mobile or follow-on technologies are developed that should largely enhance and extend mobility in many areas, and will link companies of the world in an even wider network. Wireless technologies have extended wire-based (telephone, cable television, and computer network) systems' capabilities: making mobile communication possible, dramatically reshaping the communication, providing people with new, efficient, cost effective and more flexible ways to access information and communicate with each other; today wireless technologies include radio and television broadcasting, satellites, cellular and other mobile telephone, and a variety of data communication systems

(OTA, 1995). These advanced technologies are now widely applied to businesses and allow users to access applications and data from any location.

1.2.2 Needs and Opportunities in E-manufacturing

As competition increases, manufacturers are struggling to maintain profits and increase market share, meanwhile, manufacturers have been trying all means to: reduce inventory, shorten lead time, increase productivity, improve quality, develop new products and new services, consolidate collaboration with suppliers and customers, or be flexible and change ahead to prevent uncertainty. To accomplish one or many of the above results, some managers rely on information technology to achieve shop floor automation; some managers emphasize on flexible and lean manufacturing strategies; some make efforts on the supply chain networks for the consolidation of relationship with suppliers and the improvement of customer service; and some use e-business to develop market-oriented trend.

The first wave of supply chain-related internet applications focused mostly on automation of internal work flow (including ERP systems) and procurement-related transactional activity, such as placing catalogs online and buying goods and services; the second wave of the development relates to " e-manufacturing" – the marriage of the digital factory and the internet (Davis and Spekman, 2003).

This research advocates that e-manufacturing is to bring the manufacturer together with its suppliers and customers as a whole concern in a tight control condition via the internet, to achieve a combination of cost, quality, delivery and performance that delivers the maximal benefits to each party. As the importance of communication and understanding between buyers and sellers described above, this research is to apply e-manufacturing to deliver advanced web-based Information Flow Network (IFN) that ensures information consistency, transparency and synchronisation over boundary barriers so that effective and efficient responsiveness can be fulfilled and then to propel physical material flows. Currently, manufacturing IFN is lacking in the aforesaid capabilities. There are some typical obstructions shown below that stand in the way of information flowing freely and efficiently.

1. Legacy systems lack of flexibility, simplicity and responsivity

Legacy systems are those old, in-house, back-room, pre-internet, corporate computing systems. They are a hangover from the pre-internet business world (Helicon, 2005). Legacy systems are large with hundreds of thousands or even millions of lines of codes, written in legacy languages and are built around a legacy environment (Yang, 2002). As a huge investment in legacy systems was made worldwide, it is a well-known fact that some legacy systems have not been replaced or upgraded (Helicon, 2005).

Examples of legacy systems are Manufacturing Execution Systems (MES), Material Requirements Planning (MRP) and Manufacturing Resource Planning (MRPII). These systems have dramatically improved shop floor operation, but legacy systems share the same problems: they are autonomous and operate independently with little or no interface with other applications, data has to be manually updated and consolidated. This results in the data lack of consistency along manufacturing supply chains (Yang, 2002).

The inherent limitations hamper these legacy systems to satisfy today's business climate in which customers are demanding customization, specifications and engineering changes frequently and suddenly within ever shorter lead-times. MRP is the earlier computerized application for the planning of materials acquisition and production, which is still widely used by today's manufacturers. The system has strict discipline requirements in input and reference data, inefficiency data processing, and fixed lead times regardless of the inventory level. MRP does not consider fluctuations in production time caused by machine downtime, customer requirement changes; has no responsive ability to re-evaluate a given schedule (Chan et. al, 1999). In point of fact, MRP and its further evolvement known as MRPII systems are typical 'push' systems which gratify manufacturing "make to stock" condition. The production of a certain product is pushed from one operation to the next regardless the real demand or the request pulled by the buyer. Consequently, the planning and material procurement process is too slow to respond to unexpected change (Aldridge and Betts, 1995).

2. Lack of a complete integral enterprise-wide IT system

Enterprise resource planning (ERP) is a generic term for integrated systems, which supersedes MRP/MRPII to be the central repository for all of an organisation's information. With the goal of being the single integrated information system across the enterprise, ERP systems eliminate complex, expensive interfaces between computer systems, and enable detection and elimination of process level redundancies (Teltumbde, 2000). In practice, ERP has shown its defects in integrating with plant system such as maintenance, unexpected shutdowns and variability of supply and demand, also has problems with cross communication between different ERP packages and databases (Rockwell Automation, 2005). The aim of supply chain management (SCM) is to manage the total flow of a channel from the earliest supplier of raw materials to the ultimate customer, and beyond, including the disposal process (Copper et al., 1997), but the supply chain also faces inadequate linkage with ERP, MES and Enterprise Asset Management (EAM) (Koc M et al., 2003).

3. Lack of affording the opportunity to SMEs

To date, most small and medium enterprises (SMEs) still rely on telephone, email and fax to carry out their business communications. Although the idea of electronic commerce has been around for more than three decades, the use of e-commerce between a large enterprise and a SME has not reached a vast extent as some applications are limited to large enterprises. One example is Electronic Data Interchange (EDI) which is the first e-commerce application of standardised electronic transaction between trading companies, a first two-way process for speeding up consignments. In contrast to the increasing numbers of large organisations deploying this application, many SMEs still can not afford to purchase EDI which requires the high expense of implementing the software, service and maintenance (IAC, 2001), hence a high number of transactions are required to warrant the investment in acquiring (Stroud, 1999). Obviously, placing such application is out of reach of many SMEs' financial situation. Stefansson (2001) points out that EDI is a solution made by the large companies for the large companies themselves, while SMEs do not have the opportunity to join the society.

SMEs contribute largely to national economies around the world**;** generally, SMEs constitute around 95 per cent of enterprises in different countries (Davidrajuh, 2003). For those small buyers who can not afford EDI, their inquiries about product and price, placing orders, and tracking orders have to be handled via phone, fax or email to manufacturers or to the middlemen such as distributor or retailers. If SMEs are out of this society, in fact, large companies that use EDI do not realize the full potential benefits because many of their small business partners do not use EDI (Stefansson, 2001). They will still need to employ a group of sales representatives to manually take orders, and then manually put the data into EDI. The consequences are that administration cost and time are not significantly reduced, automated order processes can not be accomplished, and lack of the horizontal integration with small customers for collaborative planning levels.

4. Lack of transparent communication viaduct over business boundaries

The traditional supply chain emphasizes long-term stable relationships with the few important business partners. Many manufacturers heavily rely on middlemen to sell their products, and some even employ middlemen to carry out customer service. As manufacturers do not directly communicate and affiliate with the end users, consumers' details, requirements, feedback and complaint are collected and archived by the middlemen who then select certain data to pass to manufacturers in their own favour and interpretation. As manufacturers do not have direct access to middlemen's customers' data, do not hold this first hand marketing data, so are unable to respond to customers' needs and problems immediately. Because of the existence of distributors, manufacturers do not know retailers actual demand; because of the existence of retailers, distributors do not know the end users actual demand. The lack of real-time supply and demand, whoever manufacturers or distributors or retailer are striving with forecasting all the time. Clearly, the opacity of information of supply and demand between the manufacturer and its remote customers result in duplicate inventory calculation occurring along the supply chain.

Generally speaking, the information flow is sequential as the physical products flow from the manufacturer through distributors to wholesalers to retailers and then to the end users, and vice versa.

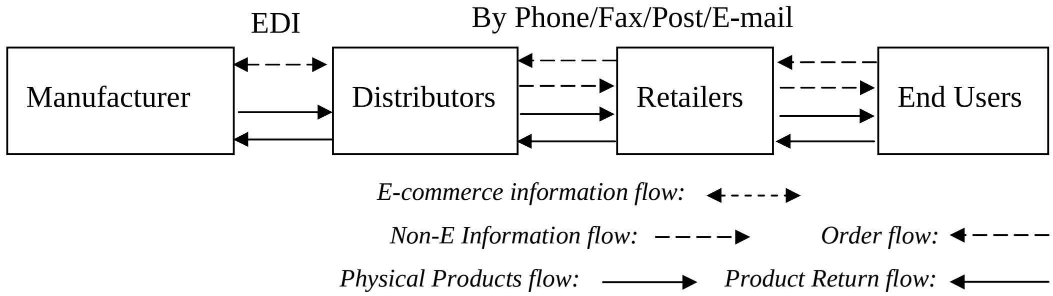

Figure 1.3 Physical products and Information Sequential flows

As showed in figure 1.3, information was conveyed from the manufacturer to the first tier distributors, passed to the second tier retailers, and then to the third tier retailers and eventually to the end users. In the same way, some queries from the end users were handed over to the retailers, then to the distributors and then to the manufacturer. But most queries were passed over somewhere. Because the data was carried from one company to another, the manufacturer's information could not be immediately disseminated to the masses. And customers' requirements could not be given straight away by the manufacturer. Traditionally, for a new commodity product launch, manufacturers needed to first get support from the distributors. If the distributors did not agree to stockpile, there was little opportunity that the new product would go into the market. Although many researchers have argued that the elimination of the middlemen will help to price leadership, most manufacturers are still using middlemen. Is it possible manufacturers can improve the relationship with distributors, while there is also a controllable communication channel to build up the direct relationship with the end users? E-manufacturing will be able to answer these questions. The adoption of e-manufacturing will give a solution to those manufacturers who are working on international orientation, customer orientation, competitive capability, and efficiency in business processes.

Greeff G and Ghoshal R (2004) made a comparison, in terms of lead-time, delivery performance and sales growth, among MRPII, lean manufacturing and e-manufacturing. The results clearly demonstrated why e-manufacturing was so important to manufacturers. The implementation of MRPII required the lead-time of 3 months, delivery performance was 90% and sales growth rate was 3%. Whereas if a manufacturer applied lean manufacturing including Six Sigma, the lead time was only 3 days, delivery performance reached 98% and sales growth rate was 8%. Significantly, if e-manufacturing was carried out, then the lead time reduced to 12-24 hours, delivery performance was up to 99.9% and sales growth rate increased to 10%.

1.3 How the Research Addresses Problems

This thesis outlines a philosophy that attempts to answer some of the problems such as inefficient information sharing and difficulty accessing information caused by traditional communication approaches. With emerging applications of the internet and tether-free communication technologies, e-manufacturing provides connective non-hierarchical information networks irrespective different IT systems boundaries, functions boundaries and geographical boundaries, even time and language barriers. It creates an e-business environment in which small enterprises can also be involved. Figure1.4 is the architecture of the novel information networks which use the internet to improve the data process including information collection, information dissemination and free response to the information.

This research will focus on the flexible web-based IFN to amplify the efficiency of the supply chain so as to meet the requirements of make-to-order. Through the web-based IFN, the end users are able to interact directly with the manufacturer. Information stopping at middlemen would be eliminated. Instant benefits can be seen in time saving and the capability of make-to-order. In addition, just-in-time manufacturing depends on real-time information to ensure the right materials and equipment are on hand substantially when production lines start, also JIT assures goods will be delivered to customers on time. The basic point of JIT is to do and provide something only when it is needed. This philosophy forces the design of business processes and information flows to be streamlined, fast, and clean (Beaver, 2001). To fulfil make-to-order and JIT, the flexible web-based IFN will help to perfect business processes through the improvement of information flow among the follow five associated areas:

1. Shop floor--front office: Plentiful information related to production realisation such as materials purchasing, customer requirements, orders to be visible to Shop floor, conversely, real time information of shop floor operation visible to the front office
2. Suppliers--suppliers--manufacturer: Manufacturers dynamically update information to various and different tiers suppliers; meanwhile, suppliers monitor manufacturers' inventory levels and automatically reorder for manufacturers.
3. Customers--customers--manufacturer: Customers autonomously placing orders
4. Customers-suppliers: Collaboration of product design
5. Logistics--Suppliers, Manufacturer, Customers: Orders on the road traceably

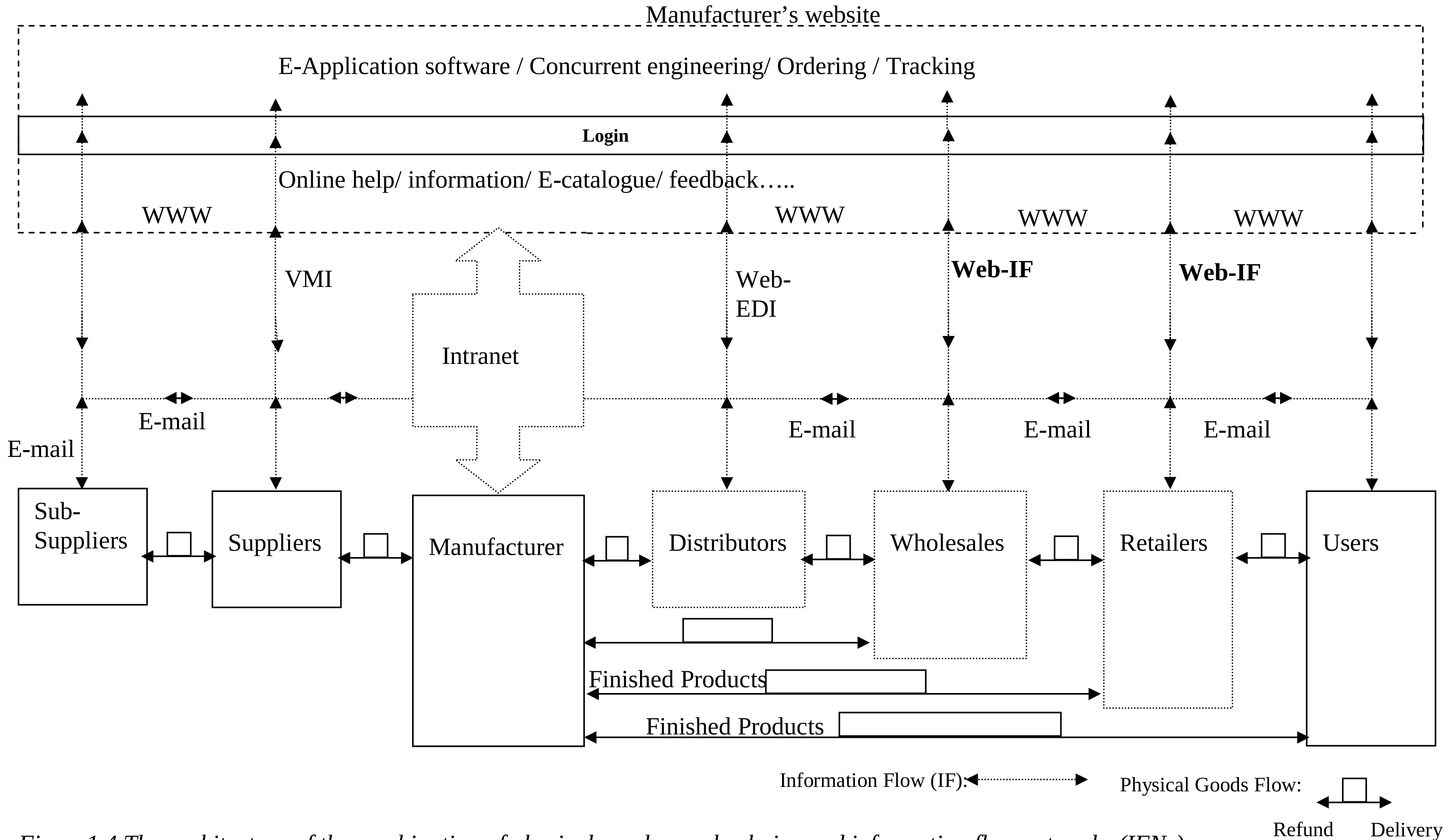

Figure1.4 The architecture of the combination of physical goods supply chains and information flow networks (IFNs)

1.4 Research Aim, Objectives and Questions

The degree and ways in which e-manufacturing can be fully applied will vary according to the products made and the markets served. The scope of this research focused on how e-manufacturing could help the integration of a manufacturer's supply chains through perfect web information flow networks (IFNs) in Business to Business (B2B) and Business to Customers (B2C). Based on the principles of e-manufacturing, the research examined a range of manufacturers to identify issues and barriers to information flows within a manufacturer and along its supply chains. The broad aim of this research is to provide theoretical concepts and web-based application-oriented models for the successful e-manufacturing in B2B and B2C.

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1. To understand current practical application of e-manufacturing in B2B and B2C within several sectors of the manufacturing industry
2. To identify the issues and barriers of existing information sharing channels across manufacturing supply chains.
3. To identify likely future trends in the application of e-manufacturing in B2B and B2C.

To achieve the above objectives, the following questions are raised:

(1) What is the current good practice of e-manufacturing in B2B and B2C?
(2) What are the issues associated with the use of e-manufacturing in B2B and B2C?
(3) What are the key factors that affect the internal assimilation and external diffusion manufacturing information?
(4) What competitive success factors are emerging from the use of e-business/e-commerce in other sectors that may be applicable to the manufacturing sector?
(5) How can manufacturers use e-manufacturing to improve their internal performance and thus improve their business partners' performance?
(6) How can manufacturers improve their supply chain competitiveness by the implementation of e-manufacturing in B2B and B2C?

(7) What are the general strategies to the implementation of e-manufacturing in B2B and B2C?

These research questions act as the organising principles throughout the research, which indicate the direction and scope of the research.

1.5 Research Methodology

The research methodology is about how to conduct a research project to meet the aims and objectives of the research (Usg.edu, 2006). It consists of a set of tasks undertaken in a set of logical manners to achieve the given objectives. The details will be discussed in Chapter 3.

The process of completing this project can be described as the progress of the new knowledge generated from the activities of Learning, Understanding, Reflection and Practice, see Figure1.5 below. Figure 1.5 is a learning cycle in which activities were repeated when the consequence fails to meet the objectives. Literature review as a basic learning means was applied to the project from the beginning until the project was finished. Case studies were deployed to investigate current e-manufacturing practice in depth within a number of manufacturing firms and identify the issues and barriers to the implementation of e-manufacturing. The comparison and learning from successful companies facilitated a greater degree of understanding of how supply chains operate now and how they could be enhanced by e-manufacturing in future. A questionnaire was designed and improved after the pilot case study; interviews were coupled with questionnaire to collect the data from the case companies.

When data gathered by questionnaire and interviews were able to answer the research questions, the broad views of the practice of e-manufacturing were formed. Based on the understanding of materials and the underlying principles, the development framework was constructed. Through the reflection stage, data gathered from the case companies were analysed, a number of hypotheses were then raised, and the framework was amended referred to the findings. Along with the hypotheses and the framework were testified in the certain case companies, the body of new knowledge in e-manufacturing was comprehended. The details of research methodology will be discussed in Chapter Four.

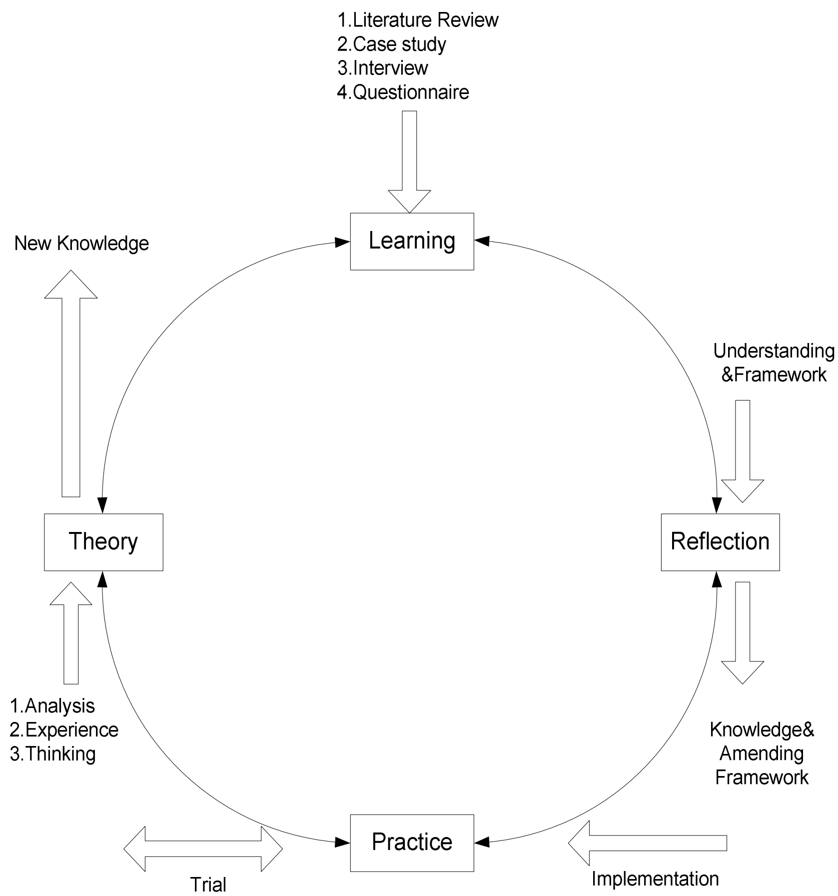

Figure 1.5 Learning cycle

2.0 CHAPTER TWO: MANUFACTURING DEVELOPMENT

Chapter Two Objectives:

- *The growth of the manufacturing industry*
- *Nine efficiencies in manufacturing development*

This chapter traces the development of the manufacturing industry starting from the late of 19th century to nowadays; nine efficiencies in manufacturing development are summarised.

2.1 Growth of the Manufacturing Industry

"There is a time for everything, and everything on earth has its special season."

--Ecclesiastes 3.1

Never have we needed a good crystal ball more than we do today. Yesterday's answers to business challenges no longer solve today's problems (Timm, 1994). The word 'manufacturing' was originally from Latin 'manu factura' which mean "making by hand", along with manufacturing development, the meaning has expanded into "making by machinery or by industrial process" literally. Today, manufacturing is more than the meaning itself. Manufacturing has became a complex activity drawing upon many theories, disciplines and technologies, reflecting management attitudes and philosophies; it is dependent upon organisational strategies and structures, influenced by economic development, political policies and culture, but also by the customers and the suppliers (Heim and Compton, eds, 1992).

The continual and rapid development of technologies is the heart of the manufacturing revolution. A study of the history of manufacturing development will help in understanding the context of the emergence of outstanding manufacturing strategies, systems and techniques, and their evolvement trend. The realisation of their benefits and deficiencies will enable manufacturers to apply the right strategies, choose the most suitable systems and use the proper techniques to boost all strategies and systems practised to their full potential. "*Study the past, if you would divine the future*" said Confucius (551BC--479BC). Without learning from successes and mistakes, things cannot be moved forward to a new solution. This chapter will go through the evolution of manufacturing systems and technologies in order to have a base-line understanding of the development of the manufacturing industry.

Three major manufacturing eras are drawn out as follow (Gunasekaran ed.,2001):

1. *Craft manufacturing: Workers were largely skilled, and work was highly skilled-low volume, high variety, customer-specific in a job-shop environment.*

2. *Mass manufacturing: Workers became largely deskilled, and work relied upon machinery to transform inputs into outputs and was narrow scope, high-volume, low variety, standard products.*

3. *Post-mass era (strategic manufacturing): Markets are now fragmented, global competition; rapid new product introduction needed with various levels of volume and variety; much greater need for flexibility, human commitment and skill.*

Craft manufacturing greatly relied upon skilled manual labour and tools. Every piece of work was made by hand, and so, every item was unique and productivity was relatively low. Man had started to use a simple device called a loom to weave thread or yarn into textiles as early as Neolithic times. A machine known as potter's wheel was used to aid making pottery in the Bronze Age. But these primitive technologies were incapable of getting man's hands free from most manual operation. Craft manufacturing is the era of the cottage industry in which almost all production was home-made, each cottage was run by an owner-craftsman who was responsible for buying raw materials, making products and selling his finished products (Talavage and Hannam, 1988). Although the manufacturing industry had gone a long way in changing, the significant changes started just after the Industrial Revolution happened in the late 18th century in Britain. The Industrial Revolution affected the way manufacturing was performed, the processes used and the products made (NRCS, 1995). The onset of the Industrial Revolution marked a major turning point in human social history; fundamental changes occurred in agriculture, manufacturing, transportation, economy and politics and many aspects of human society (World Book, 2000). The manual labour based economy began to go down to history.

There is no room to describe every innovation. This chapter sums up the nine efficiencies in manufacturing development showing how labour intensive production methods have been transferred to where they are today:

2.1.1 Efficiency in Machine and Power source (automated machinery)

Major contributions: Semi-automatic, Productivity, Standardization

Scripture says “there is nothing new under the sun”, it certainly pertains to manufacturing technologies in some ways (Hobbs, 2003). The concept of automation is neither new nor radical which has existed for thousands years. As early as 5000B.C. people had already known to use wind power to propel boats along the Nile River (Patel, 2005, Chambers, 1999), making wind be the first energy source used for transportation. The clepsydra, a type of water clock, was able to recycle itself automatically which is regarded as the earliest representative of robotic devices, supposedly invented in 250 B. C. (Hobbs, 2003). About 500-900 A.D the first windmill was developed to automate the tasks of grain-grinding in Persia (Dodge, 2001).

The era of craft manufacturing made many great inventors of history who had the amalgamation of technical skills, mathematics, scientific knowledge and experience. Archimedes of Syracuse (287BC-212BC) is one of the greatest ancient talents. He did original work in astronomy and engineering as well as in mathematics (Boardman etc., 2001). Archimedes was excellent in geometry, laid the foundations of hydrostatics and worked out the principle of the leverage. One of his great contributions is the Archimedean screw, a simple machine for raising water efficiently, purportedly used for removing bilge water from a huge ship. Archimedes’ screw was the earliest type of pump of the present day. Today, the principle of Archimedes’ screw can be found in sewage treatment plants, an auger in a snow blower or grain elevator, also in fish hatcheries used for a minimum of the physical handling of fish (Wikipedia 1, 2007). On all accounts, many existing technologies originated in antiquity, but the level of complexity and application have continued to evolve for perfection along with the changes of economic climate and existence condition year by year (Hobbs, 2003).

By the end of the Roman Empire (27B.C.—476 A.D.), when all the forms of modern hand tools had been devised almost, the second major step in the development of manufacturing was already underway by the introduction of mechanical means to assist cutting and forming with iron tools (Ian, Ed.1990). But the use of machines in the manufacturing industry was not quickly spread until the development of iron-making techniques and the increased use of refined-coal during the industrial revolution.

The causes of the Industrial Revolution were complex, but it came after a period of rapid development in science and technology. At the time, textile production was big business in Britain, several inventions of new machinery thrust the changes and growth in productivity in the textile industry that brought about the impact on other industries such as agricultural and mineral industry, transport and British domestic trade and later global economics (Gale and Kaur, 2002). Since the construction of canals, trunk lines, and railroads enabled raw materials and products to be shipped efficiently in the country, trading in the limited geographic region was expanded to a single national market which provided opportunities for the business growing (Olson, 2001). With the use of iron and steel, the need for machined metal products increased, powered machines were developed but these machines were expensive that the cottage-based craftsman could not afford (Talavage and Hannam, 1988). Along with the continuous method of driving was developed from originally human power to horse gins, followed by water wheels that were able to drive a number of machines, the cottage industry finally grew into the form of the factory, a central place where workers were gathered from homes to work together (Ian,Ed. 1999). Later on, commercial development of the steam-engine was mature over a century's evolvement, the coal-fired steam engines were soon adopted to drive almost every variety of machines through line shafting, pulleys and belting instead of the separate pole or treadle drive, the innovation of the steam engine largely raised worker productivity (Olson, 2001, Ian, ed. 1999). Since then, machines for boring, milling, shaping, slotting, planning, grinding and gear-cutting were flourishing during the late eighteenth and nineteenth centuries, and these machines began to be located in workshops offering general engineering facilities (Ian Ed. 1990). Factories were no longer constrained on the banks of fast-flowing rivers or streams. The workers had to give up the freedom of the countryside and move to houses close to the factories, regular working hours were then introduced，as well as penalties strictly enforced for failure (Ian, Ed. 1999). Later in the nineteenth century, the emergence of the more powerful internal combustion engine and electrical power generation, machines were finally widely used in the manufacturing industry and spurred manufacturing growth to accommodate the enlarging domestic market (Olson, 2001).

However, the industrial revolution could not have been so successful without the development of all-metal machine tools, making of machines to make machines was one of the most important aspects of the Industrial Revolution (Watner, 1986). Meanwhile the development of new sources of power, and the forms of new energy sources used for driving machinery in manufacturing also paved the way for the early shop-floor automation, especially electricity plays a great important role to modern manufacturing change. The use of wires instead of the elaborate systems of line shafts, electricity can be provided anywhere in a factory, each machine is run by its own electric motor, the machine location is no longer constrained by shafts. This progress allows machinery to be then arranged according to the logical sequence of manufacturing operations; this improvement drove the innovation of the production process, the product can be manufactured in a continuous sequence or flow (Schurr, et al.1990).

In addition, the discovery of the electromagnetic field in the Physics brought on new electronic machinery such as the telegraph (1832-1837), facsimile machine (fax, 1843), telephone (1874), radio (1902), and television (1925). These electronic devices are the foundation of a nation’s telecommunication infrastructure. The development of telecommunication is the great breakthrough in the history of sharing, conveying and handling messages across space and time. Telecommunications has significant contributions to the national productivity, trading and economic growth through bridging effective international communication networks (Maddock, 1995). Thereafter the first and largest electromechanical computer MARK 1 was built in 1944 (Krouse, 1982), along with technical improvements, computers have been used for the automatic processing of information for decades (Forester, 1985).

Before computer science applied to the manufacturing industry, factory automation was about automated machinery and systems such as automatic machine tools, machining centres, automatic assembly machines, industrial robots, automated inspection systems for quality control, automatic materials handing and storage systems (Irwin, 1997). A robotic device like Automated Guided Vehicles (AGVs) runs around a factory floor for transporting goods (Derby, 2005). The machining centre is to minimise handwork. The automated machinery and systems take over the majority of heavy and unpleasant physical labour, largely minimize or remove manned operation; meanwhile increase precision and enlarge productivity. These results paved the way for mass production: a single product can be manufactured in large quantities (OTA, 1983).

2.1.2 Efficiency in Scientific Management (Time and Motion study)

Major contributions: Management, Worker Labour Productivity

The emergence of automatable machines expedited manufacturing industry taking off. How to manage a machine with its enormous production became a challenge, but at the time the major issue of management was still the productivity of workers (Hobbs, 2003). There were few people concerned about applying science to the management until in 1881, Frederick Winslow Taylor proposed Scientific Management which made a systematic attempt to obtain maximum efficiency in industrial work (Hobbs, 2003, Strategos, 2007, Weisford 1987). He paid great attentions to the interlocking questions of “What is the best way to do a job?” and “What should constitute a day’s work?” (Gass, Assad, 2005). Through studying individual workers and work methods, combined with a time study, Taylor argued that the role of management was to analyse jobs in order to find the ‘one best way’ of performing any task or sequence of tasks to eliminate all false, slow and useless movements. Therefore, all work should be broken down, each individual task performed in maximum efficiency by the same workers all being well trained (Kanigel, 1999). To constitute scientific management, Taylor (1911) summarized a combination of five elements: Science, not rule-of-thumb work methods; Harmony, not discord; Cooperation, not individualism; Maximum output, in place of restricted output, and The development of each man to his greatest efficiency and prosperity. Taylor's time studies were logically complemented by Frank Gilbreth and Lillian Gilbreth's motion studies in the use of motion pictures for studying work and workers, these two sides of the efficiency improvement coin eventually became time and motion study (Hobbs, 2003, IW/SI News, 1968, cited by The Gilbreth Network, Anon). In addition to the technical aspects of worker efficiency, Lillian Gilbreth also introduced psychology to management studies, who is arguably the first true industrial/ organisation psychologist (SDSC.edu, Anon).

2.1.3 Efficiency in Flow (Assembly/Mass production/Batch production)

Major contributions: Cost Advantage, Production Process, Manufacturing System

And then, in 1910, there was Henry Ford who developed the modern assembly lines in mass production. By deploying standardized interchangeable parts, and division of labour, in 1913, Ford developed a continuous moving assembly line to manufacture automobile Model T (The Henry Ford, 2003). Reportedly, the idea of separate assembly lines and interchangeable parts had been applied to manufacture ships in Venice Arsenal several hundred years earlier than to produce cars. Mass production also appeared in the publishing industry as early as the mid-1400s; Johannes Gutenberg's Bible was published using a printing press. Although there is nothing interchangeable in an engineering component sense, coinage is in the first mass production which originated long before Gutenberg, as early as the sixth century BC. in Lydia (Ian, ed.,1990). In the automotive industry, Ransom E. Olds first created the assembly line in 1901 that had more than quadrupled his factory's output. But Ford and his associates were the first people to fully realize the potential of flow (Womack and Jones, 1996). He took all the physical elements of a manufacturing system—people, machines, tooling, and products—and arranged them in a continuous system for manufacturing automobile production (Stratego, 2007). He managed flows all the way from raw materials to shipment of finished cars (Womack and Jones, 1996). Ford also relied heavily on time studies: very specialized tasks for workers, and a separation between the planning done by engineers and the work performed by workers (Liker, 2003). By significantly reducing assembly time per vehicle, Ford's production of Model Ts gained the cost effectiveness that had made his company the largest automobile manufacturer in the world (The Henry Ford, 2003).

Early mass production depended on skilled machinists to properly fit parts together (Answers.com, Anon), but Ford contributed to the true mass production, with the aid of precise machine tools, parts of Model T were completely interchangeable and mechanized production (Iacocca, 1998). In the early 1920s, The Ford Company was assembling more than two million Model Ts at dozens of assembly plants around the world, every one of them exactly alike (Womack and Jones, 1996). The hallmarks of this system include nearly perfect interchangeable standardization of components, controllable manufacturing processes, and a simple, easy-to-manufacture standard product (Hobbs, 2003).

By the mid-1920s, sales of the Model T began to decline due to rising competition. Ford worked on only one model for too long, there was not a new design until the Model A in 1927, and by then General Motors (GM) had caught up (Iacocca, 1998). Alfred P. Sloan led GM to win the competition by establishing annual styling changes and managing diverse operations: a five-model product range from Chevrolet to Cadillac with a different pricing structure (Hobbs, 2003).

The era of Ford’s dominance based on standardization was over. The challenge in manufacturing during the 1930s shifted to product variety. As the 1950s began, demand for specialized products started to take hold. Batch production was then arriving (Hobbs, 2003).

The batch method has a cost advantage for businesses that produce a range of products in volumes, by which machines can be used more effectively, materials can be bought in bulk and workers can specialize in that task. The downside was that batch processing could create problems when trying to build a dissimilar mix of products (Hobbs, 2003). For instance, the production equipment must be stopped and re-configured before the next batch can be produced. There is a high probability of poor work flow, therefore, batch production requires very careful planning and co-ordination.

2.1.4 Efficiency in Pull System (Toyota Production System TPS)

Major contributions: Lean concept, value stream

TPS was developed by Toyota Motor Corporation in the late 1940s and early 1950s to eliminate waste and survive from the hard time after the country was decimated by two atom bombs. While many companies in the United States and Europe focused on Economic Order Quantity (EOQ) model to calculate the optimum batch sizes for production to gain economies of scale, Toyota worked toward the other way. To overcome the lack of resources, capital and warehouse, Toyota created a one-piece flow in low-volume production to be able to flexibly change for the next stage of production or customer demand (Hobbs, 2003, Liker, 2003). TPS is regarded as the next major evolution in efficient business processes after the mass production system (Liker, 2003). This system was actually evolved from Ford's system, but borrowed many of ideas from the U.S. plants, and was inspired by American self-service stores of replenishment triggered by customers (Gross, 2003, TMMK, 2006). In contrast to Ford's mass production system which was designed to make huge quantities of a limited number of models, TPS was adapted to the small production volumes of the Japanese market (Liker, 2003).

Ford preached the importance of the immediate purchasing, smooth continuous materials flows and the perfect transportation to avoid from carrying any stock, so as to eliminate waste (Henry Ford, 1922). Due to the inherent flaws of Ford's mass production system, Ford Company did not always practise all that it preaching. Huge banks of work-in-process inventories were built up by the interruptions between the discrete process steps (Liker, 2003). Pushing product onto the next stage of production under no consideration, it resulted in downstream manufacturing operations sometimes having too many parts and sometimes not enough parts to meet the production schedule; it caused overproduction or time for waiting (Womack and Jones, 1996).

Toyota learned lessons from Henry Ford, Just-In-Time (JIT) and Kanban as the major pillars of TPS, were designed to deal with what was known as “the seven wastes” identified by Ohno who is the major developer of TPS (Rushton, 2006):

1. Overproduction;
2. Waiting;
3. Transporting;
4. Inappropriate processing;
5. Unnecessary inventory;
6. Unnecessary motions;
7. Defects

JIT and Kanban improve inventory control by avoiding excess inventory in work-in-process and maintenance the appropriate level of stock in a warehouse. By applying JIT and Kanban to control physical material flow throughout the entire production process without any excess to minimise the operation cost (Chaffey, 2002). The concept of JIT and Kanban is related with the “pull system” which was inspired by American supermarkets in which individual goods were replenished as soon as they began to run low on the shelf (Liker, 2003).

In a pull system, nothing will be produced or no new stock will be ordered until the downstream process signals a need or stock drops to the re-order level. It means the preceding process must always do what the subsequent process says (Liker, 2003). JIT undertakes “the right material, at the right time, at the right place, and in the exact quantity”, the perfect input buffer inventory is considered as zero. The process is driven by Kanban which manages material into the flow-production process through a series of signals to tell production processes when to make the next part. Kanban is a technique to achieve JIT, a visual communication method to specify where to find material, where to take it, and when to pull material (Gilliam, 2004).

The basic philosophy of JIT comprises of waste elimination, goods in only when required. For JIT to work successfully requires consolidating the special relationships with key suppliers and other external partners like transportation.

However, JIT and Kanban did not gain worldwide acceptance until first embraced by Western firms in the early 1980s (Womack and Jones, 1996). Today Toyota continues to use TPS system not only to manage cost and flow, but also to identify impediments to flow and opportunities for continuous improvement (Gross, 2003).

2.1.5 Efficiency in Computer Power (Software Applications)

Major contributions: Automation, Automatic Control

The earliest digital computers appeared in the 1940s, they were huge and used clicking relays to perform computations, but the speed was slow. Soon vacuum tubes with electronic flip-flop circuits replaced relays and mechanical moving parts, the speed of computations increased thousands of times; soon after, transistors came up to replace vacuum tubes, which created a new generation of faster, more compact computers (Krouse, 1982).

The creation of the transistor in 1947 by members of Bell Laboratories was a key to the development of the microelectronics industry including integrated circuit, microelectronic storage chips and later on microprocessors. These technologies provided the breakthrough in computer capabilities, and stimulated the innovation of personal computing (Gasman, 1994). Because of these advanced technologies, computers became much more compact, faster, and less expensive. Since the 1960s the growth in the use of information system (IS) /information technology (IT) to support business activities has never been abated (Allan, 2001). The first wave of automation technologies raised in the 1950s and 1960s.

IT encompasses hardware and software. Electronic hardware is used to create, communicate, compute, modify, or display information. Software is to provide data, knowledge, or programs which are sets of instructions for directing or controlling hardware to complete tasks (OTP, 1985). However, IT encompasses many aspects of computing and technology that helps to produce, manipulate, store, communicate, and/or disseminate information.

The roles of IT in manufacturing can be seen in data storage, speeding the transfer of information and product design, supporting related business processes such as sales and distribution, supporting the management of product and process, control machinery and tools, monitoring the operations in the shop floor, assisting with administration in areas such as accounting and bookkeeping and so on (NRCS, 1994). IT has met a range of needs of manufacturing activities that are presented in the figure 2.0.

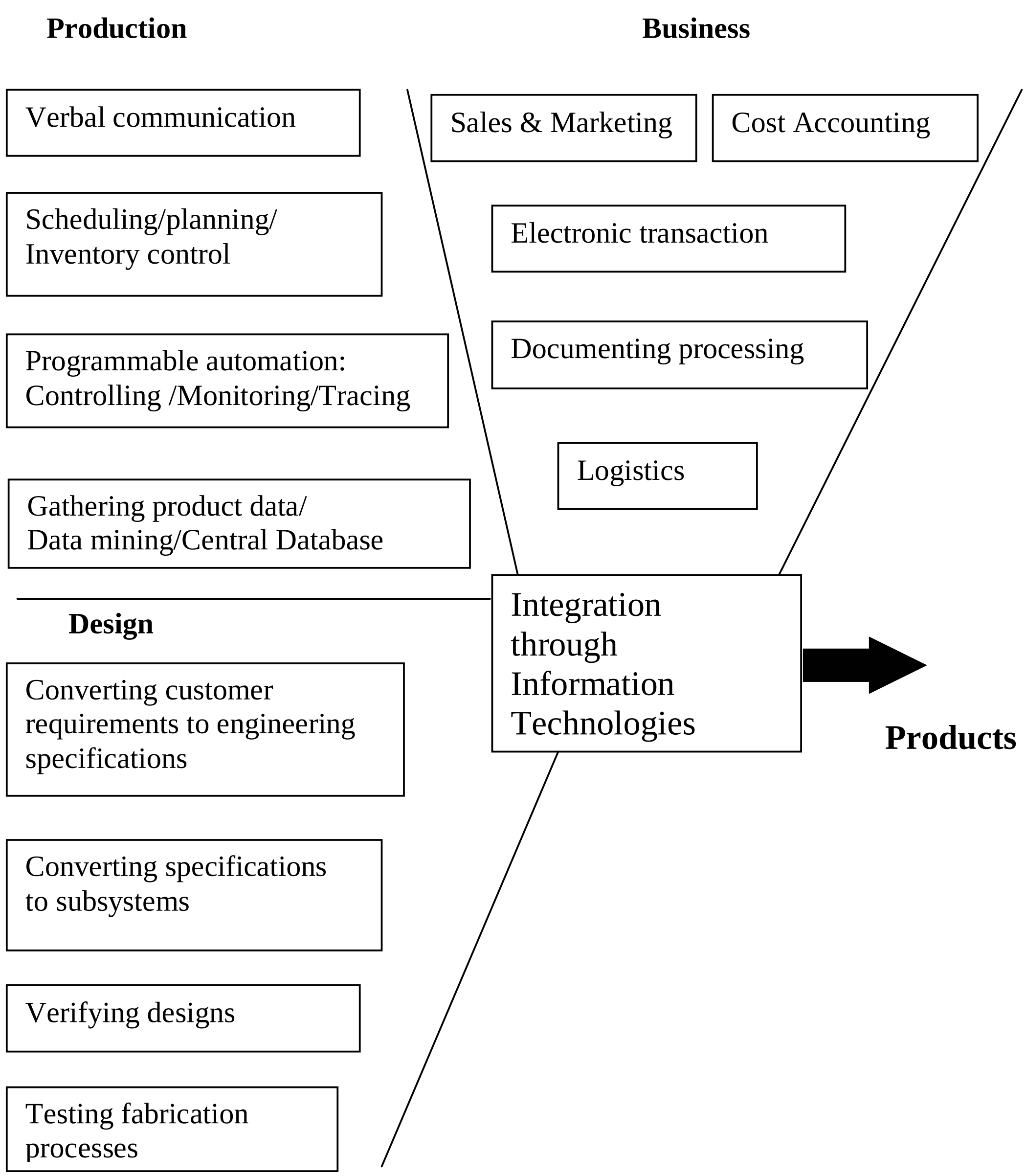

Figure 2.0: The use of IT in manufacturing (adapted from NRCS, 1995)

IT and telecommunications have lifted up a new wave of automation in manufacturing, transportation and in the office (OTA, 1985). However, different manufacturers have different levels of automation by using different software applications. Some of renowned applications are listed as below:

2.1.5.1 Computer-based Inventory Management System (MRP)

In the 1960s, effective management of the physical distribution function became an important issue; inventory management was developed to maintain the appropriate level of stock in a warehouse and work-in-process (Gattorna and Walters, 1996). Early manufacturing planning and control were purely manual or with some help from tabulating equipment, it could take companies six to thirteen weeks to calculate the requirements (Wight, 1995). In the early 1960s, the use of business computer hardware and software in manufacturing became practical (Plossl, 1994). Organizations started to design, develop and implement centralized computing systems, mostly automating their inventory control systems using inventory control packages (IC) (Hossain, Ed. 2002).

In the late 1960s and the early 1970s, material requirements planning (MRP) was used in the factory of highly complex products, these products had many thousands of parts, subassemblies and assemblies and had many steps or levels of manufacturing (Greene, 1997). Schedules had to be made for thousands of individual components, raw materials and finished goods items. This computerized MRP was devised to provide a logical approach that could simplify the process for the plan of the procurement of materials and production planning to manage inventory efficiently. MRP makes it possible to calculate requirements over a weekend and order more frequently (Plossl, 1994, Wight, 1995). The significant improvement is that MRP started to include incorporation of various operational functions such as customer demands, supplier performance, financial plans, forecasting into the same computer system. MRP provides managers with more information than the older inventory control systems could do, as well as provides a better demand forecast (Aghazadeh, S.M., 2003).

MRP determines what and when material needed by taking the time-phased master production schedule (MPS)— a statement of what was really going to be produced in which time frame; and calculates how much material needed by using the dependent demand according to the product structures so called bill of material (BOM) (Wight, 1995). MRP has the ability to suggest ordering: (a) What to order; (b) How much to order; (C) When to order; (d) When to schedule delivery (Sheikh, 2003). MRP is superior to traditional reorder point-based information systems (Cooper and Zmud, 1990) which could not present a forward visibility of receipts and issues and the future work load (Drexl and Kimms, 1998). MRP has evolved from an ordering system into a priority planning system (Wight, 1995). It eliminates part shortages and prevents the accumulation of too much of any component or materials.

A good MRP system was at least 99 percent accurate in keeping track of inventory, ordering materials, and sending instructions to each department on what to make next (Womack and Jones, 1996). However, MRP had a number of problems. MRP was frequently criticized for ignoring capacity constraints, it answered to what should be produced, but not to consider what could be produced with existing capacity (Sheikh, 2003). Today's consumer environment does not remain static. Customers requiring immediate delivery and customization increasing in complexity, these have created major challenges to the use of MRP, the manual entry and maintenance of the records has become an issue.

2.1.5.2 Integrated Manufacturing System (MRPII)

When MRP was expanded to include capacity planning, shop floor control, and purchasing, the new MRP was termed as "closed loop MRP" (Wight, 1995). Closed loop MRP allows feedback from the shop floor to be seen so planning could be kept valid and updated (Toomey, 1996).

When the financial function was tied in, MRP was evolved into manufacturing resources planning (MRPII) in the 1980s. MRPII emphasises on optimizing manufacturing processes by synchronizing the materials with production requirements (Nah, 2002). MRP planning activities performed by functions such as production control, purchasing and inventory control, but MRPII came to the further step which linked all these functions together (Irwin, 1997), and later extended to include areas such as shop floor and distribution management, project management, finance, human resource and engineering within one computer system (Nah, 2002). MRPII is an integrated approach to the manufacturing internal processes from production planning and control to purchasing materials and then to supply of finished goods (Rushton, Oxley and Croucher, 2000). MRPII provides information to all functional areas and brings all departments together into a single entity for planning and control purposes. The entire MRPII system is driven by the sales & operations plan (S&OP) drives (Wight, 1995). S&OP is known as production planning, aggregate planning, or game planning (Sheikh, 2003). S&OP is the process that brings together all the plans for the business (sales, marketing, development, manufacturing, sourcing, human resource and finance into one integrated set of plans (APICS Dictionary, 1998).

In addition, MRPII includes a simulation capability, a simulation of a manufacturing business, and a simulation of the universal manufacturing equation. Through such simulations far enough in advance, problems can be predicted and prevented rather than fixed after they happen (Wight, 1995).

However, MRPII-based planning and control framework is far from ideal across all industry segments (Higgins et.al. 1998).

2.1.5.3 Centralized Computing Systems (ERP)

When MRPII systems evolved into having direct interfaces with customers and suppliers, in the early 1990s, first-generation Enterprise Resource Planning (ERP) packages started to appear (Aghazadeh, 2003). ERP systems integrate business processes including manufacturing, distribution, accounting, financial, human resource management, project management, inventory management, service, maintenance and transportation (Hossain, ed. 2002, Nah, ed. 2002). The earlier ERP significantly improved the performance of internal business processes and also allowed opportunities for vertical integration with suppliers and distributors (AEIOO, 2005). By the mid 1990s, ERP had become a major success which provided accessibility, visibility and consistency across the enterprise (Hossain, ed. 2002). The bigger companies, especially manufacturers started to replace their home-grown legacy systems with ERP packages (Shields, 2004). The development of ERP is a never-ending process, its open architectures allow easy customisation and user interfacing. ERP vendors continue adding more modules and functions as “add-on” to the core modules, and bring new products and solutions to manufacturers (Nah, Ed. 2002). In 2000 most of the major ERP vendors introduced e-business applications powered by the internet. New modules such as CRM and SCM were developed along with the traditional ERP, e-business packages runs on the internet to allow users to remote access ERP systems and even perform transactions (Shields, 2004).

Some of the core ERP modules found in today’s new generation ERP systems including (Hossain, ed., 2002):

Accounting management
Financial management
Manufacturing management
Production management
Transportation management
Sales & distribution management
Human resources management
Supply chain management
Customer relationship management (CRM)
E-Business

Traditional ERP applications did not include a customer management aspect, in the late 1990s, building up and maintaining a strong relationship with customers was considered critical for increasing sales growth. CRM was then developed to enable companies to be more customer-focused and gain the most value benefits of ERP (Willis and Willis-Brown, 2002). CRM supported all the customer-facing processes in the organisation, is regarded as the logical next step of ERP extensions (Sheikh, 2003).. CRM provides sophisticated customers database information such as order patterns, product preferences, customer demographics and satisfaction/complaint responses. CRM helps companies develop two-way relationships with customers, in addition to gathering data for companies’ own uses, companies began giving their customers incentives and gifts for consolidating customer loyalty, such as bonus points on the member card (Robert L, 2004).

CRM applications are classified as three groupings (Karimi et al., 2001, cited from Adebanjo, 2003):

1. Operational CRM products—for improving customer service, online marketing, automating sales force, etc.
2. Analytical CRM products—for building data warehouses, improving relationships, analysing data, etc.
3. Collaborative CRM products—for building online communities, developing business-to-business customer exchanges, personalising services, etc.

Having an analogy to CRM, supplier relationship management (SRM) aims at the effective management of the supplier base. SRM enables the enterprise to manage its supplier relations (Themistocleous and Marinos Ed., 2005). In addition to SRM, distribution relationship management (DRM) was developed to facilitate the management with distributors.

There is countless application software used in all areas of manufacturing development. Product lifecycle management (PLM) is for the effective management of full product definition lifecycle. Product data management (PDM) is used to manage the product configuration, components, and part revisions for design realisation. Employee lifecycle management (ELM) enables enterprises to effectively manage their portfolio of competencies. Corporate performance management (CPM) describes the methodologies, metrics, processes and systems used to monitor and manage the business performance of an enterprise (Themistocleous and Marinos Ed., 2005). Executive information system (EIS) provides senior managers with data relevant to their work.

2.1.5.4 Computerized Manufacturing Automation (PA, FMS, CIM)

One of the best solutions for the problem of decreased productivity and declining quality is the automation of factories (Kaighobadi and Venkatesh, 1994). Factory automation refers to all activities such as goods processing, materials handling, product design, coordination, communications, measurement, monitor, and control functions that can be performed with a minimum of human effort (Carlsson, 1995). Today, factory automation involves technologies which are mainly rooted in mechanical engineering, electrical and electronic engineering, and computer science and engineering; factory automation includes automated manufacturing equipment and systems, control and monitoring systems, factory communication systems, and computer systems for automating procedures for design, planning, and decision making (Irwin, 1997). There are also automatic recognition technologies such as bar-coding and radio frequency identification (RFID). The discovery of sensors (1967) also contributes to automated operation and monitor position of an object in the workplace.

-- Programmable Automation (PA)

PA *adds computer's data communication capability upon conventional machines that enlarges the machinery's ability to increases the amount of process control possible and enables the use of single pieces of equipment and systems for multiple applications* (OTA, 1983). The launch of PA started in the mid-1950s, when numerical control (NC) for machine tools was developed and commercialized. In 1967, computer numerically controlled (CNC) machines were developed and put into use (Zhou and Venkatesh, 1999). Automatic machine control and monitoring is concerned with direct control of various operational parameters of the equipment such as numerically controlled machining tools and centres, robotic units for assembly and transportation, etc. by using embedded microprocessor based systems, programmable logic controllers (PLCs), and industrial computers (Irwin, 1997).

During the 1960s and 1970s, capabilities and applications for PA had grown. PA is divided into three general categories: 1) computer-aided design (CAD); 2) computer-aided manufacturing (CAM) (e.g., robotics, numerically controlled (NC) machine tools robots, flexible manufacturing systems (FMS) and automated materials handling (AMH)); and 3) computer-aided techniques for management (e.g. management information systems (MIS) and computer-aided planning (CAP)) (OTA, 1984).

Communication also plays a central role in the factory automation for integrating activities performed at different levels of manufacturing system planning and control. There are two types of communication networks used in manufacturing systems: data and control networks. Data networks are characterised by transmitting large data packets used to support activities involved in strategic and operations planning; Control networks are required to transmit small data packets used at machine level and shop floor control (Irwin, 1997).

-- Flexible Management System (FMS)

Along with the use of the computer in manufacturing, the integration of the computer and the machine works remarkably to the flexibility in machines and manufacturing systems (Zhou and Venkatesh, 1999). In the 1960s, David Williamson came up with so-called System 24 to operate unmanned 24 hours a day under computer control; the concept of flexible management system (FMS) was born (Luggen, 1991).

FMS is a production system consisting of a set of identical and/or complementary numerically controlled machines which are connected through an automated transportation system (Tempelmeier and Kuhn, 1993). After the growth in equipment and applications development, since the 1970s, the concept of FMS has been broadened to cope with unforeseen and unpredictable disturbance (Luggen, 1991). FMS has tended to be a business-driven solution more than a technical solution (Buzacott, 1982). The initial flexibility of FMS has expanded into flexibilities in machines, process, products, routing, volumes, expansion, operations and production (Tempelmeier and Kuhn, 1993). FMS also requires market flexibility including product variety, product customisation, product innovation, delivery flexibility, and demand flexibility (Brown, 1996). The growth of FMS enables manufacturers to machine a wide variety of products on few machines with less staffing levels within a short time and to accommodate design and engineering modifications without further investments and time delay.

Figure 2.1 provided by Green (1991) shows in a single calendar year, there was only 6 percent of the 8760 of the total time used for actual production; the rest of time was wasted due to inefficient use of second and third shifts, setup times and holidays.

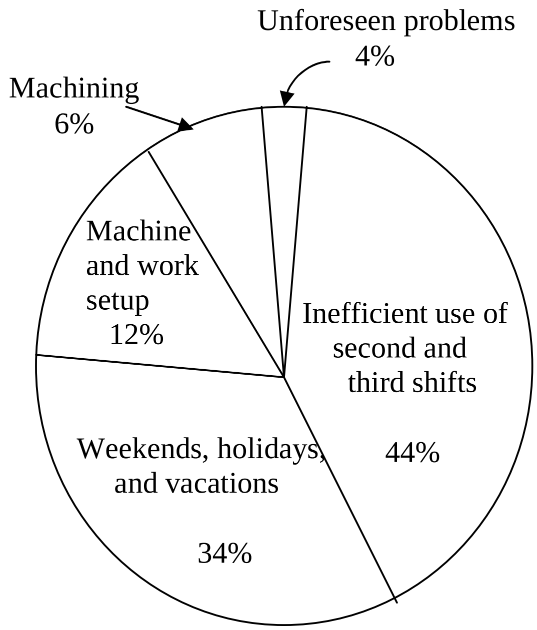

Figure 2.1: Breakdown of 8760 available hours in a calendar year to a manufacturing operation (Luggen, 1991).

FMS effectively manages as much as possible machining time to increase machine utilization and avoid excess or insufficient in-process inventory. The successful FMS will also improve rapid response to market changes and improve manufacturing effectiveness through increased operational flexibility and control (Luggen, 1991).

-- Computer Integrated Manufacturing (CIM)

Better communication on the shop floor is the efficient means to improve internal activities and reduce lead times (Weatherall, 1988). In the 1980s, computer integrated manufacturing (CIM) was emerged with the philosophy of the fully automated and integrated factory to complete rapid communication and sharing large database among manufacturers, suppliers and customers. CIM is to *provide computer assistance, control and high level integrated automation at all levels of the manufacturing industries, by linking islands of automation into a distributed processing system* (Ranky, 1986). CIM includes computer-aided design (CAD), computer-aided engineering (CAE), computer-aided planning (CAPP), computer-aided manufacturing (CAM), and computer-aided quality control (CAQC).

In comparison with FMS, CIM is mainly concerned with information processing, sharing and management among all levels of the enterprise, it links all isolated computers in different departments together into one system, whereas FMS provides the essential computer controlled manufacturing tools and systems for CIM to execute the computer generated plans and schedules(Granky, 1986).

CIM provides a central shared database that can be accessed by the different functions during the manufacturing process, such as design, development, manufacture, distribution, billing etc. The effectiveness of CIM depends greatly on the large-scale integrated communication system. The goal of CIM is to use advanced information processing technology in all areas of the manufacturing industry in order to (Chryssolouris, 2006):

- Make the total process more productive and efficient
- Increase product reliability
- Decrease the cost of production and maintenance
- Reduce the number of hazardous jobs
- Respond to rapid changes in market demand, product modification, and shorter product life cycles.
- Achieve better use of materials, machinery, and personnel, and reduced inventory.
- Achieve better control of production and management of the total manufacturing operation.

2.1.5.5 Standardized Electronic Transaction (EDI)

Electronic Data Interchange (EDI) is *the electronic exchange of business documents between the computer systems of business partners such as banks, customers, and suppliers, using a mutually agreed standard format over a communication network*

(Pitlak, 2002). EDI is the process of information transfer within computer-to-computer; therefore, the information must be structured according to predefined formats and rules which a computer can recognize directly.

Since the early 1970's, efforts have been underway to develop standardized data formats for business transactions. EDI is the process of computer-to-computer, business-to-business transaction transfer (Martin, 2002). EDI was developed to handle all aspects of business transactions such as ordering, acknowledgements, pricing, status, scheduling, shipping, receiving, invoices, payments, and financial reporting (IFLA, 1995). Figure 2.2 shows a typical flow of actions and data between a buyer, a seller and their banks.

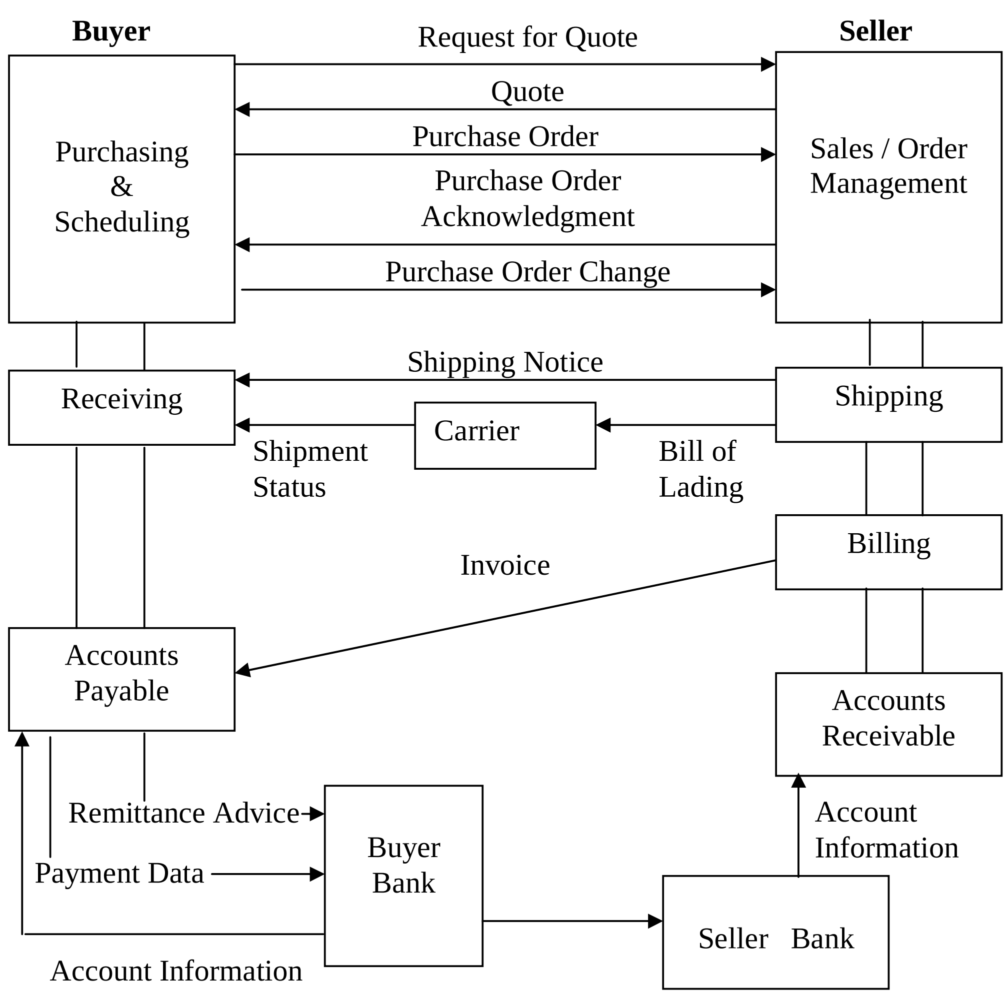

Figure 2.2 Typical business documents exchanged by business partners (Pitlak, 2002)

The implementation of EDI benefits both the sender and the receiver from sharing information in a timely manner. The benefits include (IBM Readbooks, 2003, Pitlak, 2002):

1. Reduced data entry errors
2. Reduced processing cycle time
3. Delivered standard means of communication
4. Shared electronic information easily over the organisation
5. Reduced paperwork
6. Reduced inventories and better planning
7. Improved relationships with business partners

2.1.5.6 Electronic Economic Activities (E-business /E-commerce)

Electronic business (e-business) is *the use of electronic communications networks to allow organisations to send and receive information, and this transfer of information can be entirely internal, unlike e-commerce, which typically crosses organisational boundaries* (Slyke and Belanger, 2003). Electronic commerce (e-commerce) is broadly defined as: *An electronic transaction is the sale or purchase of goods or services, whether between businesses, households, individuals, governments, and other public or private organisations, conducted over computer-mediated networks. The goods and services are ordered over those networks, but the payment and the ultimate delivery of the goods or service may be conducted on or off line (Vickery, 2002).*

E-commerce defines any form of economic activity between at least two parties conducted via electronic connection interactions, whereas e-business also encompasses an organisation’s internal operations (Wigands, 1997). Examples of e-commerce include orders received or placed on any online application used in automated transactions such as internet applications, EDI, Minitel or interactive telephone systems (Vickery, 2002). Nowadays, most of e-commerce goes through the internet. This is realized through World Wide Web (WWW), intranet, extranet, virtual private network (VPN), secure socket layer (SSL) encryption, etc (Milutinovic and Patricelli, 2002).

In general, e-commerce can be classified into four major models by the type of the buyer and seller:

Business-to-consumer (B2C) -- consumers purchase products and services from businesses (Milutinovic and Patricelli, 2002).

Business-to-business (B2B) -- businesses buy and sell among themselves (Milutinovic and Patricelli, 2002).

Customer-to-customers (C2C) -- the sale of goods and services between individuals, often via auction sites such as Amazon, eBay (Jackson, Harris and Eckersley, 2003).

Customer-to-business (C2B) -- individuals sell goods and services to companies (Jackson, Harris and Eckersley, 2003).

In addition to the above four models, there are two other models specified newly: one is business-to-government (B2G)--the trade in goods and services between the private sector and the different forms of government, whether local, regional or national (Jackson et al, 2003); the other is user to user or peer-to-peer (P2P)--individual users are able to directly communicate or share of information each other (Rosen, 2002). This thesis only focuses on B2B and B2C.

Gattorna (2003) claims that e-commerce provides not only the solutions for electronic transactions but also the standards that will enable companies to connect and communicate in an effective way, is helping to establish the standards for cross border cooperation and collaboration. E-commerce automates and streamlines the process of buying and selling, provides more reliable updating of business data, and disseminates product information available globally in real time (Milutinovic and Patricelli, 2002)

The impact of e-commerce on companies includes such areas as indirect procurement, direct procurement, product and service design, manufacturing, demand and supply planning, fulfilment and e-fulfilment, service and support, and e-working, see figure 2.3 (Gattorna, 2003). E-commerce is a vital part of e-business. Apart from elements of e-commerce, the other crucial components of e-business are (Durie, 2001):

- Organising general business processes using computers and other electronic or telecommunications devices
- Managing supply chains
- Managing customer relationships, including marketing
- Managing stock, production, procurement, workflow and shipping electronically

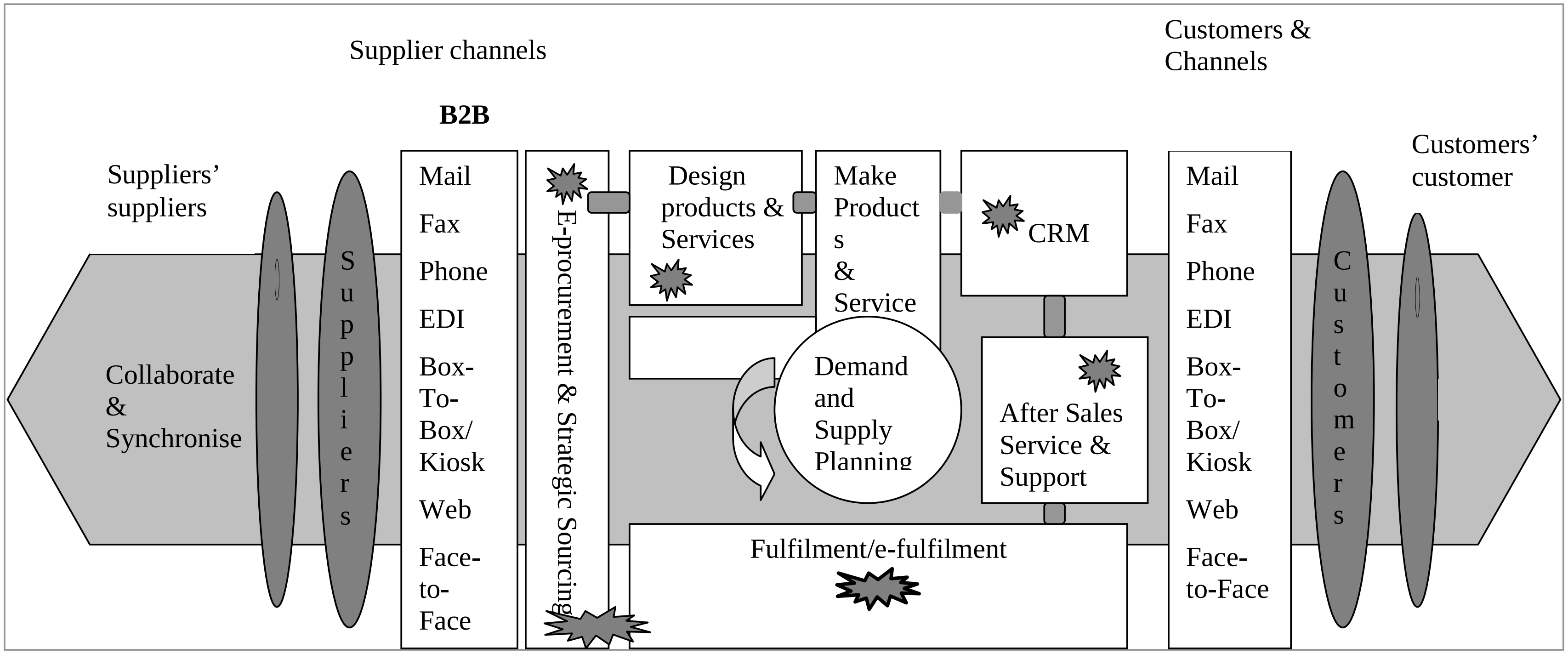

Figure 2.3 E-commerce impact on supply chains *Source: Berger, A.J. and Gattorna, J.L. (2001)*

= e-commerce Impact

2.1.5.7 Conclusion of IT applications in Manufacturing

A classification of IT can be divided into three groups (Bagri et al, 2003):

(1) Engineering design automation: including computer aided design (CAD), computer aided engineering (CAE), solid modelling (SM), and finite element analysis (FEA), etc.

(2) Manufacturing automation: including numerical control (NC), direct numerical control (DNC), computer numerical control (CNC), robots, flexible manufacturing systems (FMS), automated guided vehicles (AGVS), and automated storage/ retrieval systems (AS/ RS), etc.

(3) Administrative planning and control automation--computer applications in accounting, logistics, warehouse management, management of stocks, quality control, etc. , including manufacturing execution system (MES), management of information systems (MIS), decision support systems (DSS), electronic data interchange (EDI), electronic point of sales (EPOS), optimised production technology (OPT), group technology (GT), material requirements planning (MRPI), manufacturing resource planning (MRPII), enterprise resource planning (ERP), computer aided production planning (CAPP), shop floor control (SFC), factory data collection systems (FCS), data acquisition systems (DAS), product data management (PDM), distribution requirements planning (DRP), computer aided quality control (CAQC), concurrent engineering (CE), etc.

2.1.6 Efficiency in Quality and Zero-defect output (TQM, Six sigma)

<u>-- Total Quality Management (TQM)</u>

In the early stage, the concept of quality was referred to in-house criteria. Development in quality has gone over decades from inspection, quality control, quality assurance, and company-wide quality control to TQM (Brown, 1996). TQM *is* *the integration of all functions and processes within an organisation in order to achieve continuous improvement of the quality of goods and services. The goal is customer satisfaction* (Ross, 1999).

Japan was the first nation to move into a broader quality concept. After the Second World War, to be able to recover from the devastation and get back to world markets, Japan took the advice of the Americans --Dr. W. Edwards Deming and later Dr. Juran to adopt “high quality” as a major objective for its industries to overcome its pre-war reputation of producing cheap, low-quality products (Cartin,1999). Following Dr. Deming’s prescription of higher-quality products and services at a lower cost to satisfy customers and continuous improvement programs, Japanese companies became the most significant competitor in the global marketplace in the late 1970s (Peratec Ltd, 1994).

In the 1980s, whilst facing the strong competition from Japanese companies, America was dragged into adapting this new concept of quality as known TQM (Cartin, 1999). This improvement-focused program moved the concern of quality from resource-driven in terms of right materials, right time, right cost and right place to a quality that means a total commitment from every area at all levels of the firm, even includes suppliers and distributors in pursuing quality (Gunasekaran ed., 2001, Gibson, et. al, 1995).

As TQM does not emphasize financial measures and its consideration is narrow, TQM became less attractive to modern management, ultimately was silent in many companies; instead, six sigma turned out to be a more popular tactic (Cartin, 1999).

-- Six Sigma

Sigma is a letter in the Greek alphabet used by statisticians to measure the variability in any process. In business, it was used to measure a company’s performance (Pyzdek, 2003). Six sigma *as a statistical measure of the performance of a process or a product, a goal that reaches near perfection for performance improvement, a system of management to achieve lasting business leadership and world-class performance* (Pande, 2001). Six sigma describes how well the process variation meets the customer’s requirements (Keller, 2005).

The six sigma story began in the mid 1980s at Motorola to eliminate process defects since it was believed that process failure rates were much higher than indicated by final product tests (Brue, 2002). Six sigma is not merely a quality initiative, which is far more than TQM. Quality does not always require higher costs but more efficient and reliable processes that delivered defect-free outputs (Brue, 2002). Six sigma requires a specific problem solving project with significant potential return on investment or a bottom line result (Adams, Gupta and Wilson, 2003). Defects are eliminated through understanding, measuring, and improving processes (Brue, 2002). Cost reduction, productivity improvement, customer retention, defect prevention, and cycle-time deduction, these are the promises of six sigma, which make the six sigma is different from TQM (Pande and Holpp, 2002). Unlike some cost-cutting programs which reduce value and quality, the six sigma identifies and eliminates any waste cost which provides no value to customers (Pyzdek, 2003).

2.1.7 Efficiency in Chain (Porter Value Chain and Supply Chain)

-- Porter's value chain

Michael Porter in 1985 introduced the value chain: *a systematic way of examining all the activities a firm performs and understands the behaviour of costs and the existing and potential sources of differentiation* (Porter, 1985). Porter (1998) recognises that the value a company creates is measured by the amount that buyers are willing to pay for the product or service; if the value created exceeds the cost, then the business is profitable. Therefore all value activities should be run at optimum level and should coordinate with each other if the organisation is to gain the competitive advantage in either cost or differentiation which is a function of a company's value chain (Porter, 1998).

According to Porter, every firm's value chain is composed of nine generic categories of activities, covering almost all the internal business activities. These activities are split into primary activities and support activities. Primary activities include Inbound logistics (receiving, storing, and disseminating product inputs), Manufacturing (transforms inputs into final form), Outbound logistics (physical distribution of outputs), Marketing& sales (provides distribution channel and supporting for buyers) and Service (enhances value of product through support). Support activities include Procurement (purchasing of inputs), Personnel (Recruiting, hiring, training, development, and compensation), Technology development (R&D and other technology needed to support the firm's activities), and Infrastructure (systems for planning, finance, quality control, management, etc.). See figure 2.4.

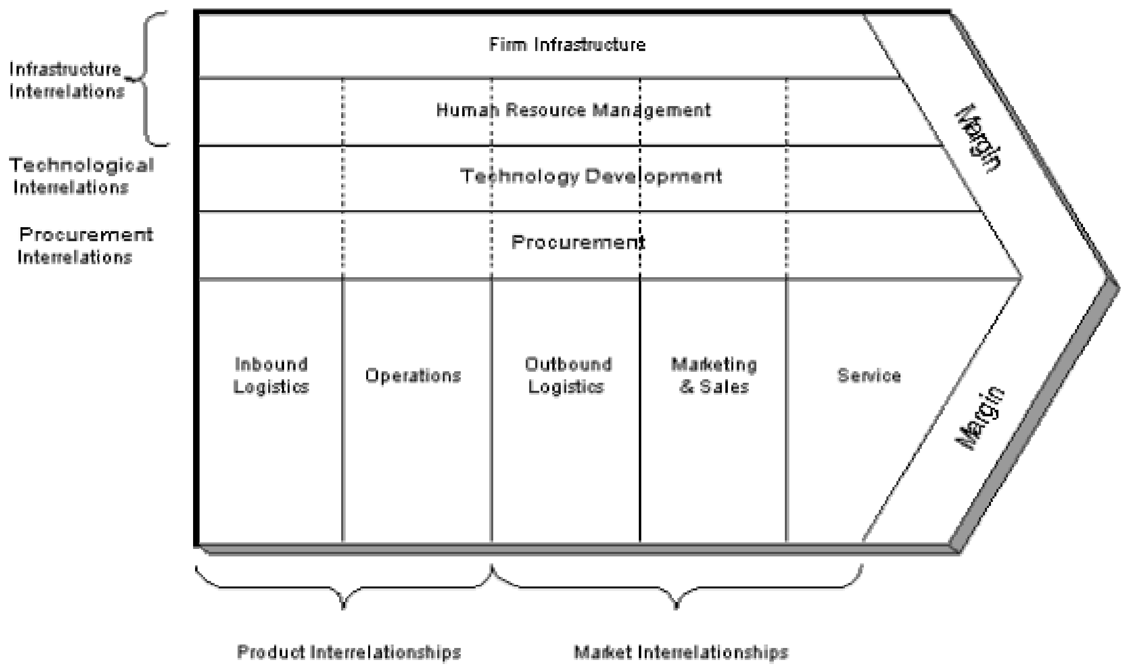

Figure 2.4 Porter's Generic Value Chain Model

(The image cited from http://www.learnmarketing.net/valuechain.htm)

A company's value chain requires that the internal interdependent activities should be connected and coordinated by linkages, linkages often create trade-offs in performing different activities that should be optimized (Porter, 1998). The value chain should deliver a margin and help in determining and gaining company's competitive advantages. Through the value chain framework, companies can diagnose and improve a company's internal activities, it will result in performing these strategically key value activities cheaper or better than its competitors; on the other hand, through the value chain, companies analyze the sources of competitive edge and determine relative strengths and weakness, so that companies can create new ways to add value to their customers (Bidgoli, 2004).

Originally Porter's focus was on the individual firm's value chain. In today's knowledge-driven, competence-driven and technology-driven business environment, the concept of the value chain has been strongly criticized over the past decade for focussing less attention on the relationships with other firms (Vesa, 2005).

-- The Supply Chain

In the 1990s, manufacturers were increasingly looking beyond their individual enterprise; it was the increasing interest in improved supply chain management (SCM) (Gimenez and Ventura, 2003). SCM *is the planning and execution of supply chain activities, ensuring a coordinated flow within the enterprise and among integrated companies. SCM activities include the sourcing of raw materials and parts, manufacturing and assembly, warehousing and inventory tracking, order entry and order management, distribution across all channels and, ultimately, delivery to the customer. The primary objectives of SCM are to reduce supply costs, improve product margins, increase manufacturing throughput, and improve return on investment* (Mayer, 2001).

SCM includes the management of the relationships among all the participants (suppliers, manufacturers, distributors, warehouse, transporters, retailers and ultimate consumers) who are involved in sourcing, manufacturing, and shipping products to the end consumer. According to New and Westbrook (2004), supply chain is the total sequence of business processes, it is embedded three integrations:

(1) Operational integration: coordinates separated business units in terms of inventory management, scheduling, transport, marketing, and new product development.

(2) Functional integration: how management functions within an organisation work together to further the organisation's mission.

(3) Relational integration: emphasizes on the immediate relationships between suppliers, manufacturer and customers and all the business partners along the supply chain.

The development of SCM started from an initial focus on physical distribution management (traffic, order management, and warehousing departments), subsequently inventory management and customer service were involved in SCM, followed by production planning and procurement, in the end SCM forms a holistic strategic role of agility and collaboration within and between organisations (Gunasekaran, 2001, Seifer, 2003). In today's fierce global market place, supply chain agility is a key to success. An agile supply chain links the market place and its distribution channels to the procurement and manufacturing operations in such a way that competitive advantage can be achieved and maintained (Quayle, 2006). Being market sensitive, agile supply chain is capable of reading and responding to real demand rather than forecast-driven demand with little direct feed-forward from the marketplace. By this, information shared between upstream and downstream partners is real time under the process alignment and a confederation of partnership (New and Westbrook, 2004). A perfect SCM brings returns in terms of inventory reduction, avoidable out of stocks, better forecasting and promotion planning, and a higher speed of new product introduction. The integration of SCM and CRM will lead to greater consumer insight and higher information sharing of customer buying patterns and behaviour, and in-store measurements so as to enhance the responsiveness of the supply chain to customers' demand (Kracklauer et al., Eds, 2004).

There has been growing interest over the past decade concerning the integration of SCM and the value chain (New and Westbrook, 2004). The value chain is extended to include marketing channel activities as well as logistics tasks, the concept of the value chain is an ideal vehicle from which the value-based supply chain was developed, and an integrated system should be designed to enable the supply chain to be cost-effective (Gattorna and Walters, 1996). In addition, there are clear linkages between value-adding activities, core competences, competences and resources. Resources form the inputs to the organisation's value-adding activities, while competences and core competences provide the skills and knowledge required to carry value-adding activities out. The more that core competences can be integrated into value-adding activities, the greater will be the value added (Campbell et al, 2nd, 2002). Core competence intimates unique capabilities that an organisation has over competitors, such competitive advantage, will maximise the share of future opportunities a company could potentially access within a broad opportunity arena

(Hamel and Prahaland, 1994). Core competence is a gateway to tomorrow's market, the core competence approach coupled with Porter's value chain can be seen as one of dimensions in maximizing corporate value creation (Value based management, 2005).

2.1.8 Efficiency in Lean -- Doing Everything With Less

The idea of lean manufacturing (1990s) was evolved in North American (Goranson, 1999). The lean concept integrates the most essential Japanese production management principles from the 1970s and 1980s, e.g. Kaizen, JIT, and TQM (Gunasekaran ed., 2001). It redefines waste. In lean manufacturing the term waste considers the waste of physical material, but also demonstrates the waste of wrong transfer of resources to the end customer. If the end customer won't pay for it, it is also wasted (Vorne, 2002).

The key lean manufacturing principles are summarized as follow (Gunasekaran, ed., 2001):

- Perfect first-time quality - zero defects, revealing & solving problems at the source
- Waste minimization – eliminating all activities that do not add value & safety nets, maximize use of scarce resources (capital, people and land)
- Continuous improvement – reducing costs, improving quality, increasing productivity and information sharing
- Pull processing: products are pulled from the consumer end, not pushed from the production end
- Flexibility – producing different mixes or greater diversity of products quickly, without sacrificing efficiency at lower volumes of production
- Building and maintaining a long term relationship with suppliers through collaborative risk sharing, cost sharing and information sharing arrangements.

Clearly, lean manufacturing pronounces to deliver maximum value and minimimum waste in the manufacturing process (Vorne, 2002). Meanwhile, lean manufacturing generalises broadly training staff instead of having specialised staffs, and empowers employees to identify and solve production problems in team and to take on the responsibility for their own work. Continuous improvement and waste fighting initiatives are central in the principle of lean manufacturing (Gunasekaran, ed., 2001).

2.1.9 Efficiency in Agile

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The term 'Agile' was coined in 1991 in the report entitled 21st Century Manufacturing Enterprise Strategy by a group of scholars lead by Nagel and Dove at Iacocca Institute of Lehigh University in Bethlehem (Cunha & Cruz, 2006). Agile manufacturing came into view in the 2000s, is defined as *the capability of surviving and prospering in a competitive environment of continuous and unpredictable change by reacting quickly and effectively to changing markets, driven by customer-designed products and services* (Gunasekaran, ed. 2001). In the 1990s and beyond, it had become increasingly difficult to simply choose one strategy and believe that this was the formula for success (Brown, 1996). It had become urgent to connect and balance all the pieces of advanced programmes that had been implemented in isolation (Duck, 1993). Agile is not flexible manufacturing or lean manufacturing, agile manufacturing evolves from FMS, CIM, and Lean. It absorbs all the advantages from the past strategic development, manages them in a concerted way, and provides the best management approaches that a business can practice. It is not only about the ability to make things better, faster, and cheaper but also about the ability to react quickly to the change and the ability to anticipate changes (Goranson, 1999). E-manufacturing technology is recommended as a promising modern technology to achieve agile manufacturing (Cheng, ed. 2005).

2.2 Conclusion

This chapter draws on literature in a number of fields: Manufacturing management, Manufacturing systems, IT systems, Supply chain, E-business/e-commerce, Customer relationship management and so on. The purpose of this chapter is not to conclude everything of manufacturing systems and technologies, but it delivers a comprehensive review of how the manufacturing industry has been developed. Nine efficiency factors were summarized to illustrate what progress the manufacturing industry has come to today.

3.0 CHAPTER THREE: LITERATURE REVIEW

Chapter Three objectives:

- *Impact of the internet on businesses*
- *E-manufacturing strategies in literature*

This chapter first summarises the impact of the use of the internet on the act of organizational communicating. This chapter also investigates the breakthroughs of internet-based applications and e-manufacturing strategies that have been advised by other researchers

Chapter Two outlines the growth of the manufacturing industry, provides a broad overview of manufacturing development. The following section will discuss the power of the internet and the strategy of e-manufacturing.

3.1 Impacts of the Internet on Businesses

E-manufacturing is concerned with the use of the internet and e-business technologies in the manufacturing industry. Technological breakthroughs in the internet are crucial to the implementation of the e-manufacturing programme (Lee and Ni, 2002). With the advent of wireless, broadband and the use of the laptop, the mobile phone and the PDA, today's access to the internet is not limited to the computer desktop only. The latest research in several areas of internet applications including: mobility, multimedia, quality of service, voice over IP and wireless access (Cellary and Lyengar, ed. 2002).

Six characteristics give the internet potential to deliver special business benefits in excess of existing IT technologies: Simplicity of use; Breadth of access; Synergy with other media; Low relative cost; Extension of existing IT resources; Flexibility of communications (Stroud, 1999). Up to now, the internet has become imperative for manufacturers who want to closely align with suppliers, customers and other business partners. The impact on corporate activities can be seen in the follow four general aspects:

3.1.1 Impact on the Act of Organizational Communicating

The internet is an application for the masses, which carries out organizational communication in an economic way: e-mail, e-conference, e-forums, e-chat system, and e-newsgroups, e-newsletters, etc. Holding a meeting is no longer limited by gathering all participants together in an assigned meeting room. Using a telephone or a mobile phone to make a cheaper international call can be achieved via the internet. Wherever employees are located, the internet allows them to access the same level of work-related information in an easy, convenient and timely way just as if they are in the office. Bulletin boards encourage free dialogue since all participants are able to post their opinions and react to others' comments. Discussion forums allow remote members of the team to work together by using an electronic whiteboard, sharing the same information and using voice or keyboards to discuss the topics with each other. As a powerful global communication network, the internet links up people, offices and operations into a single stretch, information is virtually visible and reachable, flexible and remote working becomes a reality.

The internet makes multi communication channels available for people to communicate with each other. Some fashions are presented in the Figure 3.0:

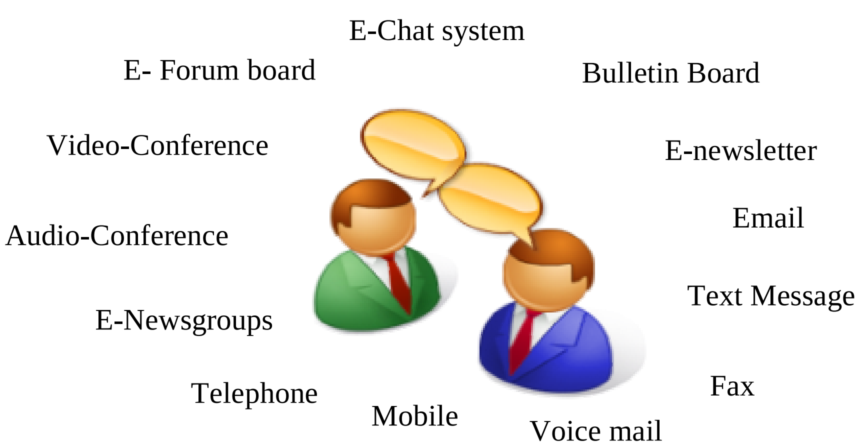

Figure 3.0 Multimedia communication channels provided by the internet

In addition, the internet also displaces the traditional forms of business data and information interchange (mail or fax). These multimedia channels also allow manufacturers to get hold of their business partners in flexible ways. There is no longer a need to hold while waiting for someone to take their call. Similarly, business partners can interact with the manufacturer by the manner they prefer. A call centre is used to represent how well the company treats its customers, where many customer service representatives are employed to pick up the phone. But the evolution of the internet creates multimedia channels to individualize each customer's contact choice, and enables the communication with the customer more effectively (Emerald Insight Staff, 2005). Information can be sent via instant messages to customers; representatives can answer customers' questions via the web.

To facilitate building online interaction, some of the techniques are suggested as below (CCS,2008),

- Provide online opportunities for people to perform the comment, consultation, polling, inquiries or complaints at any time
- Allow people to participate in real-time meetings or a discussion online, or to watch, listen or speak via webcasting or podcasting.
- Improve the post-event experience, written or taped records of an event are stored online.

3.1.2 Impact on B2C and B2B

The publicly accessible website presents several important site features such as Interactivity, Publishing applications, Community applications, Catalogue applications and Transaction applications (Zhuang and Lederer, 2004). These features imply the website is multi-functional. It is an open communication exchange place in which manufacturers can advertise their products, disseminate their products and corporate information, answer queries, obtain suggestions, feedback and complaints, and significantly creates an online market in which manufacturers have extended their linkages out over unlimited suppliers and customers. As a device for communication and commerce, the internet provides not a domestic but a global e-business network, and has changed several processes in trading and supply chain.

Using email, deploying EDI, and having a website for broadcasting company and products information are called the first wave of e-business; the second wave indicates the enhanced performance of e-business concepts and a general and massive e-business opportunity in many sectors of the economy (Hoek, 2001). The evolvement of e-marketplaces represents such second wave; it has expanded the philosophy of B2C/C2B/C2C into the prosperous B2B area (Brunn, et al., 2002).

A B2C online shop is analogous to a store on the street, but it has less investment than a physical store does and can be visited 24 hours a day, 7 days a week by customers all over the world who are able to access to the internet, electronic transactions can be completed any time, goods can be directly delivered to home. Doing business on the web establishes an open trading approach which gives sellers access to new customers and brings largers numbers of buyers; on the other hand, it expands the choices available to buyers. To maintain relationships with customers and hold the customer database, sellers encourage customers to register for receiving e-newsletters of new products and promotions or to become a member to earn points and other benefits. B2C e-commerce fuelled the first stage of e-commerce and created the e-commerce model, but the successful leadership companies engaged in B2B e-commerce define the next phase, their B2B successors will realize the full potential of e-business (Raisch, 2000).

The initial B2B e-commerce was established via EDI creating programmatic linkages between the manufacturer and its suppliers or customers, it was point-to-point interfaces via primitive computer protocols. The emergence of value-added networks (VAN) enabled EDI to deal with one-to-many relationships. Automatic electronic transactions are based on the negotiated contract. The early philosophy of B2B e-commerce centred on the buyer-seller transaction where the two entities are known to each other. The close relationship helps in automating the replenishment process and improving information transparency, but it is limited to a relative level and displays only partial efficiency that turns upon the buyer and the seller all using EDI (IBM Redbooks, 2003).

E-Marketplace appears as a cooperative distributed system that integrates participating business entities, including consumers, suppliers and other intermediaries, in which trading is conducted directly between buyers and sellers via the internet (Gupta and Sharma, 2004). E-marketplace represents an integrated body of people, systems, information, processes, services, and products (Singh and Huhns, 2005). It provides one-stop shopping place for large numbers of buyers to access a broader range of products and services offered by large numbers of sellers across various e-marketplaces; likewise, sellers can reach, discover, and develop new customers across various e-marketplaces quickly with low cost. It supports any-to-any relationships between different business entities (Gupta and Sharma, 2004). E-marketplaces enable different industries collaboration across the value chain, and delivers core value to all participants, a win-win for all (Bidgoli, 2004). It has become the digital trading zones of the world markets. The e-marketplace has been developed to handle not only buying and selling but also cover manufacturing, distribution, sales and marketing for the realization of supply chain objectives (Raisch, 2000).

A brief introduction of the classification of E-marketplaces is provided as below. E-marketplaces emerge in many different business models which may be controlled by sellers, buyers or neutral parties (Kamel, 2006):

- E-marketplaces controlled by sellers are usually set up by a single seller seeking many buyers.
- E-marketplaces controlled by buyers are also called Consortia e-marketplaces, which are established on an industry-oriented basis, usually jointly owned by several key enterprises that have the power to impact their industries, have long-term trust relationships in place and have the financial power to execute a long-term strategy (Raisch, 2000). It aims to combine their purchasing power to shift market power and value to their side.
- Neutral or independent e-marketplaces are set up by third-party intermediaries to match many buyers to many sellers, such as Alibaba, eBay etc.

E-marketplaces may be also generally classified into vertical or horizontal by the market-sector coverage. A horizontal marketplace addresses a specific function (e.g.

human resources, office supplies) and serves a wide range of industries, while a vertical marketplace focuses on a wide range of functionalities in a particular industry for better supply chain management (Kamel, 2006). Either vertical or horizontal e-marketplaces may be divided into private or public e-marketplaces depend on who has access to their services, namely private parties or the public (Bidgoli, 2004).

- Private e-marketplace: (one-to-many): run by a single company, connected to its own group of business partners
- Public e-marketplaces: run in the open by a third party, bringing multiple buyers and sellers together to exchange information, purchase products and services, and collaborate with each other.

E-marketplaces also provide dynamic trading approaches such as auctions where dynamic pricing has potential benefits for all participants to obtain efficiently the best possible price for goods and services through performing real-time interaction between participants (Milutinovic and Patricelli, Ed. 2002). Auction-based market is segmented into: (1) Open auctions: bidders know the bid value of the others; (2) Closed auctions: the bids are not disclosed. In terms of the number of participants on the buyer or seller side, an auction may be divided into four categories (Turban, 2004):

- One buyer, one seller: known as bargaining market where customers and suppliers meet their own objective functions via negotiations.
- One buyer, many sellers: (1) One model is known as reverse auctions also called bidding or tendering system; (2) Another is “name-your-own-price” in which a would-be flight ticket buyer specifies the price and other terms (e.g. the location of the seat, direct / indirect flight etc.) he/she is willing to pay for. This model was pioneered by Priceline.com.
- One seller, many potential buyers (forward auctions): trades are executed in an open and competitive bidding process, in which a seller entertains bids from buyers.
- Many sellers, many buyers (double auctions): stocks and commodities markets (exchange) are typical examples of this configuration, in which buyers and suppliers negotiate prices with a bid-and-ask system so the price is unstable

and publicly agreed upon for each commodity independent of a particular supplier and qualitative differentiations. Buyers and sellers can be individuals or businesses.

Only buyer-driven e-marketplaces are pure B2B e-marketplaces, the others are currently primarily B2B, but have the potential to be also B2C. Most of e-marketplaces have one common characteristic: they bring together multiple buyers and suppliers through the internet to match buyers and sellers' needs (Milutinovic and Patricelli, Ed., 2002). E-marketplaces bring great opportunities for sellers and buyers to trade in a more open environment toward a win-win situation and make new trading partnerships. The role of the twenty-first century e-marketplace will evolve from a simple matchmaker of buyers and sellers to deliver real horizontal trust-based industry collaboration; a perfect e-marketplace will be a fully transactional environment integrated with ERP, CAD, CRM etc., in which the relevant information will become transparent to all users to allow more participation from the multiple tiers in the supply chain (Raisch, 2000).

In conclusion, conducting businesses on the web appears to be an attractive prospect for most companies. An e-commerce website provides corporate and product catalogues information, delivers an instant awareness of price quotations and live stock availability, automates order confirmation and payment process, and allows order and customer tracking. When e-commerce moves beyond basic transactions and into being customer-responsive, businesses will increasingly use internet technologies to focus on strategic relationships with the integration of suppliers, customers and other partners to establish dynamic collaborative e-commerce that provides a win-win situation. Such collaboration allows business partners to access the company's real-time production plan and inventory via the internet. The internet is an integrated network orientation. The internet actualizes supply chain activities through the integration of the internal functional activities (marketing, logistics, production, procurement, etc) with external activities performed by different organisations. The goal of delivering win-win satisfactions determines how well firms work together with sharing risks and resources to combat competition (Overby and Min, 2001).

3.1.3 The Impact of the Internet on Existing IT systems

It was a natural development to integrate the internet and traditional IT systems (Stroud, 1999). Current systems such as manufacturing execution systems (MES), SCM and ERP systems are incapable of enabling manufacturers to dynamically and cost-effectively integrate, optimize, configure, simulate, restructure and control their own manufacturing systems and their supply networks (Zhang, et. al, 2006). Successful B2B is not dependent on a specific hardware or operating system, the key issue is interoperable that means separate systems need to be linked together by accepted standards which enable data and information accessibility and usability across different technology platforms, and then operate as if these independent systems are a single entity (Milutinovic and Patricellic, Ed. 2000).

3.1.3.1 Enlarged Interoperability

As the importance of alliances with customers, partners and suppliers to deliver successful e-commerce increases, more and more organisations use the internet to assist systems interoperability. Organisations that initially improved internal processes through ERP are now examining how the integration of ERP and the internet can help them improve processes extended beyond the enterprise to their customers and suppliers (Themistocleous, Marinos, Ed, 2005). It has been argued that the complete integration of the internet with design, plant floor, supply chain, MRP/ERP, and CRM can be considered as a successful implementation of e-manufacturing (Cheng, Ed., 2005). Web-based CRM provides a channel in which businesses can continually engage customers, accurately measure and record customer knowledge, and satisfy customers (Raisch, 2000). But CRM should not only integrate functionally at the front office but also integrate with back office functions (Bradshaw and Brash, 2001). Such e-linkage is to synchronize the requirement of supply and demand to enable manufacturers to make an order within a minimum lead time. Once a customer order notification is received through CRM, stock availability notification will be sent to the customer immediately, meanwhile, manufacturers start operation planning of an ERP (Themistocleous, Marinos, Ed., 2005).

Most small to middle-sized B2B have been locked out of e-business opportunities due to the requirement of expensive communication channels and the high cost of back-office integration efforts (Reynolds, 2001). EDI delivers the direct routeing of information from one computer to another with the same standard of translation software, but without an agreement upon such standard between the two computers, EDI processes will not work (Martin, 2002). Cross-industry players such as transportation companies have to learn and implement different EDI data structures depending on the industry they serve and the region in which they operate (IBM Redbooks2, 2003). The advent of user friendly web browsers in the early 1990s gave rise to internet-enabled EDI that are flexible and affordable to SMEs. As traditional EDI is lacking in the international standard format for data transfer and is also expensive for SMEs to deploy, the internet has facilitated EDI communications in a simple and less expensive way for non-EDI-established partners and different versions of EDI via mapping the content of an EDI message to a text file to allow users to key in information (Stefansson, 2001). One-to-one or one-to-many EDI transactions can now turn to many-to-many.

CAD has the same problem as EDI in respects of data change between the two different versions. By the integration of the internet with CAD, it enables a number of designers/engineers who are in different locations to view and manipulate each other's CAD models or drawings simultaneously across the internet. It also allows emailing a CAD design and having it analysed and converting it to another format, as well as downloading the latest drawing from the intranet or extranet anytime irrespective of where the permit of users are in the world. Such electronic collaboration facilitates suppliers, manufacturing and customers to design products together and exchange ideas at the earliest stages of the product development process, decisions can then be made faster and more easily, it results in shortening the overall product development time.

Translating data from the old system to the new e-commerce technology is one of solutions to improve IT systems interoperability other than abandoning an old system entirely (Helicon Publishing, 2005). One of the technologies is Extensible Markup Language (XML) which is a Markup languages for documents containing structured information, defines a standard way to identify structures in a document, so that richly structured documents could be used over the web, now EDI data can travel inside XML (Milutinovic and Patricelli, 2002).

3.1.3.2 Accomplished Mobility

By integrating with the internet, applications such as ERP/SCM/CRM can be mobile with users. It allows relevant people easily take data with them out into the field. By doing so, sales representatives can remotely capture sales order information and check inventory levels so that customers' queries are always able to be responded to immediately. Especially those multinational enterprises that encompass several geographically separated sites, through the internet, managers can remotely access work-related data, professional and technical workers are able to monitor and troubleshoot processes. An E-CRM solution has the web component which will allow external customers and internal sale representatives to access information anywhere via the web (Emerald Insight Staff, 2005).

Coupled with advanced ICT technologies and the development of telecommunication, organisations now can use mobile ERP to dynamically track and optimize delivery routes and schedules, and the use of hand-held mobiles and wireless devices allow such capture and retrieval of data "anytime and anywhere" to maximize the operation of the ERP system (Willis and Willis-Brown, 2002). Satellite-based global position systems have been used in business for tracing trucks and inventory. Radio frequency identification (RFID) technology is used for automatically tracking the movement of tagged inventory from receiving, quality assurance/inspection, work-in-process, packaging and final shipping and distribution.

However, the accomplished mobility delivers self-service functionality to benefit both internal and external users 24/7. For instance, customers can ask questions, troubleshoot, track orders and shipments, and make payments through a secure, self-service web portal without waiting for sales representatives. Significantly, the use of the internet enables manufacturers to deliver remote customer support with competitive edge. The advanced online remote diagnostics (e-diagnostics) capability provides a broad range of real-time online customer support services including monitoring, diagnostic, preventative maintenance, and repair to rapidly resolve problems of equipment. Such remote detecting technologies have resulted in reduction in manufacturing downtime, mean time to repair (MTTR) and needless service calls and on-site maintenance costs. Moreover, e-diagnostics are utilized not only to remotely maintain equipment, but also to be able to modify and upgrade system software from a centralized location without the need to send a technician in the field or to teach customers to do it themselves.

3.1.3.3 Impact on Suppliers' Responsibility

After decades of the growth of cross-enterprise collaboration, the trustfulness and integrity between the manufacturer and the supplier embodies the cooperative management more than just information sharing. Traditionally, the customer independently makes inventory reorder decisions and initiates the purchase order， and what the supplier can cooperate with are to communicate product pricing and availability, take the orders and in the end provide the actual goods (Bendoly, 2005). EDI have been proposed as increasing responsiveness to customers and facilitating the creation of collaborative partnerships, but EDI does not provide equal benefits to all trading partners (Swatman and Swatman, 1992). In the mid 1980s, Vendor Managed Inventory (VMI) as a concept of collaborative strategy was developed to shift responsibility of maintaining and managing customer inventory levels from the customer to the supplier through automated collaborative electronic information sharing between these two parties (Jespersen and Skjott-Larsen, 2005). At its most basic level, VMI is an inventory replenishment program in which the supplier is allowed to access the customer's essential data such as inventory levels, downstream customers' demand, historical production usage data and forecast data etc. (Bendoly, 2005). By continuous monitoring the customer's real-time inventory levels, when product levels come to an established re-order point, the supplier automatically generates the inventory replenishment order without having to be notified by the customer. VMI can be vendor controlled but also customer controlled, if the customer has multiple locations, logistics and transportation may be handled by the customer's personnel (Deshmukh, 2006). However, VMI reduces the need for the customer to place an order, is the ultimate Kanban system in which the level of inventory is never allowed to go below or exceed the certain stocking levels and no material will be delivered if the inventory is at its proper stocking levels (Paquette, 2004). Indeed VIM is a win-win strategy. Keeping large stock is seen as a way to improve customer services that could result in duplicate inventories at the supplier, distributor and retailer (Broeckelmann, 1998). By the implementation of VIM, the duplicate inventory and the waste caused by this redundancy will be removed, the total supply chain cost are therefore reduced. While the customer benefits from higher product availability and lower inventory costs, the supplier also benefits from lower overall costs, increased forecasting precise, better insight customer demand, and increased customer retention and sales (Bendoly, 2005).

VMI started in the retail business, viewed as a manufacturer, distributor or reseller to a retailer or other merchandiser (Pohlen and Goldsby, 2003). There are other similar collaborative-based programs appeared in other industries such as Supplier Managed Inventory (SMI), Continuous Replenishment Programs (CRP), and Efficient Consumer Response (ECR) initiated in the grocery industry and Quick Response (QR) in the apparel industry which are all under the umbrella term Automatic Replenishment Programs (ARPs). Too often product supply fails to match up with actual demands especially at the retail level, it results in excessive inventory or lost sales opportunities, the essence of APR is based on the principle of “pull system” in which inventory restocking is triggered by actual demands rather than relying on the anticipatory demand (Madu and Kuei, 2005).

SMI is often viewed as synonymous term of VMI, which involves the flow of raw materials and component parts inbound to a manufacturing process (Pohlen and Goldsby, 2003). Figure 3.1 illustrates the difference between VMI and SMI.

Figure 3.1 Differentia of SMI and VMI (adopted from Pohlen and Goldsby, 2003)

Continuous replenishment planning (CRP) emerged in early 1990s as an EDI-based system which extends the use of EDI links to improve inventory visibility. Customer's stock availability, the volume of sales, and products in-transit are open to the supplier, so as to the supplier can make production plans to match the customer's actual demand while keeping inventory levels as low as possible (Monteiro et al., 2003). CRP moved one step ahead of VMI with providing stock levels in retailers' stores to the supplier, for the first time, Point-of-Sale (POS) data is used to generate a sales forecast (Barratt and Oliveira, 2001). However CRP also imposes constrains on smaller organisations (Monteiro et al., 2003).

In the food industry, Efficient Consumer Response (ECR) was initiated in 1992 to transform the once adversarial relationship between manufacturers and retailers (Gattorna, 1998). Based on trust, confidentiality and mutual benefit, both parties jointly agree forecasting techniques and the supplier takes over responsibility for replenishment using up-to-date sales information and sales promotions plans from the retailer (Cox and Brittain, 2004). ECR is all about how retailing and manufacturing work together to manage supply and demand in a real-time situation to maximise consumer satisfaction and minimise system costs under a responsive, consumer-driven system (Tijskens et al, 2001). ECR promises efficiency in four core areas: category management, replenishment, promotion and product introduction.

Whichever VMI, SMI, CRP, or ECR endeavours to reduce the total supply chain cost relied on stronger partnerships and real-time electronic information transmission (Broeckelmann, 1998). These methods bring great benefits to all parties and have grown into the latest known as Collaborative Planning, Forecasting, and Replenishment (CPFR). CPFR was introduced in 1995 which strived to cover the gaps left by VMI and CRP in relation to promotion and new product introduction processes (Barratt and Oliveira, 2001), and general synchronisation in the manufacturer's internal functional departments (Jespersen and Skjott-Larsen, 2005). Briefly, VMI or CRP mainly focuses on collaboration concerning replenishment/reordering, but CFRP clearly involves a more complex set of players, focuses on the entire process and planning activities among all involved parties that include all the three processes of collaboration: planning, forecasting and replenishment, and makes use of the internet to achieve win-win and integration (Jespersen and Skjott-Larsen, 2005). Through business planning and forecasting, and the use of data from supply side and consumer side, this interdepartmental working relationship enables production, delivery, warehousing and promotion to get aligned among all relevant parties (Kracklauer et. al. Eds., 2004). CPFR distinguishes itself from SCM by focusing on the improvement of the integrated operation process, as well as the inclusion of it development possibilities that support optimization and integration of the individual processes; and the concept of SCM focus on the choice of the supply chain's strategic composition, does not go to the depths in its suggestions for how integrated processes can be taken place (Jespersen and Skjott-Larsen, 2005).

Harrold (2001) assures that e-manufacturing must form the foundations on which the e-business is built. In his view, e-business means all activities could be done in real-time and on the internet. In the full implemented e-manufacturing scenario, e-manufacturing has been understood as a kind of internet-based just-in-time manufacturing in which customers, manufacturers and suppliers can take part in manufacturing activities in a way of collaboration and online mode (Jiang, Ed. 2007). Therefore, the internet technologies breakthroughs are needed to achieve the following key requirements for successfully operating an e-manufacturing environment (Girdhar, et. al., 2004):

- Scalability of systems—once information is available to people, many more people will immediately want to make use of it
- Variety of connectivity options—to handle many data sources
- Intuitiveness or organisation of information—people should get the data easily
- Personalization of information needs
- Adaptability to constant change
- Rapid development-faster time to the market
- Legacy system integration—few people have the money and time for totally new systems on a frequent basis
- Application inter-operability
- Management

- Security
- Diagnostics

SMEs have to be ready to work with the information systems of their partners and/or customers (Ferreira, 2004). This research will investigate whether manufacturers' ICT systems and internet-enabled applications have met the above requirements; whether ICT solutions targeted to SMEs have been done well for distributed design, distributed planning and support the networked enterprise.

3.2 How to Transform Traditional Manufacturing into E-manufacturing?

E-manufacturing is to use electronically transmitted knowledge to design products, transmit orders, procure component, drive production machines, and follow it up with remote product maintenance in the field. It links factories to one another, to their supply chains, and to dealers and customers (Davis and Spekman, 2003). The broad aim of this research is to develop theories of perfection of IFNs for manufacturers to achieve the successful transformations. On the basis of this aim, the literature review will discuss the strategies of the implementation of e-manufacturing which have been developed by the other researchers.

E-manufacturing can have two applications: tactical and strategic. In the former, the internet is used to monitor the manufacturing floor and materials handling to ensure optimal operation on a remote basis, provide basic information regarding work in process, inventory and other problem diagnostics; at a strategic level, the impact is more profound, e-based systems across a supply network provide business process visibility of capacity, processing, and inventories from raw material to finished goods (Bidgoli, 2004).

E-manufacturing takes into account all aspects of manufacturing - sales, marketing, customer service, new product development, procurement, supplier relationships, logistics, manufacturing and strategy development (Cheshire Henbury's manufacturing, 2005). It requires a new approach to manufacturing and distribution systems throughout the design, operate, maintain and synchronize competencies. The strategic alignment of people, machines, materials and products is necessary to enlarge the capability and visibility of supply chains (Bidgoli, 2004).

According to Girdhar et. al. (2004), e-manufacturing is enabled to achieve build-to-order and maintain non-stop operations by the follow four competencies:

Design: the ability to rapidly deploy and reconfigure manufacturing production, fast product introduction in response to changing market demand is a critical competitive advantage and a key to growth.

Operate: optimization of process yield and consistency throughout the enterprise.

Maintain: efficient management of all company assets—materials, processes, and employees to ensure non-stop operations and optimum asset productivity in a fast-paced environment with a solid information foundation

Synchronize: tight coupling of a manufacturing operation into the greater supply chain, both up- and down-stream.

But without the aid of smooth information channels to deliver timely and transparent information, none of the above four competencies can be achieved.

Rockwell Automation (2000) identifies four key requirements to the successful e-manufacturing as:

(1) Integrated plant-floor automation architectures to accomplish near-zero downtime operation in any number of plant locations worldwide;
(2) Seamless connections to enterprise systems enabled through software and services;
(3) Comprehensive asset management and reliability-centred maintenance;
(4) Tailored e-business strategies for supply-chain efficiencies.

However, these four requirements are not sufficient for achieving successful e-manufacturing. The requirement of the single integrated database is imperative to ensure the above four requirements

To effectively implement e-manufacturing, Lee (2003) also suggests that four enabling tools need to be developed as follow:

- Data and information transformation tools:

Data exchange tools are needed to share data across different applications and across company boundaries through the web-enabled surroundings, provide a transparent, seamless and automated information exchange process to enable an only handle information once (OHIO) condition .

- Prediction tools:

To improve the utilization of plant floor assets, advanced prediction methods and tools are needed to detect degradation, performance loss or trend of failure, breakdowns, etc.

- Optimization tools:

Optimization tools are needed to compare performance value at different states for effectively monitoring the performance of manufacturing operations.

- Synchronization tools:

The synchronization element provides the required integration with e-business systems including CRM, SCM, B2B e-commerce systems by utilizing the latest predictive intelligence methods and tether-free (i.e. wireless, web, etc.) technologies.

The above discussion sets good directions for e-manufacturing research and development, but they do little to facilitate manufacturers to extend the collaborative relationships with the sub- tiers suppliers/customers. E-manufacturing is currently under development, this is not surprising when technology is always changing and moving ahead, and the internet has not been used in the whole manufacturing industry. E-manufacturing as a promising avenue, it is considered important to reconcile some basic concepts from competitive strategy and manufacturing strategy. According to Krar and Gill (2003), the biggest roadblock to successful e-manufacturing is the lack of integration. They provide some common guides to follow as below:

1. Embrace the internet—everyone in the company, especially management, must understand the change that is required, and the potential benefits of e-manufacturing.
2. Decision-making process—engineers familiar with plant floor processes, and the information can contribute greatly towards the success of e-manufacturing.
3. Leadership role—the leadership role should be definitely assumed so as to each part of the company realizes the importance of information technology.
4. Step-by-step process—never attempt to do everything at once, was a lesson learned
5. Measuring success—Initiate a program where the savings and efficiencies of e-manufacturing can be recorded
6. Establish relationships—analyse how well the company works with their customers, supply partners, distributors, and strive to improve relationships and procedures.
7. Build on foundations—Incremental successes along the way help everyone to accept information technology, until full implementation of e-manufacturing strategy occurs.
8. Expert help—Contact companies who have successfully implemented e-manufacturing for advice when problems occur (Krar and Gill, 2003).

3.3 Conclusion

The previous researches highlighted the strategies of internal manufacturing development and collaboration with the first tier suppliers/customers, but did not emphasize manufacturers should also have a concern on the second and/or the third tier suppliers/customers. If the manufacturer’s second tier suppliers are unable to deliver materials on time to the manufacturer’s first tier suppliers, it will result in the first tier suppliers can not keep their promises to the manufacturer. The domino effect should be considered. This research has taken into account this issue to deliver a complete e-manufacturing implementation.

The corresponsive research work in e-manufacturing is still under exploration. Different researchers have diverse emphases on e-manufacturing. In sum, the internet and e-business technologies are essential tools which lay the foundation for information synchronization across geographically dispersed locations and irrespective of different IT systems for levels of supply chain visibility. The strategy of integration and collaboration is essential to make the philosophy of e-manufacturing work. Therefore, this research will focus on delivery of e-manufacturing in B2B and B2C side to fulfil precisely customer requirements with quick response by the improvement of manufacturing information flows along the supply chain to improve the whole supply chain processes being of automation and connectivity, and to ensure that customer demands, material supplies and production are cooperative in a real-time situation.

4.0 CHAPTER FOUR: RESEARCH METHODOLODGY

Chapter Four objectives:

- *Two pitfalls of completing this research*
- *Research methods and techniques*
- *Processes of completing this research*

This chapter introduces the major steps of completing this research. It covers the research planning and design, data collection and analysis, the strategies used and the approaches applied to achieve the aims and objectives.

"Never have we needed a good crystal ball more than we do today. Yesterday's answers to business challenges no longer solve today's problems."

--Paul Timm (1994)

As manufacturers are enclosed in a dynamic environment, new ideas, new technologies and strategies for providing new goods and services are always the lifeblood for every manufacturer. Therefore, carrying out research for solutions and revolution will never be stopped. The purpose of the business research is to give dependable answers and new ideas to manufacturing problems, and brings up fresh strategies for manufacturing evolution (Timm, 1994). This chapter does not discuss the importance of the research, but describes the research methodology that has been applied to this project. Methodology is known as the science of methods and contains the standards and principles employed to guide the choice, structure, process and method, as directed by the underlying paradigm (Sarantakos, 2nd, 1998). A set of arrangement and plans were drawn in advance, and revised during the progress. The methodology is considered as an indicator to guide the researcher on the right direction to go through the processes of collecting, analysing and interpreting data and observations into knowledge. A faulty methodology will lead to the failure that must be avoided in the beginning.

4.1 Two Pitfalls

To avoid serious methodological mistakes, the following two main concerns were encapsulated in the research methodology:

1. Stay focus on the objectives fulfilled by right research questions

To avoid the research from flying off at tangent and collecting the inappropriate data, the research topic and questions should be kept in the mind (Timm, 1994). Defining the research questions is probably the most important step to be taken in a search study (Yin, 1994). Not know where the research should be going that makes the research awfully hard to achieve the aims (O'Leary, 2004). Therefore, clarifying the issues and problems under the research aims by asking the right business questions was the first significant issues to the research at the beginning stage.

The major aim of this research is to achieve e-manufacturing through the development of a new information flow network (IFN) that purposes to reshape manufacturing supply chain management. On the basis of this aim, seven questions were raised. The first four questions as below were designed to investigate whether or how manufacturers deploy e-manufacturing, and discover any potential factors that might impact on the successful implementation of e-manufacturing in terms of information flows. These four questions are fundamental which seeks to collect data to further general knowledge and provide a basic outline for the research.

1. What is the current good practice of e-manufacturing in B2B and B2C?
2. What are the issues associated with the use of e-manufacturing in B2B and B2C?
3. What are the key factors that affect the internal assimilation and external diffusion of manufacturing information?
4. What competitive success factors are emerging from the use of e-commerce/e-business in other sectors that may be applicable to the manufacturing sector?

These four questions are exploratory. Through seeking answers to these four questions, the gap and the opportunity of the present practice of e-manufacturing were investigated. The research findings concluded how well manufacturers had been using e-commerce/e-business technologies for achieving the agile supply chain, and illustrated causal factors that could effect the implementation of e-manufacturing. These understanding provided the underlying knowledge to answer the following three questions: the problem-oriented questions 5 and 6 and teleological question 7:

5. How can manufacturers use e-manufacturing to improve their internal performance for the effective collaboration with the business partners?
6. How can manufacturers improve their supply chain competitiveness by the implementation of e-manufacturing in B2B and B2C?
7. What are the general strategies of the implementation of e-manufacturing in B2B and B2C?

These three questions were designed to bring forward hypothesis and disclose foresight and reached the solutions for the victorious implementation and development of e-manufacturing in B2B and B2C. Question 5 and 6 were designed to know how e-manufacturing has worked. Question 7 was to deliver the solutions based on the answers to the previous six questions.

The biggest obstacle of doing research lies in figuring out what need to know and achieve (Kane, 1985), in respect of overcoming this obstacle, the following issues (Kane,1985, Gray,2004) were considered into design the above seven questions to avoid from losing sight of what the research has been set out to do:

Do these questions fit into the original objects?
Have these questions broadened/narrowed the definition?
Are these questions covering those irrelevant issues?
Are these questions able to be studied?
Are these questions relevant to practical outcomes?
Are these questions valueless or ridiculous?

These seven research questions are articulated in a row as below:

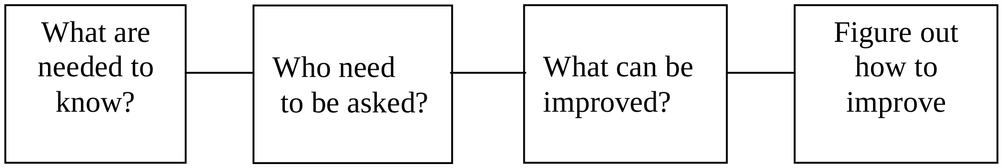

Figure 4.0 Articulated research questions

Well-articulated questions point out who need to be interviewed and what needed to find out, the right questions even reflects types of research methods/tools to be applied to achieve the aims (O'Leary, 2004). Meanwhile, the literature search was also carried out to help in determining right research questions.

2. Use combinations of research methods

Once questions have been satisfied, the concern was turned to how to best go about getting the answers. Business research is almost always problem-oriented with the objective of obtaining information to help solve a specific business problem or make a decision (Timm, 1994). Likewise, this research was to explore specific problems, obtain information and generate knowledge to solve the problems out. The combination of qualitative and quantitative approach was deployed to investigate the research questions. Such use of two or more methods of data collection in the same object of the study is called methodological triangulation (Dazen, 1978). Triangulation not only increases the validity of the data, but also enriches reliable data analysis in broad perspectives to deliver the strongest research findings (Carter, et al., 2004). In practice, it is often the case that multiple methods will be used to help to balance out any of the potential weaknesses in each data collection method (Gray, 2004).

Qualitative case studies and quantitative surveys were used successively in this study, but the case study is the major application to this research. Qualitative research *refers to a number of methodological approaches, employing methods of data collection and analysis that are non-quantitative, and aiming towards exploration of social relations,* *and describes reality as experienced by the respondents; exploration becomes its central element* (Sarantakos, 1998). It is the most appropriate approach for exploratory than quantitative research which focus attention on measurements and amounts of the characteristics displayed by the people and events that the researcher studies (Thomas, 2003). This study has a very practical focus on perspectives of real life, and understanding is much more important than collecting data. It took the early step to explore the driving factors associated with the successful implementation of e-manufacturing. As types of research questions influence research methods used (Yin, 2003), these exploratory 'what' and 'how' questions are favoured, using the case studies as the major method to collect the data for this research. In addition, when the focus is on a contemporary phenomenon within some real-life context rather than historical events, the case study is considered (Yin, 2003). Case studies are appropriate approach to real, complex, current problems, are used *as a pragmatic research tool in order to understand thoroughly the complexity of a given problem and to support decision making* (Scholz and Tietje, 2002).

Quantitative research is based on the collection of considerable data from representative samples, while qualitative research pursues fewer subjects but investigating in much greater depth (Black, 1999). A special-purpose quantitative survey can provide the information to pair with other characteristics for a desired analysis (Fowler, 2002). In this study, a small-scale survey was applied to learn about corner shops' attitudes towards e-commerce.

4.2 Research Process

The processes of doing this research can be generally understood as gathering data, analysing data, and then generating new knowledge. It includes four critical processes as follows:

(1) Definition phase: during this phase, the research topic and research questions were defined. The research proposal was completed to outline the aim and the objectives of this research and indicate the methodology by which the research could be achieved. The major proceeding of this phase was literature review that was carried out through the research as well.

On the basis of the objectives, literature review was the essential tool to help out knowing the state of arts in e-manufacturing technologies and the bottlenecks of manufacturing management development; on the other hand, through learning other researchers' work and theoretical arguments, this helps to identify the further development trends, avoid duplication of any research effort and establish research questions.

The sources of secondary information came from text books, journals, magazines, newspapers, online information, and conference papers. Manufacturing strategy, e-commerce/e-business, information systems, supply chain management and manufacturing e-supply chain implementation strategies are covered. The author started looking through the wide views, and then focused on the specific area.

Literature review contributes knowledge to the research including:

(1) The impacts of the business environment on manufacturing development;
(2) The adoption of information and communication technology (ICT) and IT in manufacturing;
(3) The advantages and blemishes of widely used IT applications such as MRP, ERP, and EDI and so on; the need to integrate the internet with these systems
(4) The use of the web-based technologies and e-business/e-commerce for the efficiency of the supply chain;
(5) The revolution of manufacturing systems from mass production, to flexible manufacturing, to computer integrated manufacturing, to lean manufacturing, and then to agile manufacturing.

(2) Data collection phase: based on the definition phase outputs, a considerable number of case studies were examined to look closely the current practice of e-manufacturing in the manufacturing industry and then to identify the issues and barriers to the effective use of e-manufacturing. Learning from the successful companies facilitated a greater degree of understanding of how supply chains operate now and how they might be enhanced by E-manufacturing. The primary case study data were collected through semi-structured interviews and observation. The interview questionnaire was designed to collect data. Most interviewees were in the management positions. In addition, case studies done by other researchers that were useful to satisfy current research objectives were collected as well.

(3) Data processing and analysis: during this phase, the data collected was processed and analysed as soon as data became available, correlations between results were defined, and the concepts were developed through constant comparison with additional data. In order to best answer the research questions, going back to case companies for more data where needed was followed up. Sufficient supporting evidence allowed having deep insight of the problems and then providing a more complete explanation of current situation and why the problems had occurred. Through data analysis, the data was catalogued, and causal relationships among variables were discussed. The research did not carry out the large-scale survey; therefore, secondary data were serviceable which complemented the primary data to reinforce the analyses and discussing.

(4) New knowledge creation and verification: with the understanding of the current practice, the final phase was to deliver a vivid description of a desired future, identify breakthroughs to overcome the existing barriers, and decide the accurate inference. The resulting theory was verified by the case companies to avoid from any wrong deliverance and impracticability.

The above processes can be illustrated by the Figure 4.1:

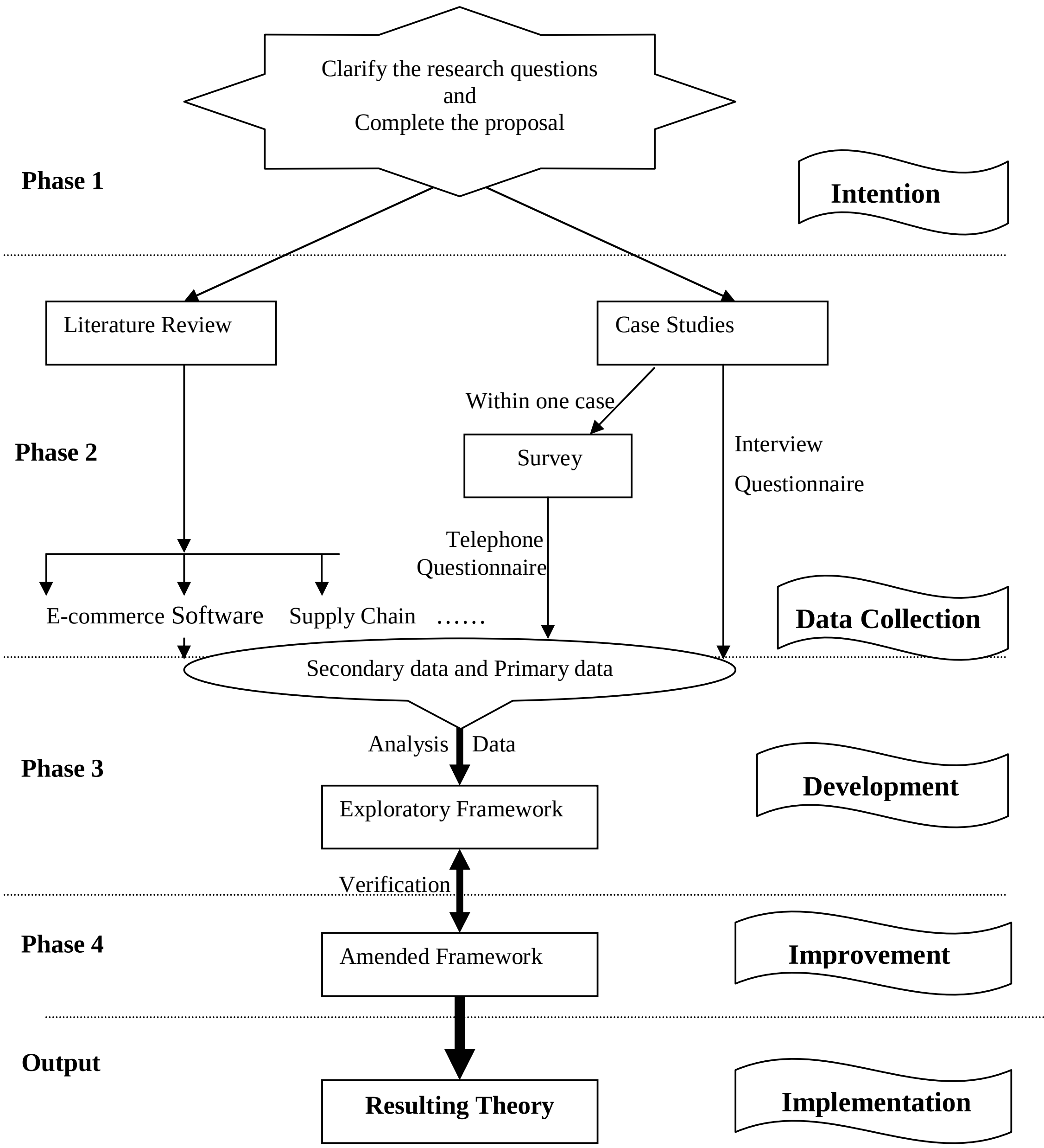

Figure4.1: The research processes

5.0 CHAPTER FIVE: COLLECTING PRIMARY DATA

Chapter Five Objectives:

- *Interview questionnaire design*
- *Case companies selection*
- *Case companies introduction*

This chapter describes how the primary data were collected. Semi-structure interview was the main approach to explore case companies. With the assistance of a questionnaire and case study mapping, it ensured all the relevant questions were asked during the interview, and quality answers were obtained and recorded.

The sources of evidence for case studies most commonly come from: documents, archival records, interviews, direct observation, participant-observation and physical artefacts (Yin, 2003). Due to the limited space here, this chapter only describes how the primary data was gathered by the interview in several case studies.

5.1 Case Study Interview

An interview is *a conversation that has a structure and a purpose, a careful questioning and listening approach with the purpose of obtaining thoroughly tested knowledge* (Kvale, 1996). The well-conducted interview is a powerful tool can be employed to study those events that do not directly come under the eyes of the participant observer (Denzin, 1978). It is for eliciting rich data on people's views, attitudes and the meanings that underpin their behaviours (Gray, 2004). The interview offers an insight into respondents' memories and explanations of why things have come to be what they are, as well as descriptions of current problems and aspirations (Gillham, 2005).

The research used semi-structured interviews to explore the issues relevant to the study. The semi-structured interview probes into views and opinions for respondents to expand on their answers that help towards meeting the research objectives (Gray, 2004). Mainly, interviews are inherently more flexible to ask questions that result in having depth of understanding, in comparison with questionnaires which are appropriate for a large-scale or preliminary survey (Gillham, 2005). In this research, the semi-structured interview with some open-ended questions obtained a wide range of viewpoints of the informants. The follow sector will talk about how the interview questions were designed.

5.2 Interview Questions

This research used face-to-face interviews to collect data with the help of the prepared questionnaire (Appendix 1.0). The questionnaire is an integral part of the research design stage. The goal is to obtain the better answers to the research's questions. The design took into account two elements: relevance and accuracy. According to Iarossi (2006), these are two basic rules that make a good question:

1. Relevance: The questions are enabled to gather appropriate information needed for the purpose of the study.
2. Accuracy: The questions are enabled to collect the information sought in a reliability, avoid being difficult to answer or embarrassing,

On the basis of the research's objectives and the above two rules, the questionnaire looked at the following issues:

Company review It aims to get data about the company size, turnover, and main products (services). The company profile discloses likely relationships between variables: a） Whether the size of companies determines the possibility of the use of business to customer (B2C) or business to business (B2B)? b） Does the nature of the products affect manufacturers to apply B2C and B2B?

Manufacturing Supply Chain It aims to know the linkage among the manufacturer, its upstream participants, and its downstream participants. This will help to understand how complicated manufacturers are running their supply chains and what factors influence the implementation of e-commence B2C and B2B.

The use of the internet It is to examine how manufacturers have been using the internet to facilitate materials and information flowing efficiently along the whole supply chain. It also investigates the degree of integration of all applications software for the agile supply chain.

Unlike self-completion questionnaire filled by the respondents, this questionnaire is the interview-administered paper questionnaire used as a reminder to remind the interviewer to ask all the necessary questions. The questionnaire not only served as prompts in asking questions, but also was used for recording the answers during the interview. Some of the questions were open and so the answers were expected to be open. Such face-to-face interview is of flexibility to ask additional questions. A few questions were raised as new issues since they were not anticipated at the start of the interview. Every interview did not repeat all the same questions. It depended on the each individual case situation. In addition, the questionnaire was piloted in the first case company and then improved to be more effective.

5.3 Case Study Mapping

The sequence of questions is very important. If the interviewer has difficulty following the questionnaire or finding the correct question to ask, the flow of the interview can be lost, together with the interest and attention of the respondent (Brace, 2004). Hence, the case study mapping was produced to lay out the clear route for the sequence of questions and keeping the interview on the track, which served as a complement to the questionnaire during the interview as additional questions to be raised.

Case Study Mapping

1. Company details

(1) Company's mission and strategy

(2) Company size (Annual sales value and number of employees) — relates to what sort of ICT should be applied

(3) Type of industry—the selection of B2B or B2C or both

(4) Structure of company

- Functionally organised
- Divisionally organised
- Matrix organisation
- Bureaucracy

2. Product

(1) Main products produced

(2) Markets addressed

(3) Strategy adopted

- Make to stock
- Assemble to order
- Make to order
- Engineer to order

(4) Product core advantages compared with competitors: lower price, higher quality, better service….

3. Operations

(1) How physical material flows along the supply chain

(2) Production processes

- Jobbing production
- Batch production
- Line or flow production
- Continuous process production

(3) Core manufacturing processes

(4) How to handle uncertainty—(for knowing manufacturer's flexibility)

(5) Any need for shop-floor improvement

4. Raw materials purchasing

- Inventory control: just-in-time, season storage, storage
- Volume of materials buying: large-scale, decentralisation
- Priority of choosing a supplier: quality, price or service
- The degree of coordination with suppliers (the buyer-supplier relationship)

5. Product distribution

(1) Channels of distribution

- Direct sales to customers
- Organised markets
- Wholesaling
- Agents
- Franchising

(2) Relationships with customer

6. Current use of ICT and IT

(1) Intranet—information flows

(2) Extranet:

- B2B extranet
- B2C extranet

(3) EDI, ERP, MRP, CRM......

7. Purpose of using ICT

(1) Aims

(2) Benefits

(3) Gap between the practice and the objectives

(4) Further investment in ICT

8. Purpose of using IT

(1) Aims

(2) Benefits

(3) Gap between the practice and the objectives

(4) Further investment in ICT

9. Integration

(1) The degree of the integration of individual application software

(2) The coordination with suppliers and customers (horizontal integration)

(3) Manufacturing internal coordination (vertical integration)

5.4 Case Companies Selection

Purposes of the case study are for demonstration and learning, therefore, the more complex and contextualized the objects of research, the more value the case study approach is regarded to be (Scholz and Tietje, 2002). Multiple-case study is strongly believed to be able to reach the substantial findings than single-case in this research. According to Yin (2003), the sampling logic and the typical criteria of the sample size are irrelevant to the multiple-case designs, instead, case selection should follow a replication, in other words, the case study serves in a manner similar to multiple experiments, with similar results (a literal replication) or contrasting results (a theoretical replication). Based on this criterion, the selection of the number of cases for this research was determined by the number of case replications and the certainty of the results. To have a high degree of certainty, the case study approach may press for five, six or more replications to expand the external generalization (Yin, 3rd, 2003).

The first case company is a wiring harnesses manufacturer which has succeeded in taking advantage of EDI and MRP to achieve the company's objectives of shorter lead time and low cost. This case was regarded as a pilot study, since the interview questionnaire was subsequently refined and improved, and some thoughts were developed. It developed a basic understanding of the case study processes. To ensure the entire series of case studies to address the research concerns, a micro-enterprise, and a medium-enterprise were involved as the second and the third case. These three case studies gave a deeper insight into the original hypothesis. To find more cases for the study, the author emailed the members of the West Yorkshire Manufacturing

Excellence Club (WYMEC) to ask for a visit. To efficiently sample appropriate cases, only those companies with email addresses were considered. If a manufacturer does not even disclose its relevant email address, it could assume that e-commerce is not their big concern. Therefore, the traditional contact methods like mail letter were not used. Sending out email was the first effort to invite companies to this study. To attract managers' attention, the electronic questionnaire was attached to the email as extra information, and it was an option whether managers filled in or not. It was 200 emails were sent off, of 45 emails were returned as error delivery addresses, of 9 emails responded that they did not do manufacturing themselves, and of 5 companies said that they were busy and could not help with this study, and of 1 said the company policy did not allow to give an interview. One company filled in the e-questionnaire instead of giving an interview. In the end, there were 12 companies replied that they would like to be visited, from which four noticeable case studies were selected based on theoretical usability and availability. Following on after emerging concepts, more case studies were carried out, including agent companies, they were not the member of WYMEC. Eventually, the sample of this case study comprised eight representative companies to support the arguments. In fact, the author has done more than eight case studies, but some of them are not exceptional cases which would not be repeated here. Most of cases took a half day for data collection. The report of each interview was produced after each visit, and then was sent to the company by email for validation. These case companies were visited several times for after the first interview. The author spent two weeks in the last case company. These eight case companies were briefly described as below:

5.5 Introduction to Case Companies

Case 1 was a leading producer of automotive wiring harnesses for car, commercial vehicle and off-highway, and for industrial applications and operates internationally. The manufacturer was able to offer 6 weeks leading time, compared with 12-13 weeks pledged by its competitors. This was achieved by the company implements the strategies of e-procurement and the tight relationships with suppliers and customers across the supply chain, coupled with using advanced IT systems like MRP and EDI.

Case 2 was a micro-enterprise of full functions of designing, manufacturing and selling military miniatures and wargaming figures. The firm sells products directly to the end customers via the internet. Through its online shop, the company took advantage of the B2C e-commerce to target customers worldwide economically and effectively. Without an agent, the company managed the shortest supply chain in which the company was able to save the cost and lower the price to satisfy customers.

Case 3 was a USA manufacturer's distributor centre in UK which supplied several brands' ranges of fasteners, components and equipments for construction and industrial applications. The centre applied EDI to work in with the 80/20 principle to achieve more with less. The company believed that 80% of the business' sales and profits were derived from the 20% of key customers. The company used B2B e-commerce to hangs on to the 20% of key distributors who generated the company's 80% of sales and 80% of profits. Through this case, it raised an argument against whether a company developed B2C e-commerce it might be affected by the company's strategies and the objectives.

Case 4 was one of the biggest international beverage and confectionery manufacturers in the world. The success resulted from accurate business strategies and a huge investment in advanced IT technologies. To be able to deliver demand-driven supply chains, the company overhauled the supply chain and supporting IT systems, a five-year IT transformation project had been undertaken to upgrade the IT infrastructure which aimed to integrate purchasing, manufacturing, warehouse, distribution, sales and marketing on a global SAP system. On an ongoing basis, global supply chain was taking steps to enlarge IT capability in terms of: global data synchronisation network, data quality, sales telephony, EDI environment upgrade, forecasting improvement, finite capacity planning, wireless warehouse management systems, product allocation ability and so on.

Case 5 was a family company had been producing quality gear cutting tools for more than eighty years. The cutters were required by the automotive, aeronautical and defense industries throughout the world. As the market was specific and the competition was not fierce, the manufacturer paid attention on the internal improvement through lean manufacturing system rather than fulfils e-commerce to reshape supply chain.

Case 6 was the sales representative of eight manufacturers, which offered a comprehensive range of world class laboratory equipments and support services. As the company was small and had the sufficient old customers, the company was not desperate to develop an online shop, but used Sage line 50 to manage automatic order processing with the old customer.

Case 7 was a world-leading agribusiness, a leader in crop protection and ranks third in the high-value commercial seeds market. The company implemented Wonderware industrial SQL server to improve over all plant productivity and efficiency by the enlargement of the ability of monitoring plant performance in real time and better analyzing plant data online. The solution provided a complete picture of the plant's processes. Chemists at the UK site were able to monitor the process in other sites in the world.

Case 8 was a world class leading designer and manufacturer of turbochargers for commercial medium to heavy-duty diesel engines and gas-derivative. The manufacturer placed the first priority on reliable supply of turbochargers to all customers. To do so, materials on time delivery was crucial. The manufacturer ran VMI warehouses to ensure materials from overseas could be delivered to the shop floor under Kanban system. In addition, a web-based supply (WeSupply) was implemented to improve inventory control visibility among the manufacturer, its first tier suppliers and its second tier suppliers.

This research is concerned with the development of e-manufacturing in the manufacturing B2B and B2C side. Each case was explored in depth. Data was gathered on any factors associated with e-manufacturing. These eight case studies are of varied circumstances, combines a number of aspects related to e-manufacturing development, they provide profound insights. Through the comparison of these manufacturers from the different sectors, the findings of each case converged at a greater degree of understanding of how supply chains operate now in the manufacturing industry; how the nature of products affects supply chain infrastructures; and how the use of the internet technology can enhance manufacturing supply chains.

5.6 Small-scale Survey

To help Case Four to identify customers' requirements for effective web ordering, a small survey was carried out in Huddersfield to investigate whether local small shops were interested in online transactions. A questionnaire was designed to be filled in by the shop owners or managers. The contact details of local shops and stores were obtained online on locallife.co.uk:
www.locallife.co.uk/huddersfield/supermaketsandconv3.asp
Sixty-three local shops' addresses and telephone numbers were disclosed on the webpage, but the website did not keep updated by the time this survey was applying. The telephone numbers shown on the website were not all correct. This was found after the telephone interview. The telephone interview was first method to obtain data, the sample was selected random. 20 telephone interviews were completed, including 6 failed calls as either the shop had been closed down or the telephone numbers were wrong. The telephone interview focused on couple questions such as whether they used the internet; what their purchasing channels were, and so on. Meanwhile, Twelve questionnaires were door-to-door delivered to the near by shops. It was the 100 % response rate: Ten out of twelve questionnaires were collected back in person in two weeks later. One out of twelve questionnaires was done by the researcher popping in the shops and talking to the owners face-to-face. The last one questionnaire was sent and returned by email to the University of Huddersfield Student Shop. The survey samples were from Student union shop, Post office, Corner shops and Asian shops.

This survey was interested in the attitude of small retailers toward e-commerce. The findings are of help to suggest what the strategies should be applied when manufacturers want to involve SMEs into their e-commerce systems.

6.0 CHAPTER SIX: FINDING AND ANALYSIS

Chapter Six Objectives:

- *Findings of this study*
- *Analysis and discussion of the findings*

This chapter summarizes the discussion and conclusion of findings which are based on primary data and secondary data.

6.1 Discussions and Findings

Through literature search, case studies and the survey, this research has come to nine major conclusions to answer the research questions. On the basis of the seven research questions, the case study paid great attention to the use of the website, the use of the internet in B2B and B2C, IT capabilities and the efficiency of the supply chain.

6.1.1 Popularity of the Website

The implementation of e-manufacturing requires an understanding of the use of websites. A broad definition of website is described as *consisting of all the materials placed on the web by a particular organisation or project or individuals* (Dochartaigh, 2002). A website does not necessarily have to be available to the public. It might be stored on an intranet/extranet, where it is available only to internal/external corporate users, or reside on a network drive somewhere on a local network, or stored on a computer’s local hard drive (Meadhra, 2005).

The study first examined whether these eight companies had their public home websites. Table1.0 shows that they did have their home websites; especially the larger companies undertook more than just one home website, as well as private websites. Case Seven had several different versions of websites to fit in well with different business purposes, different ranges of products and different countries.

Table 1.0 Does the company have a home website?

Company	Size	Number of Websites
Case One	Large enterprise	One
Case Two	Micro-enterprise	One
Case Three	Medium enterprise	One
Case Four	Large enterprise	More than one
Case Five	Small enterprise	One
Case Six	Small enterprise	One
Case Seven	Large enterprise	More than one
Case Eight	Large enterprise	More than one

In addition, according to the Information Security Breaches Survey 2006(ISBS 2006) sponsored by DTI (www.dti.gov.uk/industries/information_security), the vast majority of companies were using the internet. The findings were summarised as below:

- Nearly every UK business made use of the internet;
- 97% had an internet connection and 88% of these were broadband.
- 81% of companies had a website, with 89% of these being externally hosted.
- One in six small companies could operate their business without IT.

The above results indicate that the widespread use of the internet in the businesses facilitates and accelerates the popularization of the website.

Based on the case study and the secondary data, the first conclusion was drawn as:

Conclusion One*: The website has been accepted popularly by the most of UK companies. The deployment of the website is regarded as the necessary element of the business, at least is for the sake of having one.*

A survey did in the past by the Harris Poll (www.harrinsinteractive.com) concluded that product searching online was the fastest growing activity, increasing from 25% in 2000 to 41% in 2003 (Martel-Lawson, 2004). As more and more people surf on the internet to grasp information, the web has become a major source of information for everything. According to the Office for National Statistics' (ONS, 2006) annual e-commerce survey, the results also concluded that the deployment of the website, computer use, internet access and the use of broadband were those areas where saturation had being reached by most business groups, and the gap between large and small businesses is reducing. This survey covered most of economic divisions: Manufacturing, Electricity, Gas and Water Supply (EGW) and Construction division, Wholesale, Retail, Catering and Travel Division, Post and Telecommunications Division, Computing, Renting, Real Estate and Other Business Services Division, and Banking and Financial Division, and other Services. In total, 8,000 UK companies with the employment of 10 or more were involved in this survey, 76.8% of these companies returned questionnaires. This large survey provided the statistic data of accuracy and representation, its results were used as a complement to support this research argument.

6.1.2 Purposes of Using the Website

However, many researches have proven that the internet and the website have been accepted widely. This study went further to investigate the purposes of manufacturers using the website. Do manufacturers consider the website is vital important to the business or is of only peripheral interest?

The results show that most of these eight companies all initially invested in a home website for dissemination of companies' news and products information rather than for online transactions, whereas Case Two used the website purely for e-commerce. Case Two mainly relied upon the internet to sell its products directly to the individual customers. By the dependence on the online shop, Case Two allowed the end users to buy directly online and pay online. The goods were delivered to customers' homes by the post office. In addition, customers could customise their desired figures and give comments on the improvement of the figures by emailing to Case Two. Having an online shop, Case Two was enabled to target customers worldwide without a local distributor or agent. The company had benefited from accomplishing the shortest supply chain including only suppliers, manufacturing and the end users. On the other hand, as no commission charged by intermediaries, the production cost was therefore lower so as to consumers also benefited from getting the goods at a reasonable price. This is a sort of win-win business which satisfies both the buyer and the seller. By lowering the cost, the seller should increase the volume of the sale, and the buyer should get the bargain.

Refer to the table 1.0, Case One, Case Three, Case Five and Case Six and Case Seven used descriptive websites as online brochures of corporation information, products information and new technologies. Case Seven and Case Eight were the international enterprises, for each particular country, the websites were created in different languages. Although Case Three is the distributor and Case Six is an agent of eight manufacturers, they had not developed online shops as additional sale channels to effectively target the potential customers. Apart from the home website, Case Four undertook another two separate websites for selling its own brand chocolates and the acquisition's brand chocolates. But this consumer brand manufacturer did not intend to sell directly all goods they made to the end users via these two online shops. These two online shops were ideal for customers who liked to buy chocolates for gift, collection and any occasion, in fact some of goods could not be found in the supermarkets. The majority of products were sold via many different sales channels, ranging from grocery stores, wholesalers, distributors, petrol station kiosks, corner shops and food and entertainment venues. It was about 60% of products sold via EDI, and about 40% of the orders from smaller customers via phone, fax and email. The transactions via phone, fax and email were not as visual and stable as those via EDI with middle and large customers. Case Eight was through EDI to complete electronic transaction with its major customers, but its Aftermarket maintained two separate websites respectively for UK and USA online ordering. The websites were private, could not be rummaged by the public. Currently, ordering via the web system was not the priority for the majority of existing customers. Many customers went through the website to check the price and the stock level, once there were not enough products in stock, customers used to ring in and negotiated the possible early delivery date rather than directly placed orders online.

Table 2.0 Purposes of using the website

Company	Line of Business	Purposes
Case One	Design and manufacture of automotive wiring harnesses	-- Online brochures
Case Two	Manufacture of military miniatures and wargaming figures	-- One-many B2C e-commerce
Case Three	Supply of brands' ranges of fasteners	-- Online brochures
Case Four	Produce of beverage and confectionery	-- Online brochures -- B2C e-shop for special sales
Case Five	Design and manufacture of special cutting tools	-- Online brochures
Case Six	Supply of laboratory equipments and support services	-- Online brochures
Case Seven	Produce of crop protection and high-value commercial seeds	-- Online brochures -- B2B e-business
Case Eight	Design and manufacture of turbochargers	--Online brochures --B2B e-catalogs for Aftermarket sales

Table 2.0 indicates that the seven cases did not rely on their websites for sales while Case Two website was the principal entry port for customers to buy the products. These companies' websites were interactive, which allowed visitors to ask questions or leave feedback via email or the website, but none of these websites provided online help desks to carry out immediate audio communication. Although Case Four and Case Eight had undertaken web-based e-commerce initiatives, it was considered merely as a subsidiary business strategy. Most of these eight case companies used their websites just as an extra place to give details of their products, technologies and services. Indeed, by random searching on the internet, it could be found that there are numbers of manufacturing websites used mainly for broadcasting the enterprise information, or for online/offline customer support.

Conclusion Two: *Each company has a different business purpose to implement on the website. For these eight case companies, the purpose is mainly for diffusing information, or customer services or e-commerce. There is a lack of interest in using the website as a portal for e-business.*

ONS (2006) annual e-commerce survey also gave the same conclusion. Their results indicated that only nearly 38% of all size businesses in an across sectors excluding Banking and Finance used their websites to provide catalogue and price list information; just nearly 16% used their websites to offer after sales support, and most were using the websites for information transmission.

6.1.3 Functions of the Website

It is well known that website applications have a great impact on a wide range of activities including commercial sites such as online trading and auctions; financial services such as online banking and security trading; information sites such as online information sharing, and educational sites such as digital libraries (Gerndt, Ed.2002). The website not only provides valuable source of information, but also is the medium of communication, is the e-marketplace for business activities, prominently it is the coagulator that links up suppliers and customers with manufacturers.

This sector will talk over functions of the website to examine how many add-ons that manufacturers have missed out. Fazlollahi (2002) capsulizes five general functions of the website which ground on five perspectives on e-commerce developed by Holsapple and Singh (2000): the trading view, the information exchange view, the activity view, the effects view and finally the value chain view. In corresponding with these five perspectives, Fazlollahi (2002) describes five functions of the website as below,

1. Trading function -- Support electronic buying and selling of products and services
2. Information exchange function -- Support multi-channel communication for the information exchange among all business partner
3. Effectiveness function -- Streamline business transactions and improve customer service, reduce costs and time
4. Activity function -- Facilitate other activities such as pre-sale and post-sale efforts, and inter-corporation collaboration

5. Value chain function -- Support activities that reduce cost and add value on the value chain, thereby contributing to competitive advantages

According to the conclusions Two, none of these eight case companies had developed full functions of the website that acts as the centre element of e-business.

Conclusion Three: *The potential functions of the website have not been recognised and maximised by manufacturers, especially web-based e-business has not been the centrepiece of the business.*

6.1.4 The Growth of E-commerce

According to the table 3.0, eight firms were engaging in e-commerce. Case Five lately implemented Jobshop software to link most of the departments into one single database and process online sales orders. Five of eight case companies had been well using EDI to complete electronic transactions with their major business partners for almost two decades. Case Six deployed Sage 50 application to process orders, run credit check and send invoices electronically to customers via Sage Transaction e-mail without re-keying data, and receives payments online.

Table 3.0: The adoption of e-commerce and web-based e-commerce

Company	Sector	E-commerce	Web-based e-commerce
Case One	Automotive	Yes --EDI for sales and purchases --Internet for purchases	No
Case Two	Manufacturing not elsewhere classified	Yes E-shop	Lain on B2C E-shop
Case Three	Distributor (of Electrical equipment)	Yes EDI for sales and purchases	No
Case Four	Food & Beverages	Yes --EDI for sales and purchases -- E-shops for sales	Yes Two B2C E-shops for special products
Case Five	Metals and engineered metal products	Developing Jobshop for sales	No
Case Six	Agent (of Biotechnology)	Yes Sageline 50 for sales	No
Case Seven	Chemicals& products	Yes EDI for sales and purchases	No
Case Eight	Automotive	Yes --EDI for sales and purchases --E-catogoles for sales	Yes Two B2B E-shops for Aftermakert

As the wide range of raw materials and components requirement, Case One was dealing with around 250 suppliers, but had no power over all of them to get every supplier on time delivery. To keep on the competition, Case One promised 6 weeks leading time from design to delivery, against 12-13 weeks leading time pledged by the competitors. Sometimes customers required materials or components ordered from their appointed suppliers; and sometimes customers' orders were occasional, one-offs and specific, in these circumstances, the order was small and would not be given the priority facility by the suppliers. To keep the promise of on time delivery to customers and not to suffer the panic caused by the late delivery from the suppliers, the solution taken to cope with such weak buyer-supplier relationships was purchasing materials online directly from the distributors. Through the distributors' websites, Case One got the enough information of the products' specification, available stocks and the nearest distributors. The order could be placed online within a second. By buying materials from distributors' e-shops, the price was approximately 25% higher than from the producers, but the distributors provided the quick deliveries and good services that enabled Case One to work on schedule and keep up its good reputation of on time delivery. In addition, as purchasing the exact amount of the materials for a special order from the online distributors rather than from the producers with relatively large quantities, obviously, the material inventory effectively got to reduce.

However, Case One used online purchasing had been justified by the benefits including:

- Comprehensive product information
- Easily and quickly place the order
- Good service and On time delivery
- Saving capital

The ONS 2006 annual e-commerce survey also showed the enormous growth rates in e-commerce, especially using the internet for purchasing in Manufacturing/EGW/Construction industry, see table 4.0.

Table 4.0: E-commerce's growth rates in manufacturing industry, 2002 to 2006 (ONS, 2006)

Broad Industrial Sector		Manufacturing/EGW/Construction
Per cent		
Sold over the internet	2002	9.6
	2003	9.3
	2004	13.0
	2005	17.2r
	2006	14.2
Used secure protocols (SSL/TLS) for sales over the internet	2006	6.0
Purchased over the internet	2002	13.9
	2003	40.3
	2004	52.2
	2005	60.2r
	2006	55
Sold over ICTs other than the internet	2002	19.8
	2003	24.9
	2004	23.9r
	2005	28.5
	2006	27.7
Purchased over ICTs other than the internet	2002	16.4
	2003	21.6
	2004	21.3r
	2005	22.4r
	2006	19.4

r—revised

Although the table 4.0 illustrated the rapid increase in the number of companies undertaking the internet to conduct e-commerce, in terms of the value, sales and purchases over ICTs (non-internet EDI, automated telephone systems and email) were still taking up the great portions in the electronic trading. See the following figures provided by ONS (2006) survey, sales over the internet was increasing from 6.9 billions in 2002 to 47.4 billions in 2006, and purchases over the internet was increasing as well from 3.7 billions in 2002 to 20.1 billions in 2006, but sales over non-internet e-commerce was 99.3 billion in 2002 and 104.3 billion in 2006, and purchases over non-internet was 49.9 in 2005 and 51.9 billion in 2006. These figures indicates that e-commerce over non-internet so called traditional e-commerce was saturated since 2002 to 2006; in contrast, internet e-commerce was growing fast, even so, in Manufacturing/EGW/Construction industry, non-internet e-commerce still possessed the large share of e-commerce. In 2006, in all UK non-financial industries with 10 or more employees, the highest value of sales over non-internet was achieved by the manufacturing industry, almost £47 in every £100 spent (ONS, 2006). Obviously, traditional e-commerce was still on the track. In this research, 4 large and 1 medium case companies were using non-internet EDI to complete most of their transactions.

In general, the adoption of B2B e-commerce in the manufacturing industry was not in the infant stage. The fact is that large enterprises are focusing on long-term relationships with major business partners via B2B e-commerce rather than considering using the internet to target potential small customers.

Based on the eight case companies and the secondary data, the forth conclusion was drawn as:

Conclusion Four*: The use of the internet for purchasing continues growing in UK manufacturing industry to win an advantage, it has dramatic growth rates than others; but non-internet e-commerce is still staying stable and dominant, takes up the large portion of the total value of e-commerce. Apparently, the large enterprises slowly turn* *to internet e-commerce while many small and medium enterprises are increasing to use internet e-commerce for sale and purchase.*

6.1.5 Is Manufacturing E-Commerce Widely Open?

The benefits of e-commerce have spurred many manufacturers to invest in two-way communication applications with their existent important business partners. As introduced in Chapter Two, EDI is the legacy system of inflexibility, the communication via EDI to EDI may not be smooth if these two systems are in different formats. If companies deploy EDI to carry on e-commerce, it mostly collaborates with their existing partners, rather than open their e-commerce systems to a mass of potential buyers. Case One, Case Three, Case Four and Case Seven formed the examples. For those buyers who did not use EDI, they were out of the manufacturers' e-commerce system, they had to use phone, fax or email to place orders, and then manufacturers' sales representatives manually entered the data into the computer system. The purpose of Case Two employing B2C e-commerce was nothing less than to attract more customers as possible; in contrast, the rest of case manufacturers more concerned implementing B2B e-commerce for better collaboration with their existing important customers who also used the same kinds of e- commerce applications.

An open-ended questionnaire (see Appendix 2.0) was carried out for Case Four to investigate whether the small shop was interested in online transactions. Only one shop owner showed the interest in using online order if merchandises' price was good. It should be noted that the limitation of this survey is that interviewees were bounded to those small convenient shops in Huddersfield area. The findings could have bias, but these shops represented those in the last second tier of Case Four's downstream supply chain who did not have a direct link with Case Four and they had not formed e-purchasing custom. They had no idea of their requirements on the effective web ordering. The results also reflect that Case Four's UK competitors had not done so far to provide web-based B2B e-commerce for non-EDI small customers. This could be certified by going through their UK websites, these companies were Mars, Nestle, Hershey, Kraft Foods, Darrell Lea and Coca-cola, and Pepsico. In contrast, Hershey

Co. and Kraft Foods Inc had run a B2C website for USA customers respectively as follow: http://www.kraftfoods.com/shopkraft/index.asp, http://hersheygifts.com. Kraft Foods Inc had even taken the further step to develop a web-based B2B e-commerce (http://www.kraftezserv.com) for its all USA trade partners including non-EDI customers, but in the UK, the company was no longer accepted any more online order currently, alternatively, the direct order could be progressed via Telesales team, or by email and fax. The researcher emailed UK Kraft Foods to ask why the online order facility was suspended, the customer services manager replied that they had temporarily suspended the facility because of the process of upgrading the functionality of the website, and expected to restore order entry capability in the near future. By the thesis was writing, their website had been updated, but the online ordering system was still not allowed. However, the current website (http://www.kraftafh.co.uk/Cultures/en-GB/) provided the central repository of products information, instructs customers direct orders by phone, email and fax or indirect orders via their Vending operator, Cash and carry and Wholesale partners. Refer to USA KraftezServ.com, this B2B website had functions of e-purchase orders, product information, e-category reviews, volume reports and sales team documents under the six features. They are:

1. Digital Plan-O-Grams: access to customer specific digital shelving diagrams.
2. Product Catalog: access item data as well as digital product images and scannable UPCs.
3. PO Inquiry Tool: for customers to view all of purchase orders and get carrier information.
4. New Item Tool: Get instant access to new item data and imagery.
5. Price Lists: View price lists populated with authorized items.
6. Email Alert Tool: Receive automated email reminders that alert customers to exception information on the purchase orders.

In this survey, although most of interviewees were not expected to directly order goods from the manufacturers' websites for their shops, some of them did shopping online for their household goods and trust online shopping. It might assume that the small shops could change their attitude and take advantage of the web ordering system if manufacturers provided them with such opportunity by allowing them to access to the online inventory, and inspired them to come back to the website.

Conclusions Five: *Manufacturing B2B e-commerce is mainly for the existing important customers who have the capability and afford to carry out e-commerce. Small manufacturers use B2C e-commerce to expand new businesses with potential customers as widely as possible; while large manufacturers B2B e-commerce systems are not open to small companies, the use of B2B e-commerce is to maintain relationships with existing important customers so as to benefit each other.*

6.1.6 Inhibitors to the Deployment of Web-Based E-Commerce

Teo et al (2006) reckon that key inhibitors in the implementation of web-based B2B e-commerce are: lack of top management support, unresolved technical issues, lack of e-commerce strategy, and difficulties in cost-benefit assessment of e-commerce investments. These eight case studies suggest that six major factors have a great impact on the implementation of web-based e-commerce for selling products online:

(1) Unaware of benefits of the website

In these eight case studies, Case Two was the only company focus on B2C web-based e-commerce to carry out its majority of transactions, but the online shop was initiated to be just basic for customers' orders and payment. The owner had no knowledge of computer and the web, the company website was designed by a friend, which cost just a small amount of investment. No software was developed to produce sale history analysis, sales report and sales forecast. Information flows into Case Two website such as customer data, the number of visitors every day, which product popularly hit, and what keywords customers used to get to Case Two website, these key marketing data were not collected and analysed. The rest of case companies also did not collect these data. In addition, it was little chance that the Case Two website would appear to potential new customers by browser, even using the keywords, the home page does not pop up straight away. Not like Amazon or eBay making use of the functions of the websites to benefit both buyers and sellers, these eight companies were not familiar with the ways of fully utilising the websites. In some senses, some companies' websites were created to give a description of companies and products rather than to be serviceable and functional for buyers or suppliers. These websites were not integrated with the companies' business activities. Taking Case Eight as an example, its marketing department even managed two private websites for introducing new technologies and promoting products specifically for the existing customers, but there was no a click & buy opportunity for customers via these two sites, the ordering systems were not integrated to these two websites. If customers were interested in one of the new products introduced on the websites, customers then had to use EDI systems to place the order.

The manufacturing industry fosters e-commerce strategy especially B2B e-commerce, but it is less interest than the retail and tourism industries B2C e-commerce to mine web data, use web data strategically, evaluate websites quality, and measure the benefits of websites.

(2) Business strategy

Case Three concentrated on the businesses with the main distributors under the 80/20 principle. The 80/20 rule clarifies that of 80 percent of the total customers and the products are small customers and less profitable products, and the rest of the 20 percent are the key customers and profitable products. If companies spend too much time on the large group of less important customers and products; it could result in the critical customers being ignored. Case Three believed that 80 percent of a company's sales were derived from the 20 percent of its product offering being sold to key customers. Based on this philosophy, Case Three completely relied on major distributors to market the products, used EDI to facilitate efficient collaboration, and provided distributors with full support. If any order query from the individual customer, Case Three would advise the customer to contact his nearest distributor. Case Six was the appointed sales representative for the eight manufacturers, also behalf on these eight manufacturers to provide after sales service, as some manufacturers did not offer after sales service to customers if the customers wanted buy directly from them.

In fact, Case Three products could be sold via a website. Figure 6.2 shows that some of distributors were using e-shops to sell products to individuals.

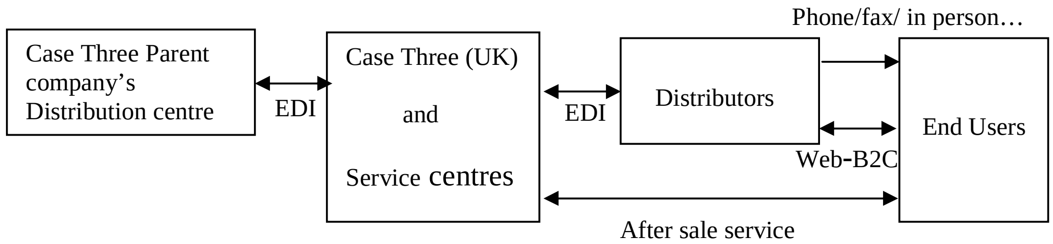

Figure 6.0: Case3 product distribution channels

Through learning of Case Three, the understanding is that whether a company develops web-based B2C e-commerce it will be affected by the company's strategies and the objectives. If a manufacturer has already a few big long-term customers taking up most of the sales, the manufacturer might not consider one-to-many relationships via the open online catalog; or if a manufacturer has built up closer relationships with agents who will add value to customers, the manufacturer might not consider to sell directly to individual end users as that is out of its capability. The research assumes that when manufacturers are satisfied with the existing product distribution channels, they might not be keen to make changes to their supply strategies.

(3) Products characteristics

All products can be presented online, but the nature of characteristics of the products will determine whether B2B web-based e-commerce or B2C e-commerce or both can be implemented, as what the products are decides who the customers are. For the products like airplanes, or those costly engineering machines like Batch Centrifuges etc., these products are not bought by the public, they are specific to the certain companies, these customers always have their own requirements to the products design, and negotiations can not be avoided before an order is made. There is no point to invest in B2C web-based e-commerce.

Case Four was a confectionary factory in which all products made were consumed by the individuals in the end. This characteristic allowed Case Four to run two B2C e-shops for individuals to buy directly from Case Four. Although Case Four had hundreds of products, the company major targeting customers were distributors and retailers, these two B2C e-shops were considered just as the extra to the prime product distribution channels. But compared with other case companies, the nature of the products which can be consumed by the public gives Case Four an opportunity to run B2C online shops. Case Two also proves that the online shop can be the wise preference for those existent or new micro enterprises of lower bargain power they make products with the following three characteristics:

1. *Rare products*
2. *Not expensive*
3. *Light weight*

Case One also advertised its website and products through online directory hold by the third party like Applegate, e4subcon, 1st directory etc., but the company did not shift its website from being a sales brochure to a B2B e-commerce website. One of the reasons as the company explained it is because most wiring harnesses were customized for individual customer's special purpose. The product was not as standard as a tube of toothpaste which could be reproduced million to suit most customers' orders.

Table 5.0 displays the comparison of the value of sales and purchases over the internet among the different manufacturing sectors from 2002 to 2006 (ONS, 2006*).* The figures show that Food, Beverages and Tobacco division was the most active sector in terms of using internet e-commerce than other sectors. It was followed by transport equipment division. In contrast, the most inactive sector was Leather and Leather products manufacturing which did not apply internet e-commerce at all from 2002 to 2006. To some extent, these figures indicate product characteristics have an impact on how willing manufacturers like to adopt the internet e-commerce, and further develop to web-based e-commerce.

Table5.0 Sales/Purchases over the internet, 2002 to 2006 (ONS, 2006)

£bn	*2002*	*2003*	*2004*	*2005*	*2006*
Manufacture of Food products, Beverages and Tobacco	*0.4/0.3*	*0.5/0.7*	*4.3r/1.2*	*8.3r/1.8*	*12.3/3.2*
Manufacture of Textiles and Textile Products	*0.1/-*	*0.1/0.1*	*0.3/0.1*	*0.4/0.1r*	*0.4/0.3*
Manufacture of Leather and Leather Products	*-/-*	*-/-*	*-/-*	*-/-*	*D/-*
Manufacture of Wood and Wood Products	*-/-*	*-/-*	*0.1/0.1*	*0.1/0.1*	*D/0.1*
Manufacture of Pulp, Paper, Paper Products/Printing and Publishing	*0.6/0.3*	*0.7/0.7*	*1.4/1.0*	*2.0/1.0*	*4.6/1.7*
Manufacture of Coke, Refined Petroleum Products, Nuclear Fuel, Chemicals and Chemical Products and Man-made Fibres	*0.4/0.4*	*3.3/0.8*	*5.4r/1.8r*	*4.7r/2.4r*	*6.7/2.3*
Manufacture of Rubber and Plastic Products	*0.2/-*	*02/0.1*	*0.3/0.2*	*0.3/0.3*	*0.7/0.4*
Manufacture of other Non-metallic Mineral Products	*-/-*	*-/0.1*	*0.3/0.1*	*0.2/0.3*	*0.2/0.4*
Manufacture of Basic Metals and Fabricated Metal Products	*0.2/0.2*	*0.2/0.2*	*1.0/0.4*	*0.8r/0.5*	*0.5/0.5*
Manufacture of Machinery and Equipment not elsewhere classified	*0.2/0.2*	*0.4/0.3*	*0.6/1.0*	*2.8r/0.7r*	*2.5/1.1*
Manufacture of Electrical and Optical Equipment	*1.5/0.6*	*2.4/1.1*	*1.1/1.5*	*1.5r/1.8*	*2.1/1.9*
Manufacture of Transport Equipment	*2.5/0.4*	*5.6/0.5*	*8.4/0.7*	*10.6r/1.0r*	*11.5/1.8*
Manufacturing not elsewhere classified	*0.1/-*	*-/0.1*	*0.4/0.3*	*0.6r/0.3*	*0.4/0.2*
Electricity, Gas and Water Supply	*0.7/0.3*	*1.5/1.4*	*3.1/2.0*	*2.7/2.6*	*3.9/3.3*
Construction	*0.1/0.8*	*0.2/1.3*	*0.2/1.8*	*3.4/2.2*	*1.5/2.7*

-: too small to display

r: revised

(4) Product availability

Case Eight Aftermarket initiatively allowed customers to buy online. There were about 9,000 products online, and came to the sales value of $1.2 million online-transaction last year. The fact was not too many existing customers chose online ordering system, once the online catelogs showed no enough stock for the order, customers used to ring in to negotiate the possible early delivery rather than to place orders online and be patient to wait for the orders. If customers requested special services, they always rang in first.

(5) Price sensitivity

Many manufacturers choose not to disclose the price online. Case One, Case Three, Case Four, Case Five, Case Six, Case Seven and Case Eight did not publicly disclose price lists online. According to ONS (2006), it was about 53.5% in 2006 raised from 40.6 % in 2005 of all size non-financial business industries used their websites to provide access to product/services catalogues and price lists.

According to Dignum's research (2002), there are two main reasons why manufacturers' websites do not contain price lists: one is that the services supporting the products are often more important than the price of the product such as timely delivery, logistic services, etc.; the other is that prices may depend on long-term contracts, quantities ordered, and the constraints on delivery. If there is a possibility products can be customized, such as raw materials alternatives, designs modification for more add-ons all these may vary the price, and negotiation is always need before the decision is made, therefore these products' price will not be as transparent as those standardised products. In an interview with an engineering company, the manager explained the company did not display products price online as it was to avoid from the competitors digging out their price, and being price-cutter.

(6) Market competition

When the market is small and the competition is not fierce, the company might focus on the internal improvement. Case Five manufactured high quality gear cutting tools that are special for the automotive, aeronautical and defence industries. The tools required high quality, each product could be long last for ten more years if use properly. The market was small, even though the margin was high, it was not easy for new entrants to enter the market. As the competition was not fierce, Case Five shared 75 percent of the UK market, confronts three major competitors in the European market, one competitor in American market, and two competitors in South American and Japanese market respectively. Case Five ranked its products of top quality and higher price compared with others. Case Five implemented lean manufacturing system to improve the internal processes, but in terms of the utilization of the internet for the direct sale without an agent, it had not been brought up for consideration. Although Case Five had designed the website to be interactive with inquirers, the website was basic with fewer functions and not too visual.

Conclusion Six: *Sales and purchase over the internet are not new to everyone, but the practice has not been experienced by every company. Web-based e-commerce needs to take into consideration many respects that traditional e-commerce does not take into account, such as product characteristics and price sensitivity.*

6.1.7 Deployment of E-Business

Since 1990s, it has become a trend that every manufacturer whatever it is large or small knows they have to have an online presence, at least something on the website is turned-on. More individuals and companies worldwide are linked electronically. E-commerce came to public attentions along with the behaviour of buying and selling over the internet has achieved. But how can the internet deliver more than e-commerce transactions? E-business has exhibited the results. E-business is a broader concept. With the aid of internet capabilities, e-business redefines old business models, integrates all the applications including both front- and back-office applications to efficiently improve overall internal processes and maximize customer value and profits (Kalakota and Robinson, 2001).

E-business is more than e-commerce transactions, in fact, many small and medium enterprises do not think it is necessary to deploy this venture, especially those small businesses while they can handle paperwork manually. As easily purchasing raw materials locally in a short distant by the owner himself, as well as uncomplicated manufacturing facilities, Case Two did not pay attention to the upstream supply chain, and manufacturing management was such simple without any assistant IT systems to make production plan and stock control. By contrast, the major challenge was to spur the downstream supply chain, namely how to make the items more appealing to buyers over the internet to increase sales. In Case Two, the development of e-commerce was much more practical than the implementation of e-business.

Case Five was a starter to deploy Jobshop applications with e-business solutions to link all the functions into one system apart from the design department. By the implementation of this application, information could be shared immediately internally and externally, and transactions could be handled electronically.

The integration of traditional and web-oriented functions is the cornerstone of a successful e-business (Shaw, Ed. 2002). Large enterprises have increasingly extended their enterprise systems to include new features e-business, but they are still on their way. Some large enterprises were the early ones to use legacy systems for decades, but they are moving slowly to e-business. Case Eight had recently implemented Oracle e-business suite 11i in its two overseas factories. One was in USA; the other was in China. In practice, the factory in China still needed a lot of manual data input to the system. The factory in India was currently implementing this e-business suite, and the forth factory was going to implement Oracle 11i was it's headquarter in UK. Most of the case companies updated product catalogs manually. The product catalogs were configured into a CD or a DVD, or printed on a brochure sent by mail; or configured into the spreadsheet or a file sent via email to the customer. The sales representative needed to send the customer regular updates to inform latest product information. Also, the customer manually imports the catalog into their purchasing application.

Conclusion Seven: *Small manufacturers pay more focus on e-commerce to reach out to more customers, while large companies take a further step to e-business in order to take advantage of the internet capabilities and improve overall business activities.*

However, the successful e-business has not been accomplished; especially manufacturers use the web as the infrastructure to coordinate with their supply chain partners that has not been scheduled.

6.1.8 Current IT Capabilities

The mission of Case One was to continuously improve the world class reputation for global delivery of quality products, services and short lead time. From design to delivery, Case One was able to offer 6 weeks leading time, compared with 12-13 weeks pledged by its competitors. The use of advanced IT systems CAD, MRP and EDI helped the attainment of objectives. Case One had used EDI for 17 years, and had become the expert over time. With its purchasing power, Case One also influenced its major suppliers to implement EDI so that orders could be placed and received electronically without having paper documents be mailed back and forth. Through analysing EDI customers' orders history, Case One had improved sales forecasting to avoid products becoming out of stock. By running MRP, production schedule could be made and raw materials could be calculated ahead of time on the basis of sales forecasting. Advanced material requirement for each future period time was sent to the suppliers in advance, which helped the suppliers improve accurate forecasting with clear clues of when Case One needed what and how many materials. Such information-driven guaranteed the suppliers always supplying Case One right materials with right quantities in the right time. The problem was MRP was legacy system which was less flexible to automatically make the production plan for an unexpected order; therefore, the change had to be made manually.

CAD technologies also helps in simplification of design cycle and reducing design time to get products to market faster, as well as the involvement of customers in the initial design stage. VeSys 2D CAD software automates common electrical design tasks, which helps to eliminate manual re-entry, enabled engineers to verify the harnesses. The application fosters collaboration with engineering purchasing and component engineers, and improved overall product quality. Cadds 5i CAD is product development and drafting software, which enables accurate calculation of wire lengths, bundle diameters, and location of splices, connectors and disconnects. However, this

2D CAD system only allowed Case One to receive electronic sketch drawing from those customers who supported the same version of CAD software.

Although these applications had flaws, the use of CAD, MRP and EDI had resulted in Case One working more closely and efficiently with both suppliers and customers. These applications played the important communication role, prompt communication across geographies were achieved, which provided the time-saving capability and paper-less exchange of information. Likewise, by the aid of EDI, Case Three had also improved the delivery availability of the standard next day delivery for free and the express delivery with charges required. All the transactions with the main distributors were through over EDI. The EDI transactions were exchanged via the networks such as virtual private network (VPN), or direct link, which depended on the network by which business partners used. The order flow chart can be simply presented as the following:

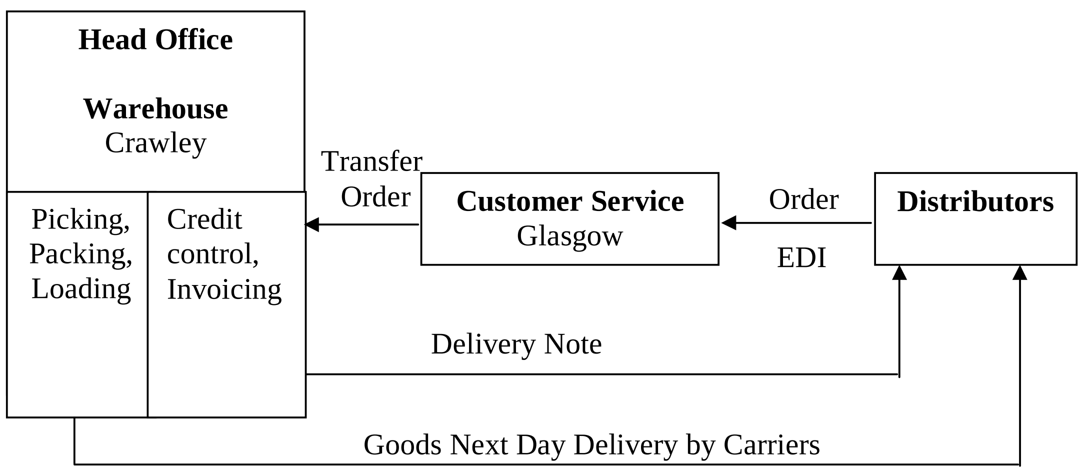

Figure 6.1: Case Three Customer order flow chart

Case Five deployed Distributed Numerical Control (DNC) to enable the central computer directly controlling multiple machine tools in the shop floor. DNC offers real-time displays, process tracking, archiving and other necessary capabilities for the shop floor control. Although DNC application improves the shop floor automated production management, it can not help in delivery of a central database for all departments to share each other.

Case Seven implemented Wonderware industrial SQL server to provide a complete picture of the plant's process and acquire real-time production data. A high-performance real-time and historical database was built up. Through wide area networks (WANs), multiple plants at different locations were connected together, and the office and the factory floor were connected. The solution provided a seamlessly integrated data which was automatically acquired from a wide variety of data sources. Mobile access to production information enhanced the shop floor visibility, as well as the ability to monitor and fine-tune several plants performance in real time. For example, chemists at the UK site were able to monitor the process at China site.

Regarding the integration of IT systems, Case Four and Case Eight had gone ahead in front of other manufacturers. Case Four had deployed IT systems since the 1970s. The SAP-based ERP platform dated back to 1994. Following the business's growth and acquisitions, the IT infrastructure became fragmented as each acquisition kept its own IT systems. The distinct systems worked incompatible. Over recent years, Case Four overhauled the supply chain and supporting IT systems, a five-year IT transformation project had being undertaken to upgrade the IT infrastructure which aimed to integrate purchasing, manufacturing, warehouse, distribution, sales and marketing on a global SAP R/3 system. This would allow all functions of the company to share the same database in the near future. Most major applications such as Getpaid, Bertha/ TXT, VMI, RFID, SKU and EDI were interfaced with SAP R/3 to achieve the synchronization of data, see the figure 6.2.

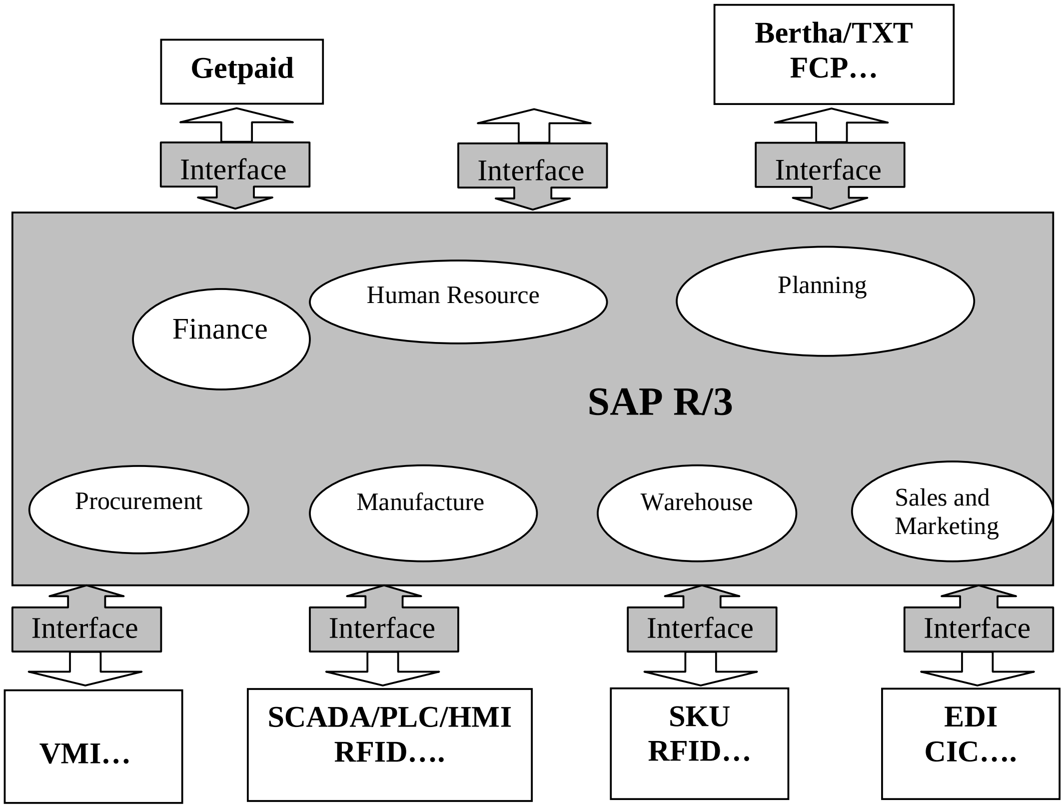

Figure 6.2 Integration of main IT systems

SAP R/3: SAP ERP system was Case Four information backbone which was built as an integrated system to deliver a single and unified database that contained all necessary data for running an enterprise such as manufacturing, supply chain, finance and human resources.

Vendor Managed Inventory (VMI): With the implementation of VMI, British Sugar was authorized to monitor the level of sugar storage at the Case 4 plant via data acquisition software and the Internet. When the sugar went below the reorder point, a signal was raised and sent to the relevant department in British Sugar to remind them to generate a replenishment delivery to Case Four. The use of VMI also improved Case Four's supply chain by streamlining and automating the billing and ordering process and the reliability of delivery. The benefits included eliminating raw materials out of stock situations, reducing inventory, reducing the administration costs for managing and placing orders, and shorter cycle times. In addition, VMI also shifted purchasing responsibility from Case Four to its suppliers.

SCADA/PLC/HMI: The integrated Supervisory Control And Data Acquisition (SCADA)/Programmable Logic Controller (PLC)/Human-Machine Interface (HMI) systems were implemented on the shop floor for process control and process monitoring. This enabled secure round-the-clock operations under the right environmental condition such as temperature and humidity. Data acquisition began at PLC level in a manufacturing line and then transferred data to the central SCADA system. The systems facilitated shop floor automation.

Radio Frequency Identification (RFID): The combination of specific stock keeping units (SKUs) and RFID provided real-time information available at the point of application. After the finishing products had been packed and before they were moved to the warehouse, each package needed to be weighed, and then they would be given a unique SKU and RFID tag which contained the number of units, flavours, colours, cartons and pallets. The information also indicated where the package should be stocked and all other required details. This information was reconciled by the warehouse so that the shop floor and the warehouse shared the same data for the stocked product. RFID and SKU improved inventory management, and also tracked products easily. The use of a handheld barcode and RFID combo readers streamlined the pick process in an orderly, accurate and timely manner, and removed operator error.

Electronic Data Interchange (EDI): 60% of the total sales transactions were done electronically via EDI. The networks used VANs or AS2.

TXT e-solution: This application facilitated the analysis of sales data and helped in determining accurate demand forecasts in real time. The solution was distributed across several European countries and was appropriate for a unique Demand-Driven supply chain.

Most of Case Four products were make-to-stock (MTS), to avoid from out of stock situations or building unnecessary stock levels, Case Four had been struggling with the improvement of forecasting accurately for ages. One of the solutions was toward data integrity and data synchronisation throughout the entire supply chain, with the aid of ICT technologies and the integration of supporting IT systems. On an ongoing basis, Case Four was taking steps to develop several aspects of IT: global data synchronisation network, data quality, EDI environment upgrade, forecasting improvement, finite capacity planning, wireless warehouse management systems, and product allocation ability.

Case Eight had more than 200 different applications software applied to the various work areas. Some of them were disparate systems, data availability was not up to the just in time requirements, as well as data visibility was weak. The backbone was Oracle 10.7. Its module responsibilities included MRP, Order Management, Purchasing and Supply chain, Engineering and Working process. MRP managed materials inventory and materials order planning, scheduled which products needed to be produced using what materials in what quantities at when they were needed. As MRP produced 8 weeks schedule and was inflexible to respond to the change and reschedule, the email system had to be used to send suppliers the purchasing schedule in Excel spreadsheet to avoid the rejection from suppliers’ MRP systems.

As a complex two-tier upstream supply chain with foundries sending castings to machinists, to improve communication among three tiers including 7 parties: Case Eight, three foundries (second tier suppliers) and three machining manufacturers (first tier suppliers), a web-based supply (WeSupply) software was applied to Case Eight and these six major suppliers. WeSupply created an e-network which enabled all trading partners were connected together to manage orders, control and view inventory levels. It was to use the internet to simplify and enhance B2B electronic communication. The solution enabled demand information to automatically communicate daily in a common format between Case Eight and its two tiers suppliers, brought them work closely to improves inventory control with visibility.

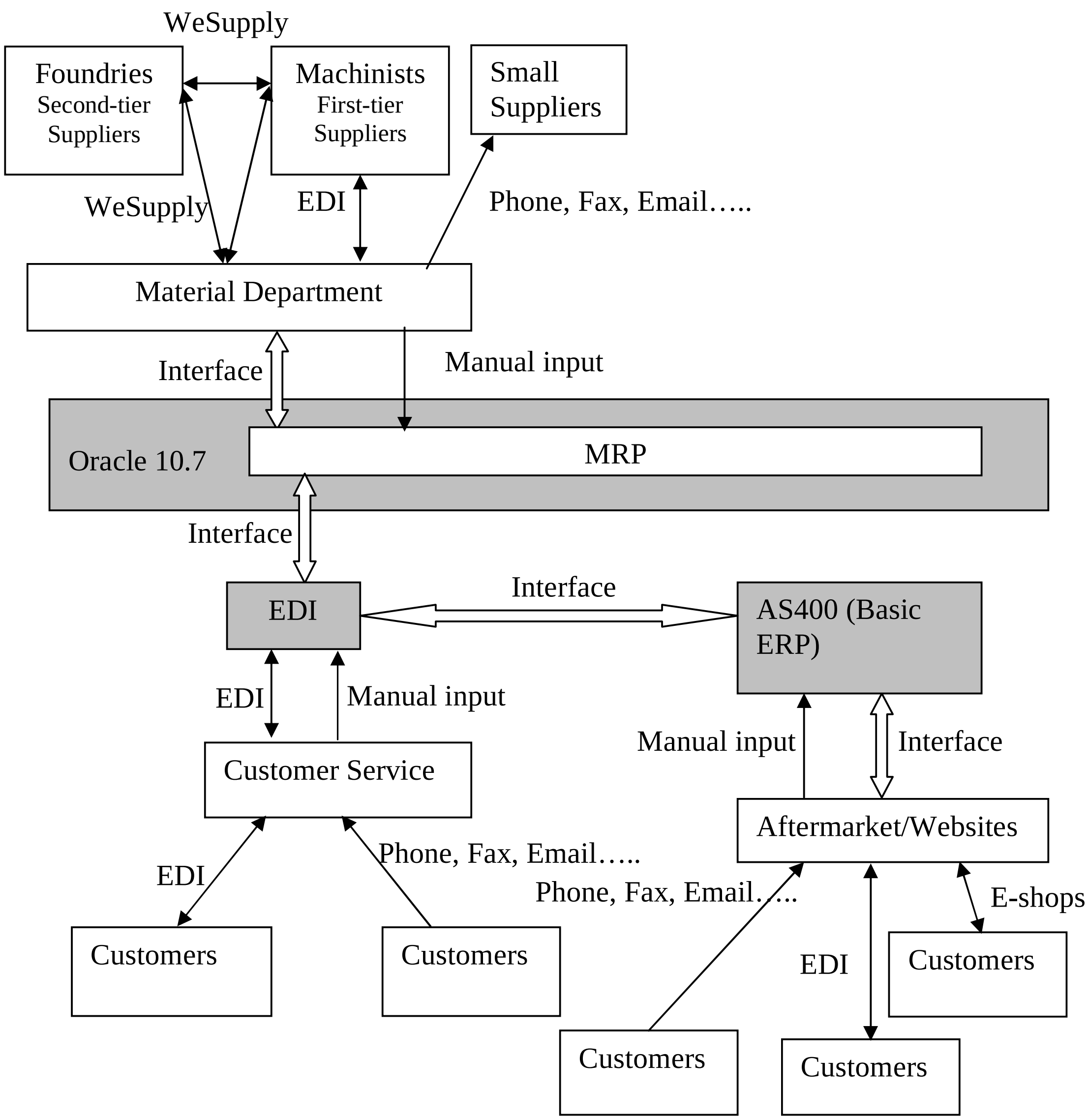

Figure 6.3 Purchases and sales supporting IT systems infrastructure

Conclusion eight: *IT systems have been recognised as being of great profitable to the organisation, and been embedded in support manufacturing daily activities. IT systems have contributed to time saving and cost saving, and the integration of IT systems enhances the agility and efficiency of the supply chain. However, current IT systems are not perfect, they are unable to deliver data integrity and data synchronization over boundaries among all supply chain partners, data manual input and data twice input are common. Web-based access to legacy systems and adding e-commerce/e-business module to ERP are still underdeveloped.*

6.1.9 Make to Order (MTO) and On time delivery

Case One regarded its product quality somewhere in the average level, but laid on shorter lead time and cheaper price being the primary advantages against its competitors by applying IT systems such as MRP and EDI described in the previous section, under Lean manufacturing. The steady demand from the old customers via EDI, Case One met 95% of total products orders. Time-based management Kanban system was applied to the shop floor to limit the amount of inventory in the process. The production Kanban card provided quick and precise information of materials requirement to save time, avoid mistakes and overproduction so as to minimize waste, and control could be maintained.

Case Four ranked its product quality on the top, but delivery performance was second to the top, and customer service was on the third position. Case Four applies MTS, but on time delivery was also not guaranteed, as forecasting was mainly based on sales history, marketing intelligence and customer forecasts. There was no real-time sales data such as point of sale, fed directly from customers. In addition, Case Four manufacturing capability and productivity were not faultless.

Case Five ranked its products of top quality and higher price compared with others. As customers' orders were not always large, and each order might have individual specific requirements, there were around 95 percent of the total orders which were made to order, the rest of 5 percent of the orders were made to stock. Jobbing production was applied to manufacture small amounts or specialised products to fulfil MTO. The implementation of lean manufacturing system improved the product assembly area through using Kanbans on the production line. Kanbans helped fine-tune production and simplified day to day flexibility to back up MTO to be feasible. Compared with products quality, Case Five did not perform very well on delivery. There was not direct communication between Case Five and the end users. Orders were taken by agents, and then passed to Case Five. In addition, Case Five did not provide an efficient channel for the customer to collaborate on a product design. The design drawing was saved in PDF format and sent between Case Five and its customers. Although the PDF file could protect the original drawing, it was difficult for the customer to improve the design diagrams. As a result, delay in manufacturing the product was not surprising.

In 2008**,** Case Eight remained the first place in reliable supply of turbochargers to all customers. Six Sigma programme had been introduced to the company to improve the business processes, which aimed to lower costs and improve quality in all business aspects. In support of six sigma programmes, Case Eight was putting efforts on improving product availability through cutting lead times and improving customer delivers. Indeed, on time delivery was currently a big problem. According to the current statistical data, CTT achieved 47% on time delivery in total. Without considering Aftermarket, CTT had achieved the record of 90% on time delivery to original equipment manufacturers (OEMs). Obviously, the major failure was Case Eight could not cope with unexpected orders from Aftermarket, especially when customers demanded shorter lead time or unstable purchasing quantities. Each department had their views in respects of on time delivery failure. The customers, suppliers and manufacturing, gave the following reasons for the shortcomings:

Customers:

- Require shorter lead times
- Poor forecasting
- Change orders in the last minute

Suppliers:

- Materials quality
- Production capacity
- Suppliers misunderstanding the schedule

Manufacturing:

- Poor forecasting
- Production capacity
- Productivity: machines down time; workers ineffectiveness and absence; materials unavailability; no daily production target

- Production planning: variability; invisibility; no consideration of manufacturing capacity

Improving profitability was regard as the second priority. Case Eight was targeting to beat the sales and volume output every quarter in 2008, and improved gross margin performance. The philosophy of pull systems was adopted; the production was based on customer demand. Productions were only made for orders; materials were just-in-time replenishment and were only moved in the factory when they were needed. Kanbans were used to control inventory levels as well. To be leaner, excessive stock levels were not allowed. When unexpected demand coming, the pull system faced a series of bottlenecks, such as materials unavailability, stock unavailability and manufacturing incapability to produce in a short time and so on.

Figure 6.4 illustrates JIT materials purchasing via Vendor Managed Inventory (VMI). Material department was mainly responsible for material plan and placing orders to suppliers. The department dealt with 72 suppliers to ensure thousands of raw materials and parts could be scheduled accuracy and be available when they were needed under its Kanban system. The biggest supplier provided about 700 kinds of materials and parts, and the second largest supplier provided about 170 kinds of materials and parts. Materials replenishment was based on just in time strategy. Case Eight deployed two kinds of VMI warehouses to control inventory and ensure materials from overseas to be delivered to manufacturing on time. One warehouse was run by the suppliers who also paid for the ship fee, such as American and Indian suppliers. The other was rented by Case Eight to store materials from Chinese suppliers. Inventories were hold in warehouses for 4-6 weeks.

Refer to figure 6.4, Case Eight pulled a materials demand signal to the warehouse every time when manufacturing needed. Once the warehouse inventory level started to fall below the safety stock margin, the warehouse would send the order requirement to the suppliers, and then the suppliers would ship the bulk of materials to top up the warehouse. The amounts of materials shipped would comply with Case Eight's purchasing schedule which was emailed to the supplier by Case Eight.

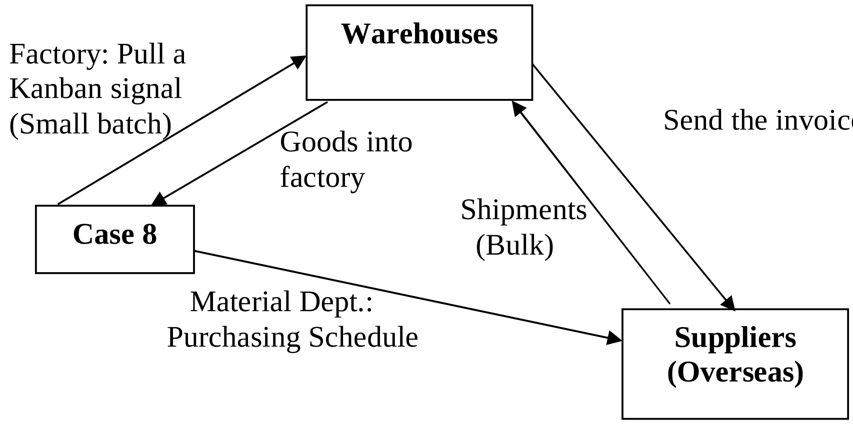

Figure 6.4 VMI material replenishment

Conclusion Nine: *Many manufacturers are using lean techniques (JIT, Kanban, Six Sigma) to reduce inventory levels and cost. This is also achieved by IT applications which have improved communication between the manufacturer and the supplier, as well as the visibility of material inventory. In practice, manufacturers with lean strategy apply MTO might face the difficulty of on time delivery, especially when the order is coming in sudden.*

6.1.10 Efficiency of the supply chain

The final discussion is about how efficient the supply chain is. There are some common deficiencies found in some of the eight case companies' supply chains:

- Manufacturers do not directly interact with end users. Case Four had achieved a target of completing electronic transactions with over half of its big customers through an established EDI system. But the company had no interactive relationships with the second, third tier customers and the end consumers. There was no immediate updated information on new products and offers to the small business. The small retailer used Cash and Carry and the wholesaler to refill the shelf.

- Products flows and information flows were segmental, these resulted in the product cycle time is extended. Customers' orders are via distributors or agents pass to the manufacturer, and finished products from the manufacturer are via distributors or agents to the end users. Case Four had the longer downstream supply chain. The finished products were moved firstly from the factory to the distributors and stored there till the retailers trigger the order, and then the products were moved to the retailers and stored there till finally delivered to end customers. If downstream buyers were not willing to buy, the seller would face the excess storage.

- The shop floor was isolated. Case Eight manufacturing plant was pushed to make the products rather than to be involved into the decision making. The shop floor people did not know what and how much was going to make for tomorrow. Production schedule was released only on the day when products needed to be made. If materials were not available, the schedule would not be released, of course no product would be made.

- IT and Business units communicate ineffectively. Initiatively, there were two objectives set by Case Eight to implement WeSupply: (1) Get the messages to the suppliers quickly; (2) Improve suppliers' on time deliveries. Indeed, problems with materials on time delivery had not been got rid of. Case Eight spent £150,000 on this application, plus £30,000 for the license for two years. The result of the visibility of information sharing had been seen, but the suppliers' delivery performance had not improved vastly.

Conclusion 10: *The current supply chain focuses on closer alignment to immediate business partners. With existing supply chain management, requirements for short cycle time in the distribution channel, total inventories reduced in the chain and duplications of logistics cost removed are not met, even though the information has became visibility to all the parties with the help of the IT technologies.*

6.2 Answers to the Research Questions

This chapter is dedicated to detailed presentation of the findings and analysis of the case study and the survey, and the answers to the research questions.

Questions One: What is the current good practice of e-manufacturing in B2B and B2C?

Answer: The potential functions of the website have not been recognised and maximised by the manufacturer. The large enterprises slowly turn to internet e-commerce. Non-internet e-commerce is still staying stable and dominant, takes up the large portion of the total value of e-commerce. Currently, there is no a good practice guide of e-manufacturing in B2B and B2C.

Question Two: What are the issues associated with the use of e-manufacturing in B2B and B2C?

Answer: The serious issue is UK manufacturers have not been surrounded by e-business environment, the use of the website as a centre element of e-business is very much in its infancy.

Question Three: What are the key factors that affect the internal assimilation and external diffusion of manufacturing information?

Answer: Manufacturers use IT mainly for planning, forecasting, scheduling, and shop floor automation. Existing IT systems are unable to deliver data integrity, transparency and data synchronization over boundaries among all supply chain partners.

Question Four: What competitive success factors are emerging from the use of e-commerce/e-business in other sectors that may be applicable to the manufacturing sector?

Answer: Web-based access to legacy systems and adding e-commerce/e-business module to ERP are suggested.

Question Five: How can manufacturers use e-manufacturing to improve their internal performance for the effective collaboration with the business partners?

Answer: An internet based computational architecture will support the sharing and transferring of knowledge and information along the supply chain, in addition, a collaborative design environment should be formed through interconnecting web-based CAD/CAE/CAM systems

Question Six: How can manufacturers improve their supply chain competitiveness by the implementation of e-manufacturing in B2B and B2C?

Answer: Web-based solutions focus on supply chain management and enterprise resource planning systems, so as to customers and suppliers can linked together into tightly integrated networks where real-time information travels immediately forwards to the downstream supply chain and is driven backwards to the upstream supply chain by demand.

Question Seven: What are the general strategies of the implementation of e-manufacturing in B2B and B2C?

Answer: As high-level of competition among industries, the need of minimizing lead times and cost has been pushing the development of internet-based applications to exchange information in all levels of an organisation and its partners. Improving data process automation, building up agile networks of partners, and developing enterprise wide communication, these are needs to guarantee efficient cooperation between partners throughout the lifecycle stages of the product.

7.0 CHAPTER SEVEN: NOVEL AVENUES to E-MANUFACTURING

By this chapter, you will know:

- *E-manufacturing specification*
- *E-manufacturing modules*
- *Methodology used to transfer traditional factors to e-factors*

The previous Chapter Six brings forward a number of issues related to the currently existing e-manufacturing systems and the factors that impact on the successful implementation of e-manufacturing. On the basis of findings and analyses, this chapter will develop close-up views on the following three aspects that lead to the successful implementation of e-manufacturing: (1) Requirement specification; (2) Modules development; (3) Implementation methodology

7.1 E-manufacturing Specification

Chapter One Introduction has presented the definition of e-manufacturing developed by other researchers. They clearly clarify the two basic elements of the philosophy of e-manufacturing are: Internet and Integration; but then their definition stresses no other than the internet is merely an almighty communication network for timing information sharing along the whole supply chain. This research interpreted the findings from case studies and literature searching, and brought in a clear explanation of e-manufacturing which emphasizes the position of the internet as below:

E-manufacturing *makes the most of the internet to enhance the capability of e-business/e-commerce so as to reform the integration and the agility of the supply chains to build up a multi-user environment. The fulfilment of web technologies creates web surroundings which provide the small company with an opportunity to be involved into the large enterprise's e-commerce systems. The website supports a visual e-marketplace in which updated information is widely available to all users under authority. E-manufacturing provides tactical approaches to enable the* *manufacturer to link up with its supply chain participants and future partners as an entity toward the same objectives.*

E-manufacturing is beyond e-business and supply chain, the above definition intimates the general e-manufacturing specifications as follows:

(1) E-manufacturing integrates all supply chain participants as an entity.

- An entity means all participants work on the same object of adding value to the total supply chain and work together to resolve problems.

- An entity means there is no functional, organisational and geographical boundaries for information sharing. Information is easily accessed; information is timely, transparent, consistent, and widely available to users for their needs.

(2) E-manufacturing improves the global supply chain efficiency and effectiveness:

- With the use of the internet to explore e-commerce to improve the transaction process and give the potential buyer to know more about the manufacturer and its products

- By the use of the e-business to allow the seamless timing sharing of information between different departments, or different companies for better collaboration

- By the use of the web technologies to integrate manufacturing internal activities with external activities into a web-based environment which allows industry collaboration in real-time in all business activities such as negotiating, purchasing, designing, planning, selling and tracking and so on.

(3) E-manufacturing responds quickly to manage the uncertainties involved in the supply chain

- Emphasizing the pull strategy to proceed the agile and customer-driven supply chain

- Seeking the real-time information from customers and data synchronizations to avoid data updated far lags behind change.

7.2 E-manufacturing Model

Web technologies make information flow among any web-connected devices easier, which is desirable for the supply chain partners to share date and collaborate well. Therefore, the thesis introduces the following four web-based models: Manufacturer-Supplier model, Manufacturer-Customer model, Access Single Database model and E-manufacturing Supply Chain model. Manufacturer-Supplier model, Manufacturer-Customer model and Access Single Database model are the side models of E-manufacturing Supply Chain model. Each model has its own peculiar requirements which are briefly explained in the following section.

7.2.1 Web-based Manufacturer- Supplier Model

One of the most popular manufacturing B2B e-commerce is electronic procurement via EDI for automatic purchasing. But EDI is expensive and limited by the fact only certain business partners can afford to implement this system; as a result, e-transactions happen to only a small number of large enterprises. If the manufacturer is to purchase from small and medium trading partners, the manufacturer has to use phone, fax and email to complete the purchasing. In fact, the EDI electronic trading solution is not universal to any size of businesses. To overcome the limitation of EDI, The web-based manufacturer-supplier model (figure 7.0) is suggested, which allows all trading partners to electronically connect each other via the web for e-purchasing, e-invoicing and e-billing programs.

This web-based purchasing model is about building the long term relationship rather than one time off business. The model builds an excellent trading partner network that is appropriate for the high degree of collaborations between the supplier and the manufacturer either in the procurement or in the design stage. This model is based on web technologies to create a dynamic virtual upstream supply chain.

(1) It entitles suppliers to access and remotely monitor the level of stock on the manufacturer's site via the web-based data acquisition software (such as VMI), and generate orders for the manufacturer. The manufacturer does not need to monitor the level of the stock and place the order.

(2) It enables the manufacturer to reach all tier suppliers for easily communication and exchange electronic data so as to speed up materials flows. Through the web-based application software (such as Wesupply), the manufacturer and all tier suppliers can work together to control and view inventory levels across the network. This effects information and physical flows among all tier suppliers and the manufacturer.

(3) It meets the challenges of better design. The supplier, the manufacturer and the customer involved in the design process can now directly exchange information and changes agreed instantly from their desktop computers no matter where they are geographically. The web-based collaborative product development software is easily accessible by all the partners, design problems can be reviewed, and collaboration happens in real time.

(4) It allows the manufacturer and the supplier to track every movement and status of the goods. In conjunction of wide range of sensing techniques, bar code, RFID tagging, RTLS (real time location system) and GPS and GLS (global location systems), everyone can keep trace the product while it is on the move, where the stock is and how the quantity is. And the use of wire free telemetry, data is uploaded to the internet; it enables users to gather data from distant and inaccessible locations, and monitor work any where. This will ensure the right amount of product can be sent to site; therefore the number of inaccurate delivers can be reduced.

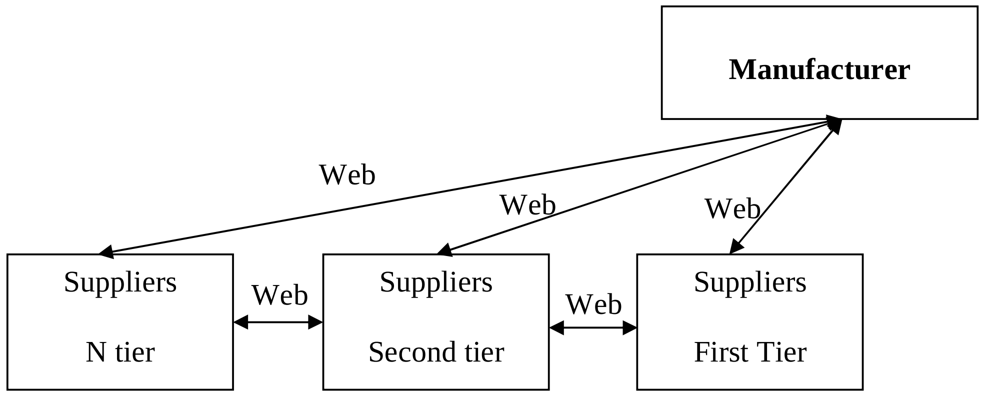

Figure 7.0 Closed web-based manufacturer-supplier model

This web-based manufacturer-supplier model ensures the visibility of the manufacturer's inventory to its suppliers; likewise, the suppliers' inventory is also visibility to the manufacturer and its upper tier suppliers. The good communication will result in the well collaboration of material demand plans between the manufacturer and its upstream trading partners. In addition, it will also remove the need for second guessing and tactical ordering for each party. By utilising web enabled remote monitoring, the manufacturer and the supplier have the flexibility to monitor inventory and goods wherever they are, and data can be viewed easily by all partners. The model will develop very tight partnerships, and form a virtual collaboration in terms of materials planning and current designs.

7.2.2 Web-based Manufacturer-Customer Model

Usually, unlike the wholesalers, the sub-retailers are not the first one to have the information of product promotion and new product directly from the manufacturer. If there is no wasted time in passing the product information to the retailer from the wholesaler, retailers could start to order as soon as the manufacturer released the information. It would shorten the time of finished products moving along the downstream supply chain, as a result, it would significantly improve product time-to-market and new product launch. Figure 7.1 is a web-based facility to help more businesses involve into e-commerce environment so as to speed up physical products flows to the end customers.

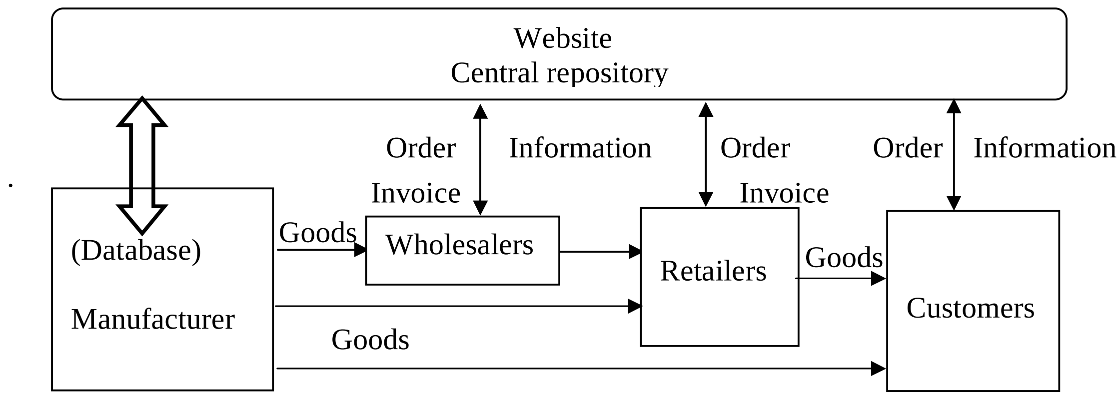

Figure 7.1: Web-based Manufacturer-Customer Model

The aim of this model is to speed up product flows along the downstream supply chain, namely, from the manufacturer to end customers by the fast process of information flows. Via the website, each tier's customers can easily access to the manufacturer's inventory, and negotiate price in their privileges. Orders can be placed by mass customers via the website; customers know immediately the availability status of the orders. On the other hand, the manufacturer also obtains the first hand data of the end consumers; this will improve forecasting and respond to customers much more quickly.

As the current SME's e-business environment is immature, if the manufacturer is going to deploy the web ordering system, it is necessary to integrate web ordering system with the traditional order systems, this will facilitate the project going well and help the small shops develop interests in online transactions over time. In addition, the manufacturer also needs to manage and balance the relationships among the manufacturer, wholesalers, retailers and small shops. If the small shop is involved in the direct sale channels, how is the manufacturer going to handle the relationship with wholesalers? And what responsibilities do wholesalers need to change? Like the figure 7.1, the major role of the wholesaler is to help the manufacturer to add value to customers, provides excellent customer service.

7.2.3 Web Access Single Database Model

This model stresses the point of the integration of the internal activities (planning, inventory management, production control, etc.) and external functional activities (i.e. procurement, production, marketing, logistics, etc.).

The research investigated the integration of web technologies with back-office systems, according to the findings, there was little use of the website for transactions, and little use of the internet for the reconfiguration of internal processes for the agile supply chain. If customers who want to know the progress of orders have to phone the sales representatives to track the orders for them. On the other hand, if a manufacturer has an e-store with shopping carts, credit card authorization, and checkout functionality for online ordering, but the orders taken on this web site has to be printed out and rekeyed into the manufacturer's other IT applications such as EDI or ERP. It causes time wasting and higher administration costs. If the web transaction system is not integrated with these internal applications which support product realisation and logistics process, the customer will not be able to check on the status of their orders from the website. As e-commerce is isolated from the other applications, the development of e-business is stopped at e-commerce stage.

If e-manufacturing is helping the shop floor to know outside world and talk to the rest of the world (Krar and Gill, 2003). The shop floor should be able to receive information of what is happening outside, and transmit real-time manufacturing information and feedbacks to others immediately. This is required to channel seamless information flows to bridge the information sharing gaps between the shop floor and the front office. Figure 7.2 shows some of main applications which support the horizontal integration among the manufacturer, its suppliers and its customers, and those applications which support the manufacturer's all internal process. These applications should interface with the backbone application for automatically feeding data into the single database.

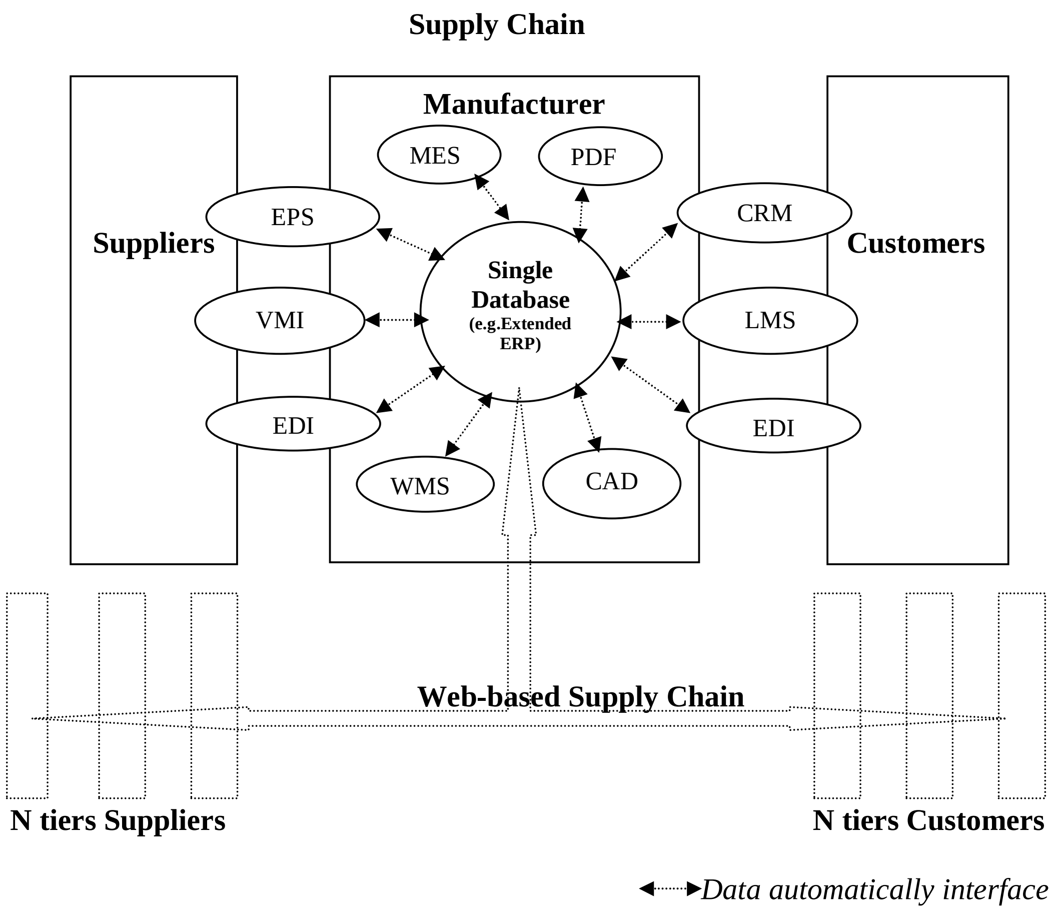

Figure 7.2 Horizontal and vertical IT applications of e-manufacturing

By this model, the shop floor would be kept updating of the amount of real time information such as customer demands, products expected to be made, and the status of materials inventory. With these clear concepts in mind, the shop floor has got the confidence and flexibility to adjust the production schedule to fit any priority or emergency order.

7.2.4 Web-based E-manufacturing Supply Chain Model

This model is the holistic model including the above three models, which emphasizes on data input automatically, data synchronization and distinct IT systems integration to transfer make-to-stock to make-to-order. This ideal model is to improve material flows along the supply chain by the fast moving information flows and automated transaction processes:

1. It allows suppliers to be entitled to access to the manufacturer's inventory and production plan;
2. It allows customers to directly communicate with the manufacturer, autonomously place the order, be aware of the order status and track the order via the website;
3. It provides the manufacturer with real time information and requirements from the supplier and customer

E-manufacturing allows each party to operate its own internal business systems, but all members of the supply chain collaborate as the same organisation. Figure 7.3 displays the difference between e-manufacturing supply chain and non e-manufacturing supply chain. E-manufacturing forms the closed loop of the supply chain, the manufacturer and all tiers of the supplier and all tiers of the customer are connectable and visible to each other. In addition, the manufacturer's suppliers and the customers are also able to collaborate via e-manufacturing networks.

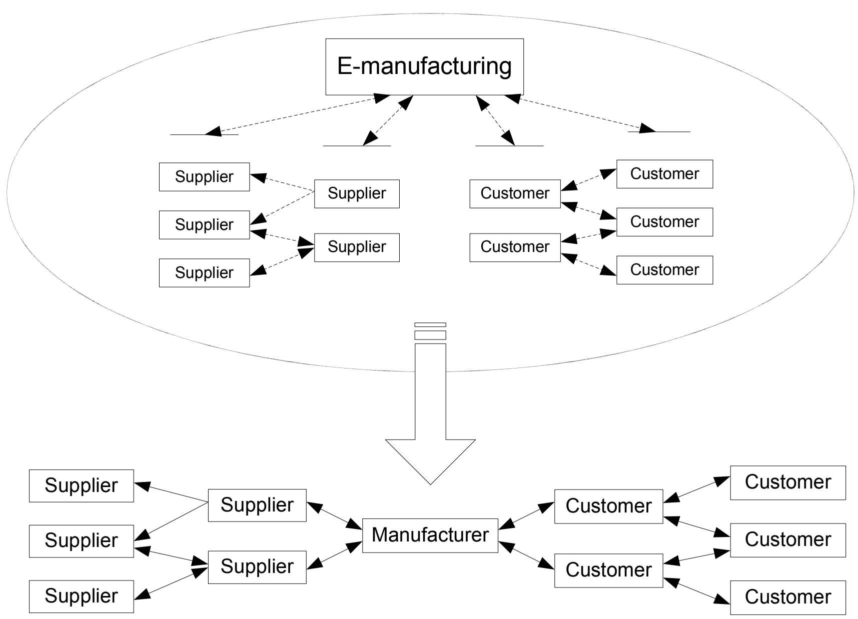

Figure 7.3: E-manufacturing supply chain vs. Non e-manufacturing supply chain

With this e-manufacturing supply chain model, orders can be placed by mass customers via the website, and suppliers monitor the manufacturer's inventory and automatically replenish the materials for the manufacturer. As soon as customers place orders or suppliers deliver the materials to the manufacturer, the manufacturer's central database will be automatically updated so as to all departments will receive timing data, on the other hand, customers are immediately notified on the availability status of the orders. The eight case companies do not apply tools to gather actual point-of-sale data. This model considers driving final customer order fulfilment back into the supply chain, as better synchronization allows the manufacturer to obtain real time demand data so as to the production plan is based on the exact needs rather than the forecasting.

E-manufacturing does not require heavily investment or completely redesigning of supply chains. The model infrastructure is taking into consideration the follow elements:

- How the internet applied to create information sharing networks among the manufacturer and its multiple partners
- How the internet applied to achieve internal and external data consistency (IT and ICT integration)
- How the internet applied to reach a flexible approach to enable manufacturers to engage in activities with the end users

This shifting focus is driven by the adoption of the internet and the web technologies as a new channel for product purchasing, distribution, marketing, and interaction with suppliers and customers. Via the web technologies, it easily creates electronic B2B connections between the manufacturer and its supply chain partners, as the web technology can automatically convert business partners' own systems formats into the manufacturer's own format to avoid data feeding inconsistency and manual process. Information exchange through EDI or the extranet is limited within two close business partners; as a result, it could not avoid from the fact of several information flow gaps along the whole supply chain. Information from the second tier supplier is directly transferred to the first tier supplier, but the information is filtered and selected to be past to the manufacturer by the first tier supplier. In contrast, information transmission through the manufacturer website, information flows are consistent and continual over business and geographical boundaries.

However, the use of the internet and web technologies as the infrastructure not only facilitates the manufacturer to accomplish dynamic virtual supply chains, provides a better means to coordinate with its close supply chain partners, but also it is an effective channel to reach out to the second and N tier suppliers/customers and potential business partners, and then bring forth long-term business partnership.

7.3 Development Methodology

E-manufacturing has lots of to offer, but it depends on the level of the development. From the analysis of the case data and survey results, e-manufacturing developments require a number of distinct phases of evolution.

Stage one: Creating web-based e-business enabled

The first specification of e-manufacturing is to bring all supply chain members together towards the same objective of adding value to the whole supply chain. Therefore, any information related to achieving this objective should be opened to all members and shared each other based on the complete trust. The internet is regarded as the perfect medium for speeding up information sharing; in conjunction with the web technology, many business processes can be automated. The website is important to any company, lays the foundation for e-manufacturing, but simply having a web presence is no longer the advantage over the competitors and to attract visitors compared to the situation of a few years ago (Geest, 2001).

E-manufacturing is to build a web-enabled enterprise of visible e- supply chains. Since the concept of bringing legacy systems onto the internet, most of business activities can be conducted automatically via the web. Given the website should have the basic functions as a physical shop in which customers can view, search, negotiate, buy and pay for products, but also have the functions much more beyond a physical shop can provide, in terms of B2B collaboration, such as design collaboration, and purchasing and ordering automatically, and so on. The development of an almighty website is much more difficult than to set up a physical shop, which needs to consider many factors such as:

- What the attractiveness of the website should be
- How accessible and visible the website should provide
- What business services the website is going to supply
- How rich information the website is going to provide to meet suppliers and customers needs
- How the website provides the incentive required to keep customers buying online on a regular basis
- How the web technology integrates with the internal IT systems for data synchronization and automatic input
- How rapid the website is able to respond to queries

Normally, shoppers like to ask questions and get answers immediately. The personalisation of the website has been proved to be helpful to customers, which includes the functions of the online telephony to allow questioners to have an instant two-way communication with the seller. A good website comprises these four elements: how it looks like; how easily it can be discovered and used by online searchers; what information and services it provides; and how quick it responds to askers. A satisfying website should have the functions described in previous chapter. The company develops the full functional website will gain the business from the customer. B2C e-commerce has been using the website as its centrepiece to impress customers, to attract potential customers and retain old customers. In the long term, the investment on the website will be paid off. In a word, a website not only delivers the kind of information and communication network from it appearance, indeed, it is astonished by the enhancement of relationship networks, especially, through web-based e-commerce, the manufacturer researches out SMEs and provides facilities for SMEs to take part in e-commerce.

Wireless e-commerce as an addition to e-commerce has been around for several years, now voice-based e-commerce is on the way (Bidgoli, 2000). Bevocal (bevocal.com) provides the suite of automated voice and data applications to improve customer self-service interaction. netECHO provided by internetspeech.com allows users to use voice commands to surf any website, search for information, check e-mail and conduct e-commerce by a telephone, not necessarily by a computer. Given audio access, customer satisfactions and loyalty will be largely enhanced.

Stage two: Construct web-based e-business architecture

This research made the further improvement on information flow networks under the strategy of e-manufacturing. Quality of information requires no other than real-time, reliability, consistency, comprehensiveness, and standard. And if information could not be easily read, used, obtained, transferred, retrieved, and exchanged, information would lose its value. The previous section presents web-based models which imply e-manufacturing is information-driven manufacturing developed to support customer-oriented supply chain. The construction of web-based e-business architecture is the second stage to be followed. There are some issues need to be considered: How to utilize of web-based e-business systems to operate supply chain, what technologies should be put in place to support this architecture and what the strategy should be reinforced.

As discussed in Chapter One, manufacturers are facing the common problems of information discontinuance, delay, and invisibility caused by distinct IT system incompatibility, different functions uncooperativeness, and business and geographical boundaries. To minimize these barriers, it should be suggested

- Each firm has a unified database to meet the differing requirements of all users: plant and business information, equipment control, resource planning, production planning and scheduling, and process planning and control are accumulated in the same database. All functional activities involved in the development and delivery of the products and or services should be integrated as well.
- All unified databases of each supply chain member are connected via the network.

- IT and business units need to communicate effectively. If information sharing between the supplier and the material department is perfect, but if the material department is not aware customer orders immediately, or not aware the capability of the shop floor, the performance of on time delivery could not be able to improve.

Web-based e-business system provides the online communication channel in which B2B communication is via their unified databases. This allows business partners to go beyond EDI to look at the manufacturer's inventory and production schedule, to view the actual manufacturing operations via the website. If an order from the internet is not in stock, if there are enough materials to make the order, the system would automatically send the order to the shop floor to arrange the production; if there are not enough materials, it will automatically prompt the purchase order processing system to order the item from the supplier, or directly prompt the supplier if VMI is applied. If the order is in the stock, it will inform the warehouse to departure the goods, also email the customer automatically when the goods have been shipped. See figure 6.4, information can be handled easily, sent and received automatically. Information flows inside the enterprise through the single database to or from the external business partners' databases. Orders processing, confirmation of orders, credit card processing, order and customer tracking, keeping customers informed of special offers or latest company news, all these activities can be automatically done and viewed through the online shared database.

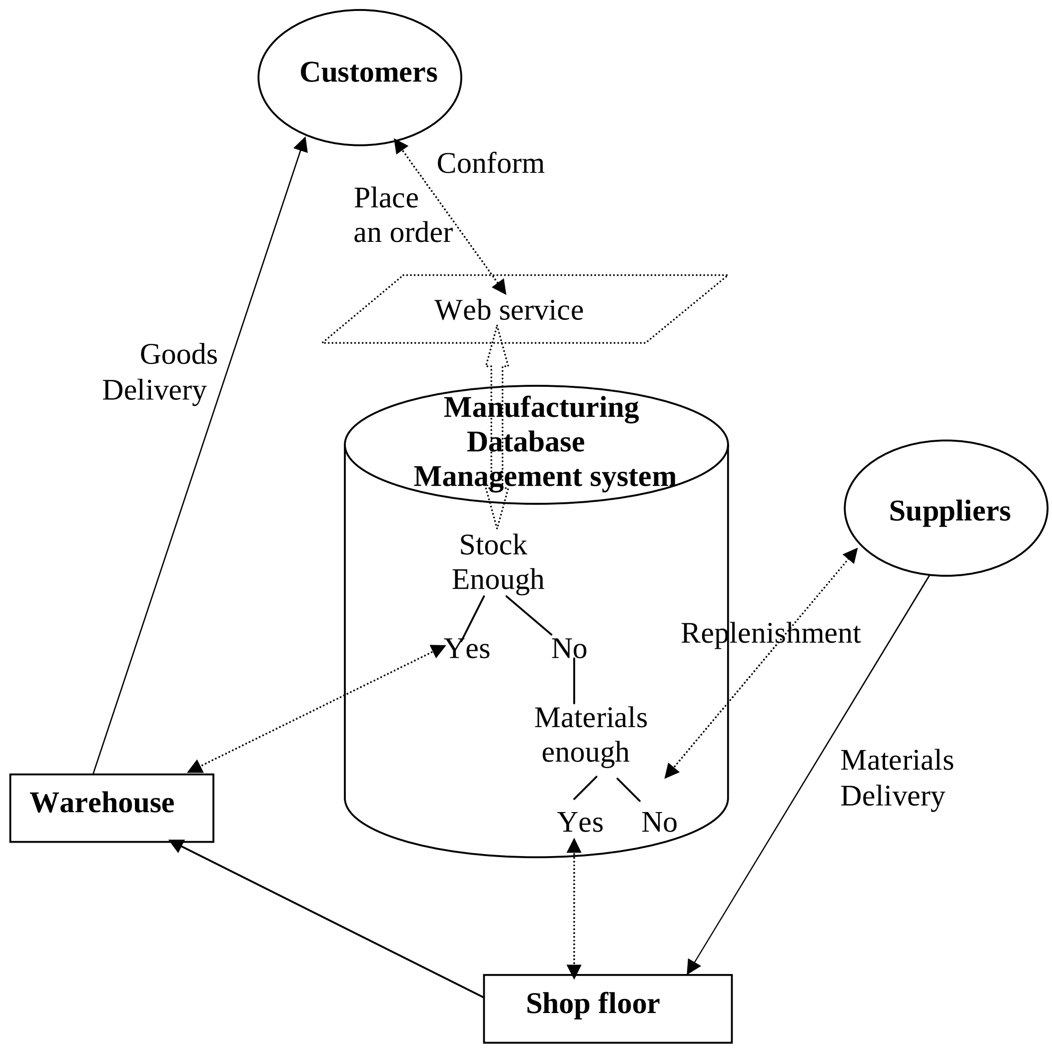

Figure 7.4 Automated decision-making by web-based e-business systems

Stage Three: Performance measurement before and after the implementation

Performance measurement is the critical stage to the successful implementation of e-manufacturing. The right measurement will drive performance. Different company has its distinctive manners for the implementation and establishes its own measures. The objectives of the implementation of e-manufacturing should be set out in advance, as well as performance metrics should be identified clearly. The general goals could be everything that the manufacturer likes to improve, such as customer service, time to market, product development, cost saving, lean and agile and so on. The solutions rely on the established objectives and criterions to be evaluated whether the solutions have been successful. What have been improved, what can be further improved and what have not been improved these queries become clearly.

7.4 Conclusion

This chapter explains the new definition of e-manufacturing, describes the development of e-manufacturing models to ensure the manufacturer to share accurate, standards based enterprise data with multiple trading partners, as well as suggests three principal steps to assure the successful implementation of e-manufacturing.

8.0 CHAPTER EIGHT: CONCLUSION AND RECOMMDATIONS

Chapter Eight Objectives:

- *Whether the research objectives have been met*
- *What this research has contributed to knowledge*
- *What the research limitations are*
- *What recommendations for further research are*

Finally, this thesis comes to the conclusion. This chapter draws the conclusion of the study in terms of the achievement, the contribution, and the limitation. It ends up with the recommendations for the further research.

8.1 Conclusions

This section recalls and summarises the one aim and the three objectives that have been met, and the findings and the contribution to the knowledge.

8.1.1 Meeting Research Objectives

This research moved along the course of the methodology described in Chapter 3. The four objectives outlined in the Chapter One have been met.

Objective 1: To understand current practice in the application of e-manufacturing in B2B and B2C across the supply chain within several sectors of manufacturing industry.

The researcher looked at the adoption of B2B and B2C e-commerce in UK manufacturing industry. The general situation is most manufacturers are not in an e-commerce environment, especially SMEs are still running business in non e-commerce way. The use of the internet for emailing is common, web-based e-commerce for resourcing is usual, but in terms of web-based e-commerce for selling to potential customers has not been such usual as for purchasing used in the manufacturing industry. Aged problems such as short lead time, forecasting accuracy and on time delivery still trouble large enterprises and SMEs.

Objective 2: To identify the issues and barriers to the implementation of e-manufacturing across supply chain.

Objective 1 assists the understanding of the current practice of e-manufacturing based on literature searching and first- hand case studies. Several case companies unfolded the level of the implementation of e-manufacturing in their own organisations. There are three common critical facts stunting the adoption of e-manufacturing:

1. The business strategy affects the implementation of e-manufacturing. Most large manufacturers and many medium manufacturers are interested in dealing with the large wholesales or distributors, the potential massive customers are blocked out from their e-commerce systems.

2. The concept of the integration of the supply chain is well known, but such integration has not been carried out to the core. The relevant applications have helped the purchasing department cooperate well with the supplier, and facilitated the marketing and sales department to improve customer service. But there is lack of integration cross the purchasing department, the shop floor, and the marketing and sales department within the manufacturer’s internal functions. Therefore, information is not always real time and reaches the right people directly; as a result, the performance could not have been improved.

3. The board-level executives do not understand the benefits and functions of web technologies; as a result, there is no sufficient interest in using the internet to improve business processes.

Objective three: To identify likely future trends in the application of e-manufacturing.

Objective 2 has identified the current information systems architecture is not an overall design which can assort with e-manufacturing. The importance of IT systems integrity is recognized, in practice, some of applications lack of end-to-end integration. In addition, the existing architecture does not encourage small and medium enterprises to take part in e-commerce. To become the overall integration, IT integrity should also associates with business function integrity. Internet trends are leading to the need for more collaboration in planning, scheduling, designs, purchasing and selling. As MTO strategies require no product is made and shipped until an order is triggered, as a result, there are no finished goods or manufacturing inventory, all customer orders might not be fulfilled to meet their satisfaction in terms of stock and delivery time. The research then focused on the investigations of internet technologies and how to reconfigure IT systems to diminish the pull system's inherent problem: Lean conflicts against the delivery time.

Objective four: To develop web-based communicative information channel models to facilitate the successful implementation of e-manufacturing

In the Chapter Seven, several web-based models for e-manufacturing were introduced. These models facilitate web-based e-business in which buying and selling experience can be achieved online. In these models all the information for closing a bargain is visible and available online to the interested buyer and the seller, and the relevant business activities can be also achieved online.

8.1.2 Summary of Findings

In summary, the body of the research findings is as follow:

Finding 1: The website has been accepted popularly by the most of UK companies. It has been regarded as the necessary element of the contemporary business, at least is for the sake of having one.

Finding 2: The purposes of the use of the website are mainly for diffusing information, or providing better customer services or carrying out e-commerce.

Finding 3: The potential benefits of the website have not been recognised and maximised by manufacturers, especially web-based e-business has not been the centrepiece of the business.

Finding 4: The use of internet e-commerce continues growing in UK manufacturing industry to win an advantage, especially for purchasing, it has more dramatic growth rates than others; but non-internet e-commerce is still staying stable and dominant, takes up the large portion of the total value of e-commerce. Large enterprises slowly turn to internet e-commerce while many small and medium enterprises are increasing to use internet e-commerce for sales and purchases.

Finding 5: Manufacturing B2B e-commerce is mainly for the existing important customers who have the capability and afford to carry out e-commerce. Small manufacturers use B2C e-commerce to expand new businesses with potential customers as widely as possible; while large manufacturers B2B e-commerce systems are not open to small companies, the use of B2B e-commerce is to maintain relationships with existing important customers so as to benefit each other.

Finding 6: Sales and purchase over the internet are not new to everyone, but the practice has not been experienced by every company. Web-based e-commerce needs to take into consideration many respects that traditional e-commerce does not take into account, such as product characteristics, price sensitivity and so on.

Finding 7: Small manufacturers pay more focus on e-commerce to reach out to more customers, while large companies move further step to e-business to take advantage of the internet capabilities to improve overall business activities. However, the successful e-business has not been accomplished; especially manufacturers who use the web as the infrastructure to coordinate with their supply chain partners that has not been achieved.

Finding 8: IT systems have been recognised as being of great profitable to the organisation, and been embedded in support manufacturing daily activities. IT systems have contributed to time saving and cost saving, and the integration of IT systems enhances the agility and efficiency of the supply chain. However, current IT systems are not perfect, they are unable to deliver data integrity and data synchronization over boundaries among all supply chain partners, data manual input and data twice input are common. Web-based access to legacy systems and adding e-commerce/e-business module to ERP are still underdeveloped.

Finding 9: Many manufacturers are using lean techniques (JIT, Kanban, Six Sigma) to reduce inventory levels and cost. This is also achieved by IT applications which have improved communication between the manufacturer and the supplier as well as the visibility of material inventory. In practice, manufacturers with lean strategy apply MTO might face the difficulty of on time delivery, especially when the order is at short notice.

Finding 10: The current supply chain focuses on closer alignment to immediate business partners. With existing supply chain management, requirements for short cycle time in the distribution channel, total inventories reduced in the chain and duplications of logistics cost removed are not met, even though the information has became visibility to all the parties with the help of the IT technologies.

8.1.3 Contributions to Knowledge

Based on the literature and the results of the research, the study demonstrates the main findings and achieves the objectives that prove significant contributions as follow:

Firstly, this study presents the pioneering research on web-based e-manufacturing, supplements the existing literature on the implementation of e-manufacturing. E-manufacturing has become a popular research title, but there is lack of detailed explanation of e-manufacturing on literature. As a result, manufacturers who deployed applications of e-commerce or e-business, they recognised themselves as completely being of e-manufacturing. This thesis provides the definition contributes to a clear and depth understanding of e-manufacturing which emphasises the importance of the internet to bring all supply chain participants to work together as an entity. And the specifications give a detailed view of the implementation of e-manufacturing.

Secondly, the analysis of the results of the case study and the survey produced detailed description, identified and defined the problems. Evidence from the study raised the issues, and the analysis contributes directly to the understandings of phenomena as well as to the development of theories and strategies. The survey raised a salient point of SMEs attitude to the adoption of e-commerce.

Thirdly, Chapter Seven provides the conceptual models that will help manufacturers to design an overall web-based system for the pull system; these models also help the software company develop the advanced applications. These models not just facilitate the transaction online, but also provide the opportunity to reach the potential customer and the potential supplier, and the most significant contribution is the real integration of cross-functions and cross- enterprises.

8.2 Recommendations for Further Research

8.2.1 Research Limitations

This research has applied the necessary techniques of the case study and the survey to ensure the reliable research results. However, there are some limitations need to be discussed here.

1.0 Most of the case companies using single respondent

The interviews were targeted to the senior managers and the data collation was from one respondent in most of these case companies. To diminish bias caused by relying on only one interviewee, Case 4 and Case 8 were exceptions. The researcher spent a period of time in these two companies so that cross-validating responses from more than one informant from different functions were met.

2.0 Not all influencing factors under discussion

The study examined only a few of variables that impact e-manufacturing implementation. Several other factors, such as security, finance, company structure, and complexity of processes, also influence implementation of e-manufacturing, but these factors were not considered in this research. In terms of the integration of the supply chain, this research focused on the relationships among the supplier, the manufacturer, the distributor and the customer, in contrast, the cooperation with transportation corporate was given less attention.

3.0 State-of-the-art internet technologies not be introduced in details

The achievement of e-manufacturing highly relies on state-of-the-art internet technologies. As numerous web-based applications software exists and more and more new applications are coming out, this research did not spare the space to describe all of them.

Despite the above limitations, this research provides a rich picture of the e-manufacturing practices across many companies.

8.2.2 Recommendations for Further Research

To mitigate the possible bias, future research might consider collecting data from more than one respondent per firm so as to compare the perceptions of different people in the same company. The further work could investigate more different sectors of manufacturers and distributors/agents to grow healthy web-based e-commerce environment.

This research develops the general modules and strategies for the implementation of e-manufacturing. The further work should focus on the latest web-based applications since innovation in software will bring solutions to new challenges. The software development needs to illustrate how these technologies function, and investigate whether these technologies have matched new challenges and whether they deliver the initial promises.

With respect to the impact of context on the implementation of e-manufacturing, the further study should also consider other measures such as business strategies and manufacturing systems.

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APPENDIX

Appendix 1.0: E-manufacturing Questionnaire

Please complete this questionnaire by using your mouse left button to place a cross in the appropriate box, if you want to change the answer, click on it again.

Your Name:

Position:

Telephone:

Email address:

E-manufacturing concerns the use of the internet and e-business technologies by manufacturing industries to improve all aspects of performance. This survey aims to investigate how e-manufacturing is currently implemented and what should be improved.

It should only take around 5-10 minutes to complete this questionnaire.

Company Name: Website:
Industrial Sector: Main Products/Services:
Please cross your latest annual turnover (£) m=million: ☐ *Less 1.4m* ☐*1.4m-6.99m* ☐ *7m- 34.99m* ☐ *More than 35m, please specify:______*
Number of Employees: ☐*10 or less* ☐*11- 49* ☐*50-249* ☐ *More than 250*

The questions below may be provided with multiple answers, please click all that apply.

1. Are your main products rare or are they relatively commonplace?

Please click a number with 1 being rare and 5 very commonplace ☐*1* ☐*2* ☐*3* ☐*4* ☐*5*

2. What is your product process choice?

☐*Project* ☐ *Jobbing* ☐*Batch* ☐*Line* ☐ *Continuous*

3. Please indicate the percentage usage of the following process strategies:

☐*Make to stock (   )%* ☐*Assemble to order (   )%* ☐ *Make to order (   )%*

☐*Engineer to order (   )%* ☐ *Others (   )%*

4. Please give the unit price range of your products (in pounds)?

From £__   __________to £____   _______

5. How would you describe the marketing demand for your main products?

☐*Steady demand* ☐*Variable demand* ☐*Seasonal demand*

☐*Falling demand* ☐ *Growing demand*

6. Please tick the approximate number of your shippable end items.

☐*1-10* ☐ *11-25* ☐*26-50* ☐*51-100* ☐*Over 100, please specify:*

7. On which of the following channels of distribution you are relying

Channels of distribution:	Approximate percentage of the total sales	Do resellers add value to your products? Yes/NO	How do the customers place their orders? By Email, Phone, Fax, Post, EDI, Website or Others
Direct sales to individual consumers			
Organised markets			
Distributors			
Retailers			
Agents			
Franchising			
Others(please specify):			

8. Please tick the approximate number of raw materials.

☐*1-10* ☐ *11-25* ☐*26-50* ☐*51-100* ☐ *Over 100*

9. Is your strategy for most materials purchasing:

☐*Just-in-time* ☐*Seasonal storage* ☐ *Make to stock Storage*

☐*Others please specify:*

10. How do you order materials from suppliers?

☐ Phone ☐Post ☐Fax ☐Email ☐ Website ☐EDI ☐ Others, please specify:

11. What is your perceived ranking against competitors with respect to the following factors? 1 is low, 5 is high.

Description	1	2	3	4	5
Product Quality	☐	☐	☐	☐	☐
Product Cost	☐	☐	☐	☐	☐
Delivery Performance	☐	☐	☐	☐	☐
Rate of New Product Introduction	☐	☐	☐	☐	☐
Use of IT	☐	☐	☐	☐	☐
Customer Service	☐	☐	☐	☐	☐
Position among your competitors in the market share	☐	☐	☐	☐	☐

Information and Communications Technology (ICT) is the fusion of computers and telecommunications. With a communications channel, such as the Internet or other information services, ICT has enabled individuals and organisations to access data anytime and anywhere, and brought innovations in products design, operation processes and even organisational structures.

12. Please specify what ICT application software has been applied to your company?

13.Who is allowed to selectively access to your database over the extranet?

☐ *None* ☐ *Customers* ☐*Suppliers* ☐ *Branches* ☐*Partners* ☐*Transportation*

☐ *Others, please specify:*

14. Your website is designed for:

☐*Business-to-Business (B2B)* ☐*Business-to-Customer (B2C)*

☐*B2B and B2C* ☐*Informational* ☐*Interactive*

15. Does your website disclose the products' price? ☐Yes ☐No

16. If not, please explain the reasons:

17. If you do not sell the products directly to the end users through the internet, why not? Please state:

18. How satisfied are you with your current IT systems? *Please click a number with 1 being lowest and 5 being the highest* ☐*1* ☐*2* ☐*3* ☐*4* ☐*5*

19. What is the level of integration of all application software so as to the only one database to be accessed? *1 being non-integration and 5 being the highest degree:*

☐*1* ☐ *2* ☐*3* ☐*4* ☐*5*

20. What applications have been integrated? Such as: EDI +MRP, or ERP +CRM.......

Please state here:

21. The integration of the shop floor with the top floor is traditionally considered the weakest link in the enterprise. Are you facing the same problem?

☐ *Yes， please specify:*

☐ *No*, What are your solutions?

22. Supply chain management efficiently integrates suppliers, manufacturers and customers together to deliver flow co-ordination. Do you think your supply chain needs to be improved?

☐ *Please specify the problems with suppliers:*

What application software has been used to cooperate with the suppliers?

☐ *Please specify the problems inside the factory:*

What application software has been used to improve internal communication?

☐ *Please specify the problems with customers:*

What application software has been used to be able to close to customers?

23. Please cross all of the following ways in which you use the internet:

Do you use the internet for	☐Yes	If you are unsatisfied with the performance, please specify
Email	☐	
Internal communications	☐	
Post product schedules	☐	
Inventory information	☐	
Speed up product process	☐	
The integration of shop floor with the top floor	☐	
Data sharing with business partners	☐	
Marketing/ advertising	☐	
Generating direct sales	☐	
Providing customer service/support	☐	
Electronic banking	☐	
Billing, invoicing	☐	
Purchasing, ordering	☐	
Improving customer relationships	☐	
Improving supplier relationships	☐	
Integration with IT application software like e-EDI, e-ERP, e-CRM	☐	

Appendix 2.0: What do you think is the best way to place an order?

Shop name: ______________________________

Your name: ____________________ Your Position: ____________________

Contact Number: ____________________ Email: ____________________

1. What brands of confectionary products and beverage do you sell? If you do not sell Cadbury’s products, please indicate why?

2. Why do you choose these products?

3. Which brand is the most popular in Sweet, Gum, Chocolate, and food drink?

4. Do you directly order from manufacturers? If yes, please going to question 6.

5, If not, what are your purchasing channels?

6. If yes, in which aspects you think the manufacturer needs to be improved in terms of products and customer services? In which aspects the manufacturer has done well?

7. Where do you get the information when the manufacturers are running the promotion?

8. Would you find an update / alert by e-mail useful?

9. How do you place an order? By phone, fax, email…..

10. Which is the best way? Why?

11. Do you have any communication problems with your suppliers?

12. Are you satisfied with your suppliers? If not, please explain.

13. Do you have access to the internet?

14. How well can you use the internet, please rank between 1 and 5? (5 being the highest)

1 2 3 4 5

15. Do you used to buy things for yourself or your family from the internet?

16. Are you expecting to directly order goods for your shop via the manufacturers' website?

17. What information would you like to see on the internet page?

18. What extra information would be helpful to know in order to make a decision about and order?

19. What would you like to suggest the website should look like?