CIM Implementation in Developed and Developing Countries

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Master of Engineering

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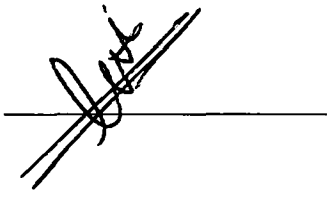
Declaration

I hereby certify that this material, which I now submit for assessment on the programme of study leading to the award of Master degree, is entirely my own work and has not been taken from the work of others save and to extent that such work has been cited and acknowledged within the text of my work

Signed  ID No 53128141

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Abstract

CIM Implementation in Developed and Developing Countries

Khaled A Saeed

Implementing integrated advanced technologies is an effective approach towards solving most problems in today's competitive global market Computer Integrated Manufacturing (CIM) technologies are presented as a solution to manufacturing organisations which need to perform well

This research describes the major issues and problems facing developing countries that wish to implement CIM In this investigation, Libya is taken as an example of a developing country, while Ireland is used as a model of a more developed country, which has already implemented components of the CIM technology in some of its industrial companies This research demonstrates the effect of CIM technology on Irish industry by investigating the cost effectiveness of implementing CIM, reduction of the production time, reduction of the product cost and management efficiency

To carry out this study, 267 questionnaires were distributed to manufacturing companies in Ireland in order to help establish the status of CIM within manufacturing companies, to study the effect of CIM on Irish industries To study CIM in Libyan industries, four Libyan companies were investigated to assess the CIM level in their companies and the possibility of implementing CIM technology m Libyan companies as a developing country
The main findings of this research are that successful implementation of CIM depends on sufficient initial and continued investment from within the country and outside Furthermore, in order to implement CIM successfully it is vital that there is sufficient expertise and trained workers

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Chapter: 1 Introduction

1.1 Background

Due to rapid developments both in new technologies and new production management techniques the industrial environment is changing and the pace of change is accelerating (1) Resources, markets, manufacturing processes and product strategies are also significantly changing Increasing international competition means that only the most productive and cost–effective industries will survive (2) Globalisation has increased opportunities for across border trade, and higher standards of living in a world where technology has become the driving force behind the structure of domestic production

This vital power, however, resides in the productive enterprises, and is derived from their ability to introduce technological innovation continuously Enterprises introduce technological innovation through acquisition (technology transfer) or self-generation (technology development) to enhance their market competitiveness Thus, proper management of technological change, particularly at the productive enterprise level, has become the most important consideration for development (3)

Computer Integrated Manufacturing (CIM) is a management and manufacturing strategy which entails the integration of design, engineering, manufacturing, logistics, warehousing and distribution, customers and suppliers, sales and marketing activities, financial management and the overall control of the enterprise (4)

"CIM stands as innovative application for yesterday's proposals and the newer application required today and for the future" (5)

Nagalingam and Lin (5) point out that researchers working two decades earlier had already stated that the future of engineering was unavoidably linked with the application of computer integrated technology They explain that implementing integrated advanced technologies provides opportunities to achieve competitive advantage, which is financially viable in an intermediate to long-term time frame, making it an effective approach towards solving the problems of decreased productivity relative to labour costs and consequent rise in unit costs, which are continually plaguing present day manufacturing managers Indeed, any changes in the technology have an effect on products, employees and organisational structure and the relationships between them, as shown in Figure 1 1

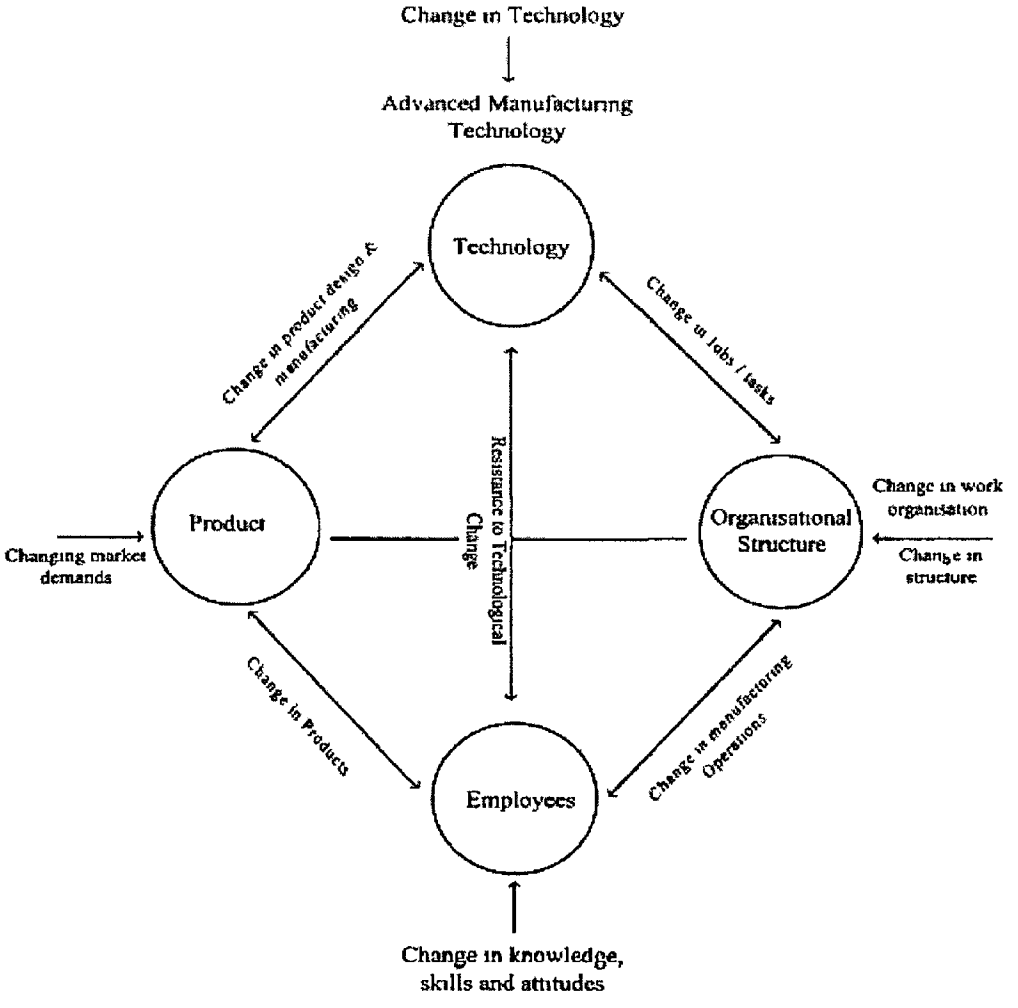

Figure 1 1 Conceptual Framework of Technological Change and Posited Relationship (6)

Recent years have been an exciting and fascinating time to be involved with manufacturing because so much has happened Computer Integrated Manufacturing (CIM) is the latest development in technology but alongside CIM are terms such as agile manufacturing and world class manufacturing (7)

Companies that are already using CIM have reported general benefits of faster purchasing processes, reduced business cycles, higher inventory turnovers, faster response times and overall improved service

An American electronic company, for example, saw its manufacturing cycle times reduced from several days to no more than a few hours, while its quality improved dramatically (8) Other important benefits of CIM are improved productivity, lower product cost, increased product quality, and a reduced inventory (9)

Despite the importance given to CIM, it is still something of a manufacturing mystery due to the continued disagreement about what CIM is, and more importantly, what is not (4) The conflicting and competitive demands of today's market have led to recent research trends focusing on the application of CIM in manufacturing Many variations in manufacturing methodologies were developed and proposed by researchers to revitalise manufacturing industries Therefore, today research into CIM is conducted with increased vigour to meet the requirements of industry with the latest facilities and tools available in the market and to reduce the mismatch In addition, the trend in CIM research is moving towards finding new ways and tools to turn the futuristic factory into a reality (5)

Because CIM is not yet fully defined and because it includes many layers of technology, manufacturers must understand both the potential gains and

possible consequences before implementing a CIM system The purpose of this research is to explore the major issues and problem areas facing developing countries that wish to implement a new technology such as CIM in their companies Libya is used as an example of such a country This research also discusses the benefits to the Libyan manufacturing industry, which could be achieved by using Computer Integrated Manufacturing For this purpose, the level of CIM use in manufacturing in Ireland was used as a model

1.2 Aims of Research

The primary aim of this research is to estimate the benefits gained from the successful implementation of the components of Computer Integrated Manufacturing (CIM) system in some companies in Ireland and demonstrate the importance of these benefits to overcome problems faced by industries today This research also aims to review the evidence of CIM effectiveness and efficiency in helping industry to survive in today's competitive global market This research explores the possibility of encouraging developing countries' industries (for example Libyan industries) to start investing in and implementing CIM A further aim is to explore the barriers and obstacles to implementing CIM both in Ireland and Libya

1.3 Research Objectives

The research has been broken into three main objectives

1 To conduct a literature review on The CIM system and establish the rationale behind CIM, the components of a CIM system, it's benefits and a critique of the CIM system

2 To distribute questionnaires to manufacturing companies in Ireland to establish the status of CIM within manufacturing companies

3 To conducting interviews with some manufacturing professionals in a sample of Libyan companies to explore why they do not currently use CIM and the possibility of implementing CIM in the future

4 Assess information collected to form a set of recommendations that may contribute to improving the status of the utilisation of CIM in the Libyan industry and increase it's use in Ireland

1.4 Thesis Structure

The structure of this thesis reflects defined steps in the research process The literature review presented in Chapter 2 was essential to collect the background information on CIM in Ireland and Libya From that point it was important to collate some primary research It was decided that the most appropriate way to do this was through a questionnaire distribution m Ireland and structured interviews conducted in Libya This is detailed in Chapter 3 The analyses of the data from both the questionnaire and the interviews were addressed in Chapter 4 The results of the data analysis were discussed in Chapter 5 A number of recommendations were generated from this research These recommendations are detailed in Chapter 6

Chapter: 2 Literature review

2.1 Overview of Manufacturing

It is important to analyse the significance of manufacturing and it's different components before starting to analyse the CIM system This chapter will discuss the varying aspects of manufacturing and their relationship to the CIM system including manufacturing systems, major manufacturing functions, the manufacturing cycle, computers in manufacturing, historical developments in advanced manufacturing technology and automation in manufacturing

2 1 1 Introduction

"Manufacturing is a production business that is intended to make a profit" (9)

The main aim of any manufacturing business is to convert raw materials into quality goods that have value in the marketplace A manufacturing system is used to combine resources such as capital, human labour, materials, equipment, and energy in order to produce goods that can be sold at competitive prices (9) Figure 2 1 shows the inputs and outputs of a manufacturing system However, for Ghosh (10) in today's context manufacturing is more than just production, it includes product development and design, production planning and engineering, quality issues, materials handling, tooling and maintenance, and processes and operations These disciplines, which relate people, hardware and systems to the business/market criteria, define the overall manufacturing strategy in any company

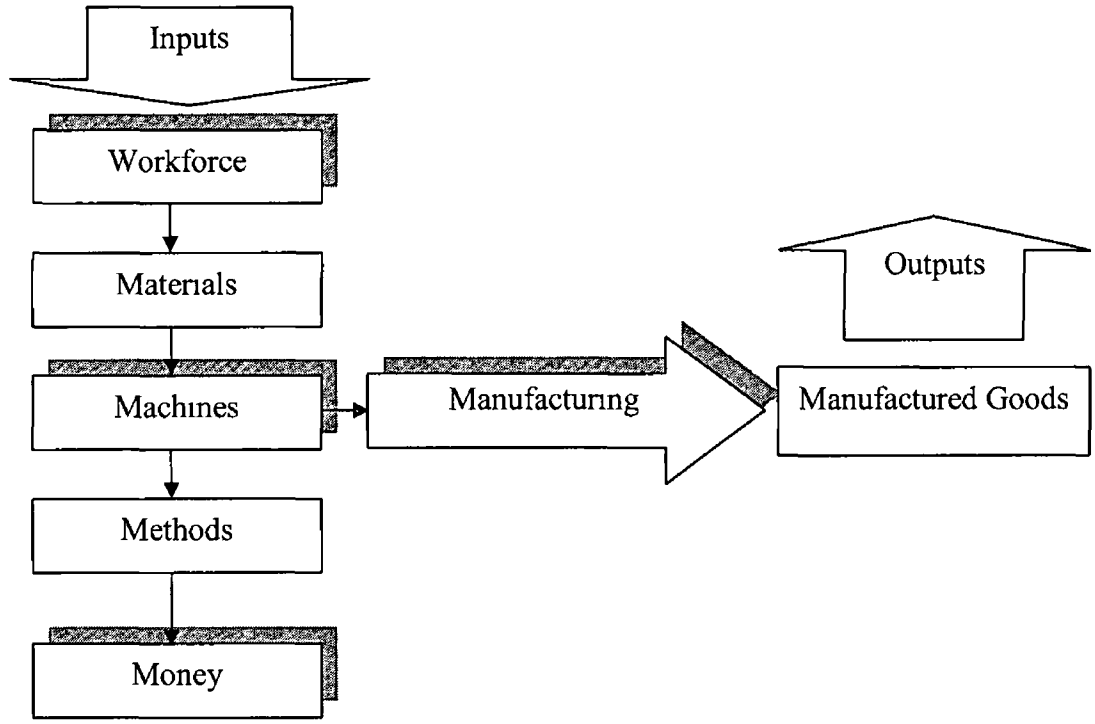

Figure 2 1 Manufacturing Systems

In recent years the scope of manufacturing has changed, at the same time the global market for manufacturers has altered and has become more and more competitive According to Ghattas and McKee (11), the world today is quite different from the world of 50, 20, or even 10 years ago New products appear on the market every day and are replaced by even newer models faster than we can purchase the older ones It is very difficult for enterprises to continue with their traditional functions in such competitive environments Therefore, manufacturing enterprises have had to improve the efficiency of their systems to try to produce higher quality products more economically and thereby become more competitive in world markets Figure 2 2 shows recent changes affecting present market conditions

Figure 2.2: Present Market Condition (5)

CIM technology is considered, by some, to be a conceptual approach to helping manufacturing organisations optimise the way in which they function in order to achieve the best possible performance within necessary constraints and respond to the difficult environment in which they operate (2). For today's manufacturers the key notions are: technical innovation (new product development and factory automation), market-oriented production (multi-product, small-batch production and product diversification) and global manufacturing (international production and multinational corporation). Computer Integrated Manufacturing (CIM) systems are realisation of the necessity of integrating theses basic manufacturing issues together as a manufacturing strategy (12).

Because of the global competition, which exists today, not only from Japan and Europe but also from low cost labour countries such as China, manufacturing managers must implement innovative and advanced technologies (13). As far

back as 1990 Sackett and Heslop (14) highlighted that an organisation must be able to positively embrace these advances if it is to remain competitive More recently, Masood and Khan (13) added that the manufacturing engineer today must not only understand but also be able to plan for these new technologies to survive in the present world condition The impetus for CIM, then, has been based on the perceived need for today's manufacturing industry to respond to changes more rapidly than in the past (13)

2 1 2 Manufacturing Systems

Zhang and Alting (15) define manufacturing systems as 'systems that perform a sequence of transformation processes to convert the initial ideas of product design into realistic finished products that have value in utilisation and the marketplace' According to whether manufacturing systems are controlled manually or automatically, they can be classified as either Traditional Manufacturing Systems (TMS) or Automated Manufacturing Systems (AMS), respectively Figure 2 3 depicts this classification

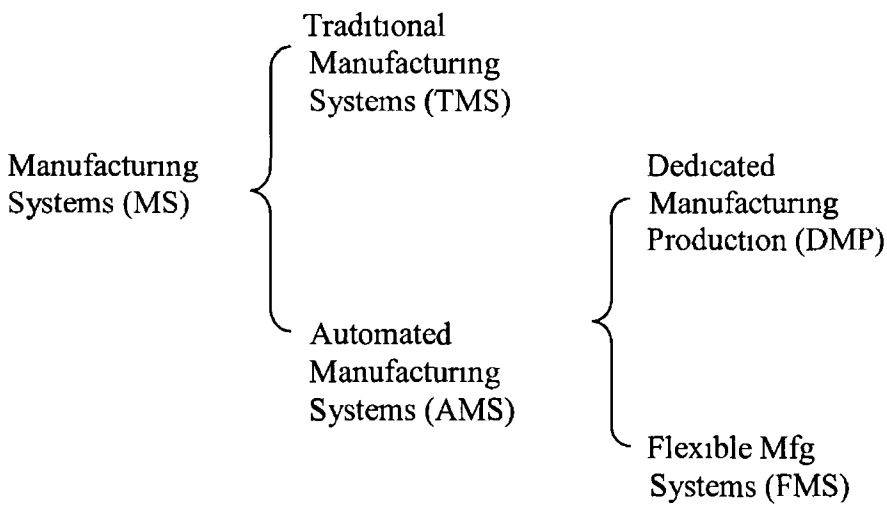

Figure 2 3 Classification of Manufacturing Systems (15)

According to Foston et al (9) many enterprises using traditional manufacturing systems find it difficult to meet customer demands in a timely manner, produce competitively priced products of a high quality and reliability, and provide timely and dependable support services Inflexible and inefficient traditional systems are losing their greater share of the market, resulting in a decrease in sales Returns On Investment (ROI) decrease as a consequence, causing additional problems such as a loss of financial support, reduction in equipment acquisition, increase in time for developing a fully automated factory, and a reduced ability to compete in the world marketplace (9) Systems introduced today must be able to adapt to future changes The rigidity of systems has proved a major obstacle to upgrading a system or the adoption of a new philosophy, such as Enterprise Resource Planning (ERP) or Just In Time (JIT) (14)

2 1 3 Major Manufacturing Functions

A manufacturing system consists of a multitude of functions, which are interconnected When designing a manufacturing system, the functional relationship between functions is of great importance As a result, activities are placed in groups to form major functions (9) Foston et al (9) outline the following major functions

1 Business Function (business systems) Marketing, Inventory Management, Early Planning, Production Planning and Control, Finance, Operations Management, Operational Research
2 Engineering Function (engineering systems) Design, Drafting/Graphics, Problem Definition, Synthesis, Analysis and Optimisation, Evaluation, Documentation, Product Review, Product Presentation

3 Human Resource Function (human resources systems) Labour Relations, Education/Training, Recruitment, Work Motivation, Management, Customer Relations, Law

4 Production Function (production systems) Fabrication, Assembly, Inspection and Testing, Materials Handling, Material Monitoring, Process Monitoring and Control, Data Collection

As the above functions and operations must work together through common procedures to accomplish the business strategic plan, it is vital their interdependency is considered As Mair (16) explains, it is important to bear in mind that no single aspect of manufacturing is a guarantee of success, especially computerisation, it is the manner in which the company operates as a homogeneous unit that is important

2 1 4 The Manufacturing Cycle

The manufacturing cycle includes all activities and operations from product inception and design, up to and including product delivery, support, and service as shown in Figure 2 4

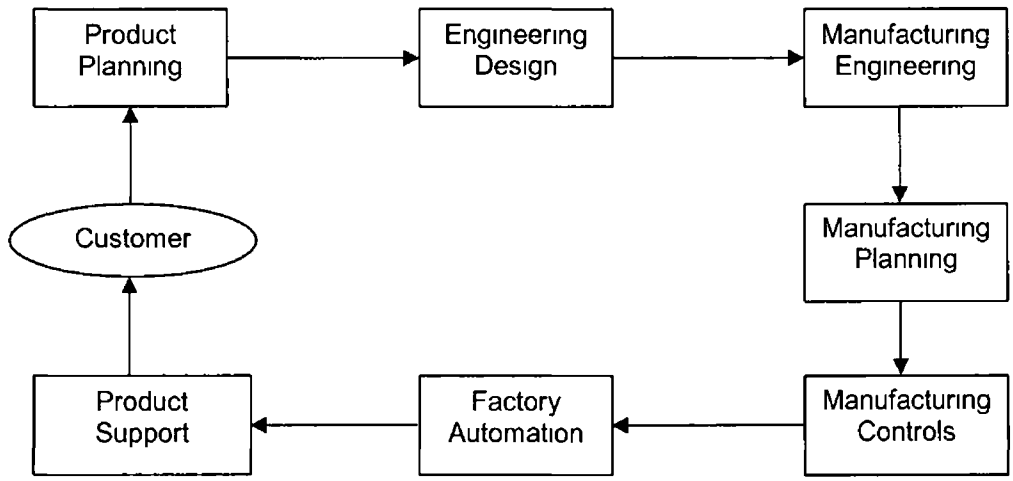

Figure 2 4 Conceptual Manufacturing Cycle (9)

Clearly, as Foston et al (9) illustrate, the steps in the manufacturing cycle, as shown in Figure 2 4, vary somewhat depending on the type of industry, product, size of the company and management system

2 1 5 Computers in Manufacturing

Before computers were used to control manufacturing processes and to process data, the manufacturing environment relied upon the foreman and craftsmen, who were almost totally isolated from management (17) By 1986, Kochan and Cowan (17) were able to state that many manufacturing concerns already used computer equipment to considerable advantage, particularly in design and drafting, production control, machine control and order processing In all these applications, the computer has been employed merely to perform a job previously done manually, in the same way but more efficiently

By 1988, Weatherall (18) claims that the computers used in manufacturing industry have not only contribute to decision-making, but also directly control much of the production equipment Integrating (i e connecting) these computers was the next logical stage in the evolution of computer systems, this integration would inevitably make a radical difference to how a company is run and what it can achieve Foston (9) concured with this view, pointing to the computer's ability to receive and handle large amounts of data, coupled with their fast processing time, which makes a system approach indispensable

This view was also supported by Rembold et al (19) who stated that there was clearly sufficient evidence that the computer would be one of the main tools for a factory to be more responsive to the demands of the future market New ways for more efficiently utilising information and for integrating the computer into

the design and manufacturing processes must therefore be found Over the years, computers have changed the internal structure of manufacturing organisations, their methods of operations, and their external relationship to society (9) It is important to note that simply having computers is not enough to ensure success The company's operations must be carefully planned and integrated together and computers used intelligently to enable and enhance this In recent times, the evolution of computing is proving of considerable interest for solving real world problems in the manufacturing industry It is providing an alternative to the more traditional analytical approaches to solving problems in manufacturing It is considered that the successful use of these advanced computing systems will have increasing impact in the future (20)

"In order to gain advantages in today's highly competitive, global market, research and development of a next-generation, intelligent manufacturing systems are in great demand worldwide" (21)

2 1 6 Historical Developments in Advanced Manufacturing Technology (AMT)

As illustrated in Figure 2 5, around the year 1900, factory mechanisation facilitated mass production to meet the consumer's demands for improved products By the year 1930, transfer lines and fixed automation were created to facilitate very large mass production systems This resulted in the development of programmable automation By the year 1950, numerical control (NC) was developed as an innovative approach to programmable automation (22)

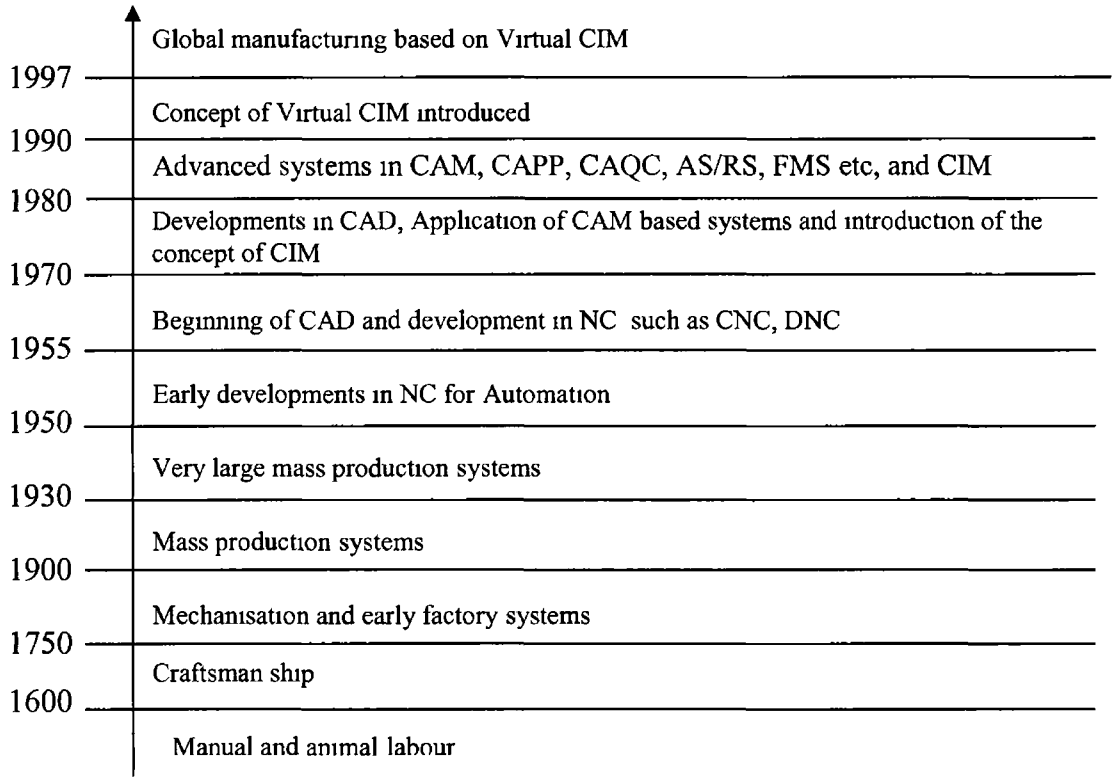

Figure 2 5 Developments in Manufacturing Technology (13)

With the developments in commercially available computer technology in the 1970s, the application of computers in manufacturing started to emerge producing a variety of new technologies, all of which are collectively named as Advanced Manufacturing Technologies (AMT) These AMTs could consist of semi to fully automated systems or equipment (22) The majority of manufacturing companies embarked on AMT initially by investing in a single area of AMT and then expanding into different areas one after the other thereby reaching their current level of investment in AMT (23) CIM is a natural progression of AMT However, as Nagalingam and Lin (5) note, to be successful in the application of CIM, first the integration of AMTs had to be achieved, as computers act only as subordinates to the technologies The level of integrated manufacturing systems in today's factories should not be

underestimated Indeed, Zhang and Alting (15) state that integrated manufacturing systems make up a major part of the factories of the twenty-first century

2 1 7 Automation in Manufacturing

Foston et al (9) defines automation as a system that is relatively self-operating Such a system includes complex mechanical and electronic devices and computer-based systems that take the place of observation, effort, and decision by a human operator The term automation implies the concept of mechanisation (mechanisation refers to the application of machinery to do work previously done by humans, horses, oxen, etc) with the added feature of automatic control The term 'factory automation' is used to encompass the equipment and techniques used either to eliminate the need for human work, as with mdustrial robots, or to assist humans, as m Computer Aided Design (CAD)

Theoretically it is possible to automate all aspects of manufacturing from product design through to final assembly (16) In some companies, completely new technology will have to be introduced, but in others, existing islands of automation will need to be connected (17) CIM is usually based on various forms of automation already existing in the factory CIM provides the opportunity of integrating each specialised component (24)

The principle advantages of automation in manufacturing environments are (16)

- Automation when applied properly will increase the wealth creation ability of a company

- Automation improves labour productivity and also improves the efficiency by due to the following points

1 Quality is improved by removing the human element

2 Production rates are increased over those possible by manual methods

3 Working conditions are improved where automation displaces human workers from tasks, which are dangerous, hazardous to health, unpleasant, or tedious

4 The predictability and consistency of automation means that the flow of work through the factory can be more easily monitored and controlled

2.2 Computer Integrated Manufacturing

Computer Integrated Manufacturing (CIM) has been and still is in focus, but studying CIM is not an easy task Although it is a relatively new concept (the new term was coined by Harrington in 1973), CIM has received a great deal of attention from production and inventory control managers, consultants, and researchers (4) Some feel that CIM is nothing less than the full use of computer-aided technology For others, CIM is the use of machine vision, automated handling systems, robotics, and flexible manufacturing systems Some view CIM as an information-based system, which represents one way of managing, structuring, and representing the corporate database Finally, to still others CIM is primarily a strategic system, which draws on computer technology to help the enterprise to meet the needs of its marketplace (4)

CIM has potential applications in manufacturing strategies, such as agile, lean

and virtual enterprises and offers a number of useful opportunities for improving competitiveness It is therefore important to study further development, applications and implications of CIM in the next generation of manufacturing organisations (25) Maximising profit is the overall objective of every company This is achieved by optimum utilisation of assets and optimum customer satisfaction, i e on time delivery of good quality products at a competitive price CIM represents a new production approach that will allow factories to deliver a wide variety of products at a low cost and with short production cycles The new technologies of CIM are needed to develop manufacturing environments that are faster, close coupled, integrated, optimised, and flexible (13)

2 2 1 The Meaning and Origin of CIM

"CIM addresses the total information requirements of an enterprise making it a business strategy rather than an automation or computerisation strategy, its aim is the success of the company or enterprise as a business entity" (26)

A large number of definitions of CIM can be found when reading publications associated with CIM Researchers have been trying to define the concept of Computer Integrated Manufacturing since the 1980s The concept of CIM was initially coined by Dr Joseph Harrington in 1973 in the book "Computer Integrated Manufacturing" However, until the early 1980s, CIM did not become a commonly known acronym, as it exists today

As Nagalingam and Lin (5) comment, the definition of CIM has various connotations depending on its application Hannam (7) observes that 'CIM is a

company's business strategy because this will identify the company's markets, its customers, its products, its key technologies and where it is to gain its competitive advantage' According to Attaran (8), CIM is less of a strategy and more of a concept It is a way to use technology and techniques to integrate a business CIM is the management of technology rather than being a technology itself Foston et al (9) agreed with Attaran (8) that CIM is a concept, although they define it as the concept of streamlining the product processes and support activities by bringing together and sharing manufacturing information from business, engineering, production, and human resources systems Bedworth et al (27) report that some people emphasise the fact that CIM is a management philosophy in which the functions of design and manufacturing are rationalised and coordinated using computer, communication, and information technologies Others see CIM as a tool to be used to achieve or facilitate defined corporate goals or strategies It is a way of doing business that emphasises an automated coordination of information and effort throughout all the functional areas of a company (28)

In 1997, Hassard and Forrester (29) concluded that there is a general agreement that CIM is an encompassing term for the integration of product design and engineering, process planning, and manufacturing activities The definition is often widened to include the integration of computerised systems for sales ordering, finance and inventory control These interface with design and production throughout the phases of manufacture, from the initial customer design specification or order through to the product's delivery From the researcher's point of view, computer integrated manufacturing means different things to different people and different enterprises There is not one all-

encompassing definition of CIM because CIM is designed to adapt to the needs of an enterprise and to be applied to a specific situation Everyone will therefore have their own definition of CIM and each company will implement it in a slightly different way

2 2 2 Meaning of Integration

Integrating computer technology and manufacturing is not an optional matter for a company that intends to remain in business As Nagalingam and Lin (5) point out, effective integration of CIM requires an in-depth understanding of all the technologies and a comprehensive knowledge of all activities in all functional units of an enterprise For many years, some companies and individuals have appreciated the potential benefits of integration The concept of the total integration of all industrial functions is partly captured by the CIM wheel of the Society of Manufacturing Engineers (USA) (see Figure 2 6) The wheel emphasises the totality of the integration as well as the requirement to have both architecture to provide the integration and a strategy relating to the organisation and management of company information and data (7)

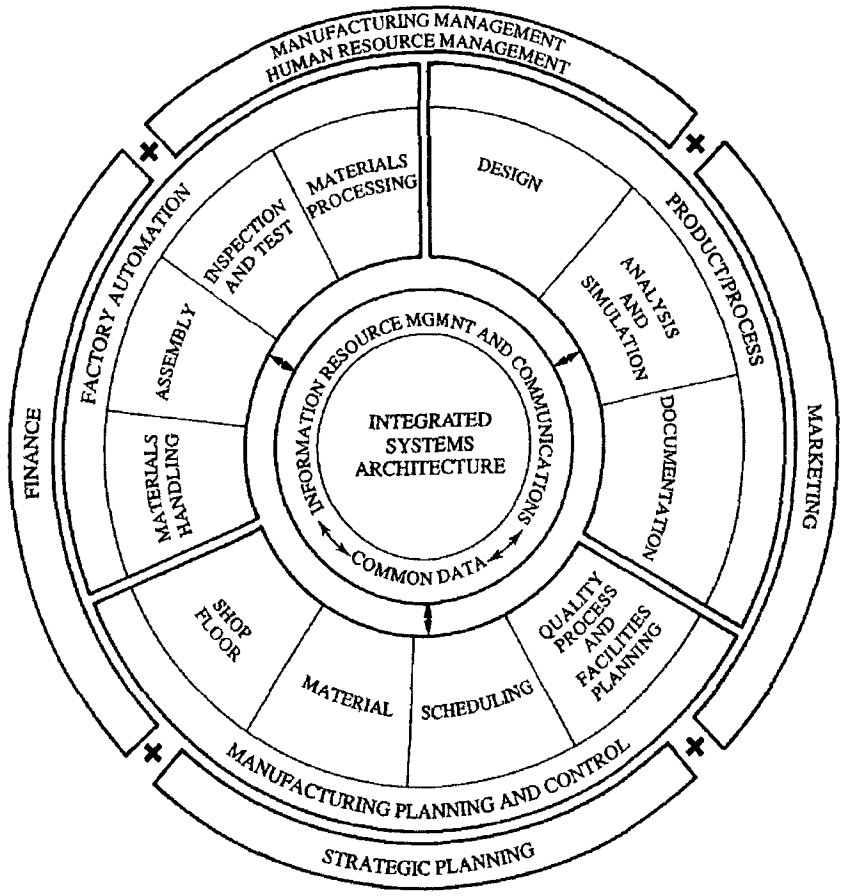

Figure 2 6 The CIM Wheel The Society of Manufacturing Engineers, Dearborn, Michigan, USA (7)

Integration is essentially the unity, connection and interrelations between the different elements and processes of a given manufacturing system There are two main types of integration within this – functional integration and technical integration Functional integration involves the incorporation of the necessary processes and functions connected with performance of specific tasks into the manufacturing system Technical integration means physical unity of the system elements (30) Technical integration can concern equipment, information and data Information Technology (IT) tools currently constitute the basic methods of technical integration of manufacturing systems A manufacturing system which has all the basic functions integrated with the use

of IT tools is called the Computer Integrated Manufacturing (CIM) system (30)

An integrated CIM system includes three levels of integration covering physical system integration, application integration and business integration (31) leading to the total integration of the manufacturing enterprise and is called Integrated Automation System (IAS) (22) It is possible, by integrating information and organisations, to make an enterprise small again from the point of view of administration, information sharing and management (13) To support the integration of manufacturing processes, which work in isolation, an effective and efficient means of data storage and processing must be provided It is generally accepted that CIM aims to achieve effective integration of the various computer-based manufacturing processes, including the sub-processes such as Computer-Aided Design (CAD), Computer-Aided Manufacturing (CAM), Computer-Aided Production Management (CAPM) and the other various items of manufacturing automation that constitute Advanced Manufacturing Technologies (AMTs) (29) Figure 2 7 shows an example of a totally integrated automation

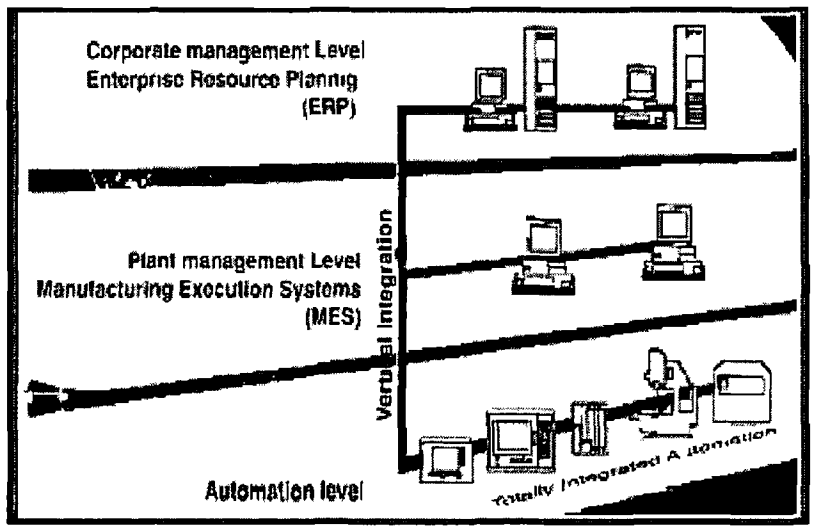

Figure 2 7 Totally Integrated Automation (22)

The integration of technologies brings the following benefits (5)

1 Creation of a truly interactive system, which enables manufacturing functions to communicate easily with other relevant functional units
2 Accurate data transferability among the manufacturing plants or subcontracting facilities at in-plant or diverse locations
3 Faster responses to data-changes for manufacturing flexibility
4 Increased flexibility towards introduction of new products
5 Improved accuracy and quality in the manufacturing process
6 Improved quality of the products
7 Control of data flow among various units and maintenance of user-library files for system-wide data
8 Reduction of lead times, which generates a competitive advantage
9 Streamlined manufacturing flow from order to delivery
10 Easier training and re-training facilities

Nagalingam and Lin (5) observed that although the benefits of integrated technologies are very difficult to quantify, integration provides a competitive advantage by linking new and existing hardware and software of the technologies, together with database management systems and data communications systems into a coordinated and efficiently managed process

2 2 3 Information Technology (IT) and CIM

Information technology (IT) may be defined as the convergence of electronics, computing, and telecommunications It offers the opportunity for completely new ways of working through systems integration All sectors of the economy have been influenced by the development of IT applications (32) Kumar et al

(22) found that IT helps in the enhancement of a CIM company's competitive advantage in three major ways

- By changing an industry's structure and thus creating new rules of competition,
- By creating competitive advantage through the development of new ways of outperforming the company's competitors, and
- By creating entirely new business, often from within a company's existing operations

Furthermore, as customer demands change, IT also allows firms to react to these changes and adapt the way they work together and interact, while maintaining reasonable costs (22)

2 2 4 Components of CIM

The following elements are the essential ingredients of a CIM system, most of these components can be installed individually, thus allowing CIM to be approached in a step-by-step manner (16) It is also important to note that CIM can range from as little as two machines whose interactions are coordinated by a computer to a fully automated plant (33)

2 2 4 1 Computer Aided Design (CAD)

Computers have been used in the product cycle to facilitate the design process since the early 1960s When computers are used, the process is referred to as a Computer-Aided Design (CAD) It is a broad subject addressing applications in many activities of the design function In summary, CAD is a process that uses computers to assist in the creation, modification, analysis, or optimisation of a

design Typical design activities involving a CAD system are preliminary design, drafting, modelling, and simulation (9) Figure 2 8 shows the hardware of CAD

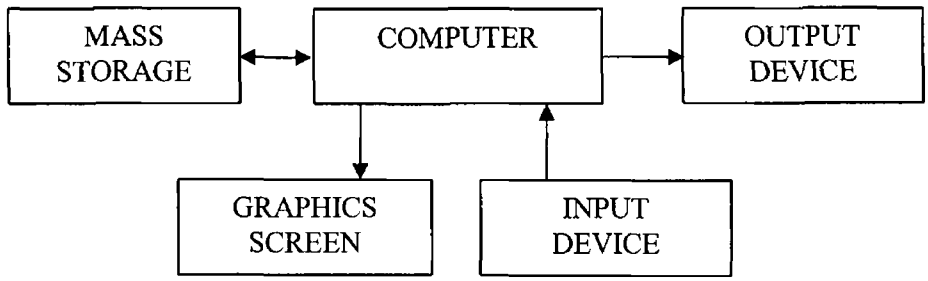

Figure2 8 Hardware of a CAD System (16)

Computer aided design is most commonly associated with the use of an interactive computer graphic system (15) The computers that provide the building blocks and design, through CAD, provide the launch applications for greater integration, and these topics are the foundation of CIM (7) CAD is not new, however, the way it is used has changed As CAD is where the conception, design, and development stages of manufacturing occur, it is not surprising that CAD is often the driving component of CIM (34)

2 2 4 2 Computer Aided Manufacturing (CAM)

CAM is the use of computer technology in the planning, management, control, and operations of a manufacturing production facility through either a direct or indirect computer interface with physical and human resources of the company (9) The term Computer Aided Manufacturing (CAM) has been defined as covering many areas from information processing and decision making to

manufacturing and machining (15) Computers are used in such areas as inventory control, scheduling, machine monitoring, and management information They are mainly used for transferring, interpreting, and keeping track of manufacturing data With the aim of speeding up data access and to ensure that all users work from a common design database, management concepts are applied to CAM operations (9) Figure 2 9 shows the typical functions in Computer-Aided Manufacturing

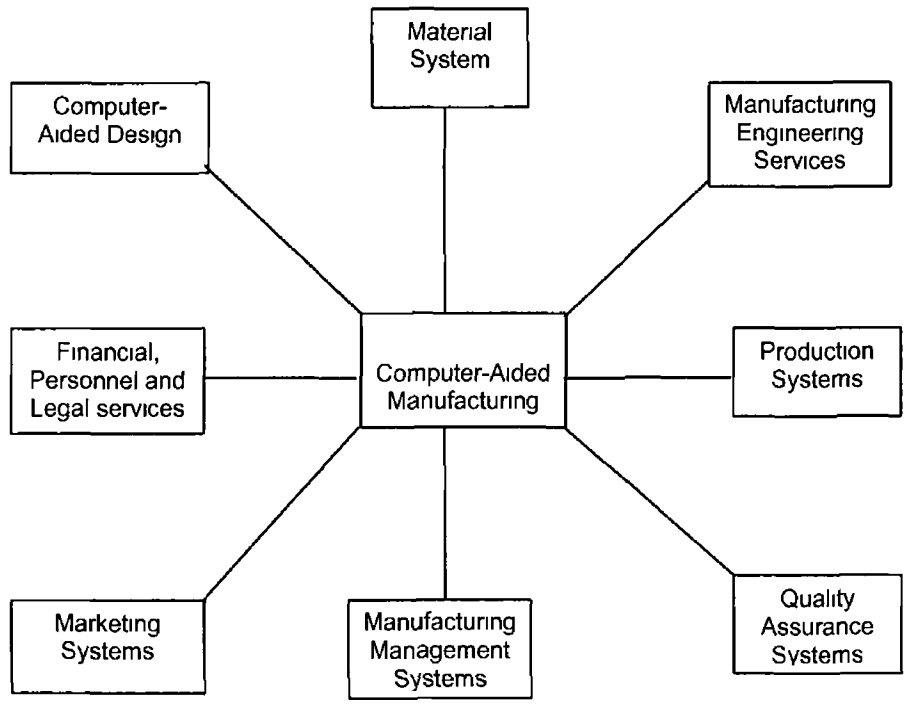

Figure 2 9 Typical Functions in Computer-Aided Manufacturing (9)

In summary, the heart of Computer-Integrated Manufacturing is CAD/CAM Indeed, as Hannam (7) points out, many of the workstation-based CAD systems of the 1970s were marketed as CAD/CAM systems because they were seen as a means of ensuring integration In addition, the advantages of CAD and CAM can be optimised when combined with other elements such as Automated Storage and Retrieval Systems (ASRS) for parts, Computer Aided

Process Planning (CAPP), and Management Information System (MIS) As Mair (16) states, when this is done efficiently in conjunction with a common computerised database and Electronic Data Interchange (EDI), then the CIM concept is essentially achieved

2 2 4 3 Computer Aided Processes Planning (CAPP)

One of the most important functions of manufacturing engineering is often seen as process planning which involves the creation of detailed plans for the production of a part or an assembly Related to this are the functions that determine the cutting conditions and set the time standards for processes Process planning is now aided by Computer Aided Process Planning (CAPP) It is evident that a well developed CAPP system can reduce administrative work in manufacturing engineering whilst also providing assistance in production (9)

CAPP has been recognised as playing a key role in CIM As the American Machinist and Automated Manufacturing Society has reported, a computerised process planning system has essentially four goals (15)

1 reduce the clerical load of plan preparation on the manufacturing engineers and skilled process planners, who are in short supply,
2 optimise existing plans using the best available information on machines, tools, speeds, etc,
3 standardise what are known to be the 'best' process plans for families of components within a company, thereby capturing the knowledge of the skilled planners, and
4 standardise production times/costs particular families of components

In short, most companies are solving the problem of automating process planning and overcoming the shortage of skilled process planners by using CAPP (15)

2 2 4 4 Flexible Manufacturing System (FMS)

"Improvement of performance depends on exploiting plant flexibility"(36)

In recent years, competitive pressure has forced many companies to adopt and to plan quickly for changing market conditions This problem led to the conception of Flexible Manufacturing Systems (FMS) (19) This commonly refers to computer integration of the many individual automation concepts and technologies into a single production system FMS has come to mean a group of automated machines capable of processing a variety of products through different process routes under full computer control (18) FMS can, therefore, mean any automation application from the use of CNC machines or robots, to entirely automated factories (9) Rembold et al (19) point to a trend, which can be observed in highly industrialised countries, where the customers have a preference to purchase more and more products that have specific options Thus the traditional transfer line principle becomes too rigid Therefore, Flexible Manufacturing Systems are becoming economically attractive

The key aspect of FMS is its ability to adapt to change and not just the degree of automation it incorporates A basic framework for an FMS is a well-defined manufacturing system A manufacturing system usually includes a complete set of processes, resources, and equipment brought together for a specific purpose Flexible manufacturing requires real-time information and decision making to

take advantage of the built-in flexibility of the system It is important that CAD and CAM be integrated to take advantage of the FMS By ensuring the reduction of manual intervention and prices process control, the successful integration of CAD and CAM technologies into an overall FMS can result in a significant increase in productivity, reliability, and repeatability (9)

2 2 4 5 Robotics

Developments in robot technology have greatly affected the fabrication and assembly processes on the factory floor An industry robot plays an important role in the computerised materials-handling system as it can be programmed to perform a variety of manufacturing tasks The Robot Industries Association (RIA) defines the industrial robot as a 'reprogrammable multifunctional manipulator designed to move material, parts, tools, or specialised devices through variable programmed motions for the performance of a variety of tasks' The use of robots in manufacturing offers the potential for improved productivity never before possible (9) What is more, they have the additional advantage that they can work in an environment, which is unpleasant for humans (7) The robot represents flexible automation as opposed to hard or dedicated automation and so it fits well in the framework of CIM systems (19) Therefore, it plays an important role in CIM system

2 2 4 6 Automated Guided Vehicles (AGV)

Newer technologies such as Automated Guided-Vehicle (AGV) systems offer some of the most existing opportunities for making materials handling a vital portion of CIM They are usually integrated with other devices such as robots

and Automated Storage and Retrieval Systems units and also with machine tools (36) An AGV system (primary system) can be used to transport parts and materials between machine lines and storage areas, depending on the complexity of the AGV system The central computer downloads commands to a floor-level computer, which in turn translates general commands into specific dispatching instructions to the AGV system (9)

2 2 4 7 Automated Storage and Retrieval Systems (ASRS)

One of the most automated forms of storage that has been applied in manufacturing so far is the Automation Storage and Retrieval System (ASRS) Able to operate in an unmanned environment and interface directly with an automated transport system, the ASRS is being widely used on the shopfloor to operate in conjunction with a flexible machining system, permitting it to run unmanned for extended periods of time (17)

2 2 4 8 Artificial Intelligence (AI)

Artificial Intelligence (AI) is the branch of computer science concerned with designing intelligent computer systems The power and potential of AI tools for planning and control of manufacturing processes has been proven by many research projects and actual implementations (19) Chorafas (24) observes that AI solutions integrate with and assist, rather than compete with, the human element Artificial Intelligence (AI) enables computer systems within CIM to make judgmental decisions based on accumulated experience (37)

2 2 4 9 Just-In-Time (JIT)

Just-In-Time (JIT) is the theory that an enterprise should make and deliver parts just as much as are needed, no more or less, and just at the right time, no earlier or later, and just at the place where they are required (38) Delays in delivery of raw materials and parts results in longer lead- times and poor performances (39) Just-In-Time is an approach for performing the production function It has been used in Japan since the early 1950s (9) It attempts to reduce the inventory cost by producing smaller quantities With JIT there is less material in the workflow, and the amount of workspace that is needed is reduced Companies using JIT find they can use more space for production and less place for inventory (9)

For JIT to be effective it is necessary to have a uniform supply of goods throughout the system in order to ensure appropriate co-ordination of operations and to ensure free flowing movement of goods and materials throughout the system from supplier to final product This potentially could be a disadvantage, as it demands that each element of the process is completed on time in order for the next stage to be accomplished also on time This may be difficult to control JIT also follows a more rigid production schedule since it requires a more or less level production This would appear to be more appropriate in a repetitive manufacturing environment (40)

Some new terms have developed within recent times that reflect the progressive nature of modern manufacturing processes, these are lean manufacturing, responsive manufacturing and agile manufacturing (5) As stated by Santarek (30) "Lean Manufacturing (LM) involves addressing the product strategy, product development, supply chain, manufacturing and

product distributions for the production of diverse products in small batches It may further consist of out-sourcing and effective integration between the suppliers and subsidiaries" The concept of agile manufacturing is similar to the concept of LM by placing the emphasis on small batch sizes However, it does differ in that it requires a reduction in the length of time for product development, the ability to customise product features as required, and to incorporate highly adaptive, flexible and efficient manufacturing practices in the product development and manufacturing cycle It further involves effective integration of technology, business activities, enterprise and people (30)

2 2 4 10 Material Requirements Planning (MRP)/Manufacturing Resources Planning (MRPII)

Material Requirements Planning (MRP) as well as Manufacturing Resources Planning (MRPII), is an important concept with a direct relationship to CIM (23) Companies now generally use MRP and MRPII software to plan the implementation of the Master Production Schedule (MPS) Hannam (7) states that MRP uses the bill of material to provide exact details of every part of every product to be produced, inventory control provides the necessary information regarding current stocks, and information on suppliers' delivery from purchasing The scheduling of purchase of materials is thus facilitated As Foston (9) states, "the Material Requirements Planning (MRP) function is a set of processes that use the bill of materials, on-hand and on-order inventory data, and the master plan to determine when to order raw materials and components for assembled products" (9) It proves very expensive to hold inventory as funds that could be used for other manufacturing resources are

tied up and unavailable In modern manufacturing structure, an attempt is made to work without inventory or to reduce it to a minimum However, in most functions some inventory or safety stock is required The aim of inventory control should be to ensure provision of items of need within the time of need MRP is a means of inventory management, which provides insight into the manufacturing inventory It is a method of assuring that items are available when they are needed (19)

2 2 4 11 Enterprise Resource Planning (ERP)

In order to support the financial, manufacturing and distribution processes of a company MRP, MRPII and ERP are used widely The Enterprise Resource Planning (ERP) system is one of the most widely accepted means of obtaining a competitive advantage for many manufacturing companies Zhang et al (41) Defined (ERP) systems as "configurable information systems packages that integrate information and information-based processes within and across-functional areas in an organisation" They defined successful ERP implementation along two dimensions

1 Improvement in performance
2 User satisfaction

ERP is probably the most rapidly growing system m operations today Thousands of companies have implemented or are in the process of implementing an ERP system It is important for the company to choose those ERP systems that are easy to adapt to the needs of the customer so that the cost and time for customisation can be made as short as possible Moreover, it is necessary to upgrade the ERP system regularly because advancement in

technical results are continuously developing Most companies who use ERP set performance goals of the ERP projects which include cost reduction, business processes integration, time, cost, etc (41) After implementation, the appropriate use of ERP systems can advance the competitiveness of an organisation even further Over the past decade, organisations have spent billions of dollars implementing Enterprise Resource Planning (ERP) systems Companies adopting ERP systems have focused mainly on improving transaction handling through the development of standard business processes and through integration of operations and data (42)

2.3 CIM Strategy

Both in terms of the daily operation of the factory and in changes performed in the production environment, CIM, as a strategy of the factory of the future, has the potential to have a great impact on the manufacturing enterprise as a whole (15) The impact of CIM strategy touches every part of the company's activities, and this means that all personnel in the company, from the shop floor to management need to be aware of the changes going on around them (17) CIM can be thought of as the initial strategy for achieving the 'factory of the future', it has been defined as a strategy for linking existing technology and people to improve the manufacturing process CIM strategies must be developed with a full understanding of a company's overall business plans (see Figure 2 10), and as shown by the work of McGuigan and Jun (1) this means involving everyone from the managing director and the marketing director to the production manager and the shop floor staff

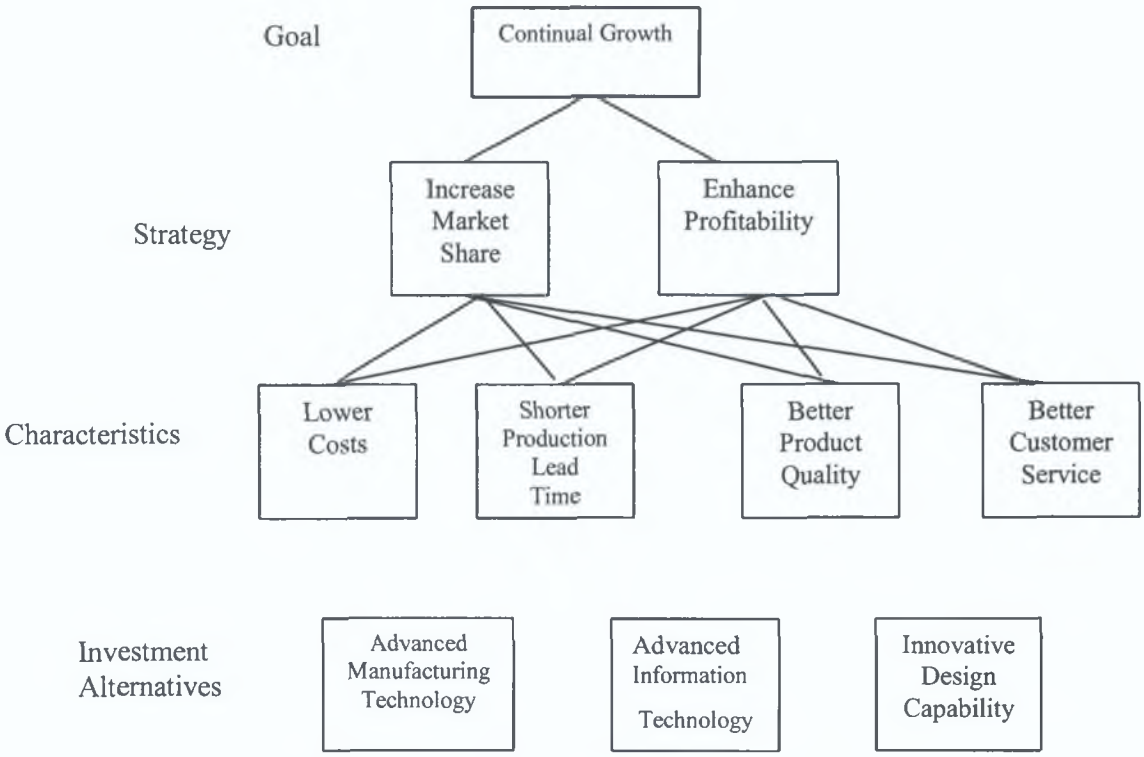

Figure 2.10: The hierarchy of Advancement Investment (43)

In a traditional setting, the social/organisational structure forms the focus of the enterprise, and the equipment is used as a means to accomplish the tasks and functions associated with the enterprise. In contrast, in a CIM system, the structure and function of the enterprise change so that the organisational focus is determined by the technology, and the human participants in the system are often oriented toward servicing the technology in order to make maximum effective use of it (2). Since investing in CIM is not for the sake of the technology itself, it is important to have the resulting business and manufacturing processes meet the target performance (43). To ensure this there must first be a corporate strategy that is designed to generate a sustainable competitive advantage for the firm. The structure, orientation, and objectives of the CIM system implemented must then reflect this strategy (4).

2 3 1 Planning for CIM Implementation

Before a company can start to draw up a plan for CIM it must first analyse its business and determine a priority of business objectives (17) Attaran (8) notes that CIM is not a quick fix programme It is a long-term strategic bet that will involve lots of hard work and successful integration requires proper planning and the overcoming of several obstacles CIM strategy needs to encompass the entire enterprise rather than a limited part of it, such as the manufacturing area, if it is to influence the future of the entire enterprise The CIM strategy must, therefore, be derived from the business strategies of the enterprise Andersin (38) argues that this implies that a top-down approach rather than bottom-up one, must be followed in CIM strategy development Kochan and Cowan (17) concur, stating that top management support for CIM is essential and that top management must be made aware of the strategic aspects of CIM

Implementation guidelines applicable to the implementation of any project will include the elements of a feasibility study, initial system design and detailed system design While this is true for CIM, the following guidelines are also necessary when implementing CIM All departments, from accounting through quality control and beyond, feel the impact of a CIM installation Not only must systems and procedures be recognised, but the attitudes and skills of people in the company have to be altered and upgraded Daniel (44) stresses that it is important to recognise this at the beginning Teicholz and Orr (36) also found that it is also important to realise that CIM systems will not be implemented overnight, they will be installed in stages over a planned implementation schedule

Successful CIM systems need the active support and cooperation of the people who are involved in the system, stretching from upper management to the individual workers who interact directly with the manufacturing equipment (2) CIM is not the magic answer to improve productivity - without appropriate support system CIM will not be effective Hashmi and Cuddy (26) found that very often the application of CIM decreases the productivity of a company rather than enhancing it This is mamly due to fundamental misunderstandings about CIM itself Foston et al (9) also points to poor planning for CIM as being one of the major contributors to unsuccessful implementation of the system

There are a number of resources, which need to be present before implementation of CIM should be considered Hashmi and Cuddy (26) suggests three main resources

- Human resources
- Technological hardware resources and
- Capital resources

The human resource factors in factory automation are as crucial as the financial and technological factors Human resources development should both update people and teach them how to manage change Chorafas (24) notes that enterprises must focus on training and upgrading their human resources to cope successfully with the new technology Almost as important as forming the right strategy for CIM implementation is the management of human resources While finance and technology have a great influence over the success of CIM implementation, human resources are often more influential Such an important change as CIM must have complete workforce support (17)

Foston et al (9) goes as far as to suggest that if the management do not conduct a social revolution when implementing CIM, it may in fact reduce the rate of return, causing the organisation to become less competitive The reluctance of factory managers in the United State to apply CIM appears to be centred on risks associated with the technology There is an additional and perhaps larger risk if advanced manufacturing technology such as CIM is adopted without the right human resources strategy for an organisation

Hashmi and Cuddy (26) believe that there could be two reasons for the failure of the system, firstly, the management might underestimate the need for human resources and secondly, because of the absence of a critical mass of trained personal in a particular area, there may be a lack of trained professionals available for recruitment

The success or failure for any system is dependent on the people who use it It is vital that the impact of the system on the employees is considered carefully during development As Weatherall (18) indicates, CIM requires people integration as well as computer integration Many people will be required to support and maintain the CIM system Enough time must be devoted to developing and executing the necessary employee retraining programmes required by CIM technology (36) In order to assure success of the implementation phase it is necessary to motivate people by creating an atmosphere conducive to CIM implementation Andersin (38) writes that the following ideas are thought to be of value

1 human systems such as rewarding, job enrichment, and continuing education should be redefined to support the overall integration of the organisation

2 everybody should be made to understand the CIM strategy and the CIM

Due to the essential nature of CIM, efficient communication between the discrete CIM elements are of central importance Problems in communication may easily result in the implementation of CIM being impracticable Lack of effective intercommunication facilities between different computer hardware and software systems within a company needs to be rectified before any progress can be made (26) Another difficulty encountered when implementing CIM is the fact that the CIM system itself is changing Accelerated developments in computer hardware and software technology are making existing systems out of date Thus, any existing system must be capable of incorporating new developments without causing serious inconvenience to the support personnel (23) Two of the main reasons suggested for the relatively low uptake of CIM in particular is the reluctance of the management to broach such a large capital investment programme and indeed the level of capital investment required With CIM, the enhancement of productivity is a long-term process and it is not very easily identifiable for attribution to the implementation of CIM Thus, unless company management and future business planners are absolutely convinced of the long-term benefits of CIM, they will not be prepared to invest a considerable amount of capital (26)

2 3 1 1 CIM Implementation Guidelines

The implementation of CIM systems is not a simple issue and it therefore requires effective planning and control from an initial CIM investigation, all phases in between, up to and including post-implementation review (9) as Figure 2 11 shows

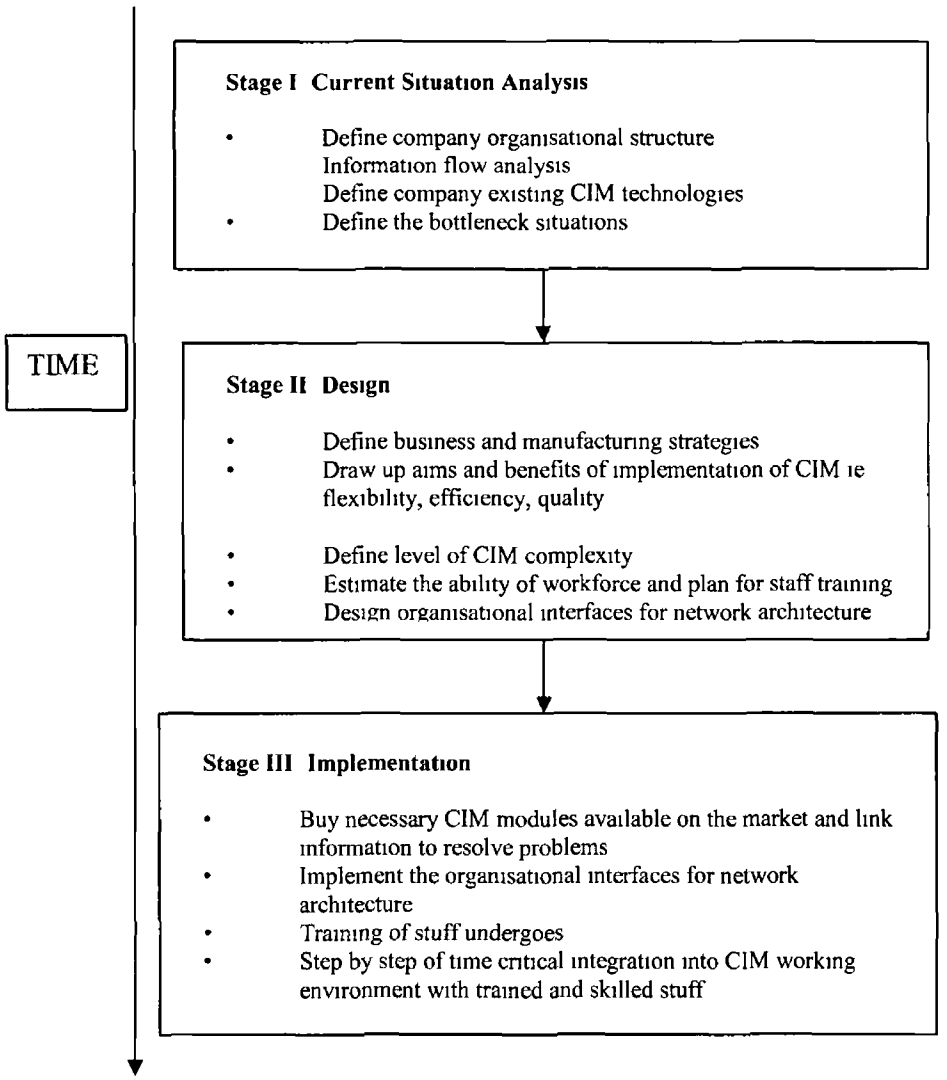

Figure 2 11 Framework of the Design and Implementation of CIM (13)

The CIM implementation guidelines according to Hannam (7) are

- Ensure that the company has a strategic vision, not all companies have a business strategy, which adequately identifies their longer-term goals It has been emphasised that CIM is a means of achieving particular strategic objectives
- Ensure that the company can communicate effectively with its employees and that it starts to communicate to CIM, involvement and communication are very important to the success of CIM

implementation Training is also important so that potential users start to understand the technology It helps to show the company thinks that the technology is important for everyone, it helps to show that everyone is important to the company

- Appoint a consultant/facilitator, few companies considering a CIM implementation are likely to have experienced CIM implementers in-house It is the company that understands its business, its needs, how it operates and how it would like to operate Consultants clarify all these issues and bring in expertise on CIM, they can also provide some of the training required It is better and cheaper that the CIM implementation tasks are carried out by members of the company who already know the company, rather than by outsiders
- Segment the implementation and identify priorities, Because CIM can affect so much of a company's operation, it is sensible to implement it in phases, which are self-contained as far as is practicable Then, experience can gained from the initial implementation phases, which can feed into later stages

It can be concluded, then, that the following areas have to be considered by any enterprise considering implementing CIM (45)

1 CIM is expensive in terms of hardware costs, software development, and requires dedicated personnel for the planning and implementation phases A typical corporate CIM plan may take as long as five to ten years to fully implement

2 CIM requires management to clearly express corporate goals and manufacturing strategies

2.3.2 Training and Education

According to Kimble and Prabhu (46), the most common obstacle when attempting to implement CIM was insufficient or inadequate training on how to use computer systems and failure to take account of the need to change people's attitudes through a programme of education. It is clear that when developing new technologies, enterprises must simultaneously develop the people who have to mange and operate this technology. Hutchin (47) points out that there is a requirement to study training needs within the organisation in order to guarantee that the workforce are capable of making best use of the technology.

Kenaroglu (32) focuses particularly on the fact that training is essential for the promotion of IT in developing countries. He claims a stronger focus on training in computer systems that is application-oriented and geared to local and national needs is essential. Deficiencies in these factors prevent the widespread adoption of information technology in developing countries. Ghosh (10) generalises that Advanced Manufacturing Technology (AMT) can today be properly implemented only after

1. Establishing employees' perception of their work on highly automated systems/computer assisted environments, and
2. Making recommendations designed to improve employee motivation, satisfaction and productivity.

For any new technology, such as CIM to be successful appropriately trained professionals is one of the major pre-requisites (26). Ghosh (10) adds that management and professional staff are likely to require further training or retraining (experiential learning) as are other groups of employees, as part of

advanced manufacturing strategy Rembold et al (48) maintain that education of computer use should come about informally from actual "hands-on" experience

A fundamental ingredient of CIM is the company's educational policy and how to make it work for the company Efforts should be made to motivate employees early during the CIM implementation and seek their commitment to the programme (9) Furthermore, training needs to be linked to the company objectives (47) A lack of education-industry linkage would affect the technology base negatively whilst the human resources base would not be complete without a proper continual education training strategy (10)

As Weatherall (18) makes clear, external experts, the academic world and computer manufacturers can make a significant contribution to a CIM implementation project The implementation of a CIM system is a combined effort by people with many skills There is knowledge needed from marketing, engineering, manufacturing, computer sciences, industrial engineering and so on When we talk about integration, people are needed who understand the complex functions of a manufacturing system and who are capable of tying them together They should have special skills in working with experts from various fields and organisational levels to coordinate their work and tie it into an integrated functional system (19)

To sum up, technological advances have created a need for increased education and training, therefore education and training programmes throughout the enterprise should be a vital part of the CIM implementation process According to Foston et al (9) it is useful to form a CIM action team on education, early in the CIM planning process The primary mission of this team should be to

address educational issues He also suggests the following educational issues for any CIM action team

1 A CIM awareness programme for all levels of the company
2 How to upgrade worker's technical skills to deal with new equipment and system
3 Where and how to find trained or trainable personnel in the company
4 How each employee can be a key player on the CIM team
5 Specific types of technological skills needed in a CIM environment
6 Implementation and evaluation of the company's CIM educational programme

2 3 3 Support and Management Commitment

According to Hassard and Forrester (29), it is clear that top management commitment is essential for the successful introduction and operation of CIM As far as management is concerned, decision makers need to be equally assertive in knowing how best to utilise the system that they have invested a substantial amount of capital in They must be aware of all the CIM facilities and make proper use for the decision making process towards long term enhancement of productivity (26) Figure 2 12 shows the drivers for change management Small and Medium sized Enterprises (SMEs) must have top management involvement and commitment in order to ensure a successful CIM initiative and a CIM compatible organisational infrastructure, which includes the requisite skills, appropriate training and education, and adequate incentives and rewards (49)

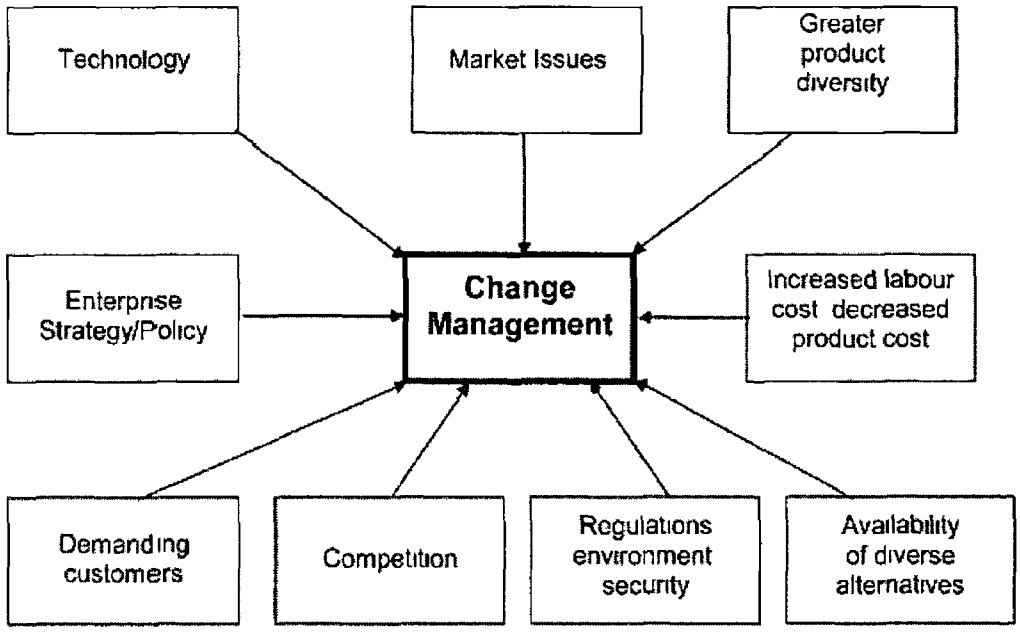

Figure 2 12 Drivers for Change Management (22)

2.4 CIM Benefits and Obstacles

CIM includes such activities as the design of product/process, the purchase of materials, manufacturing technology, information resource management and total quality management CIM utilises enterprise-wide computer-aided technologies to maintain quality, speed new product development, minimize costs and maximize flexibility to respond to ever-changing customer desires (13) Subsection 2 4 1 discusses the potential benefits of CIM while Subsection 2 4 2 discusses the barriers and obstacles to CIM implementation in the modern manufacturing environment

2.4.1 Benefits Gained from CIM

The operation of a CIM system may give the user substantial benefits compared with traditional systems The work of Rembold et al (19) has shown the following typical benefits

1 Reduction of the in-shop time of a part by 30-60%

2 Reduction of design costs by 15-30%

3 Increase of productivity by 40-70%

4 Better product quality, reduction of scrap by 20-50%

Hashmi and Cuddy (26) stated that the application of new technology improves the product quality and reliability whilst at the same time increasing productivity and lowering the unit cost Thus, the question is not whether companies should employ new technological developments in manufacturing but in what form, and when if they are not using them already

2 4 1 1 CIM as a Competitive Tool

In the current highly competitive global market, continuing and enhancing competitiveness requires many companies to increase the use of new developments in manufacturing technologies and concepts (26) To an increasing degree, being competitive depends on companies being able to make efficient use of the new manufacturing technologies This is in turn means that managers and professional staff need to be well informed about potential applications for these new technologies in manufacturing industry (10)

Hashmi and Cuddy (26) indicated that in order to increase competitiveness companies need to reduce the production cost as well as the selling price of a commodity In view of the wider marketing opportunity for all, this means the cost of producing a product and its selling price should be lower than all other competitors It is widely accepted that Computer Integrated Manufacturing has had a significant impact on the competitiveness of industry Significant increases in productivity, reduction of production costs and the ability to

modify operation quickly are amongst the gains made when applying CIM technologies (50) According to Masood and Khan (13) the competitive advantage of CIM in industry comes from its ability to

- Maximize the flexibility of the manufacturer in responding quickly to changes in the environment,
- Develop a large quantity of new products quickly,
- Produce small production runs of custom-made items efficiently

Traditional manufacturing paradigms cannot deliver all these goals at the same time, but CIM holds the potential to do so The efficient and effective application of CIM will help industries face the global and local competition with a high degree of confidence (5)

2 4 2 Barriers and Obstacles

There are several obstacles to the decision to invest in CIM These obstacles include management perception and commitment, lack of planning, integrated challenge, organisational structure, strategic barriers and human barriers and each are discussed in turn in the reminder of this section

1 Management perception and commitment

According to Attaran (8), recent studies show that executive ignorance and lack of top management support are important barriers to proper CIM implementation Too many executives still view the computer as an enemy, not an ally, and as a cost, not a competitive asset Their beliefs are a drawback to implementing CIM, which will not succeed without top management's support (9) Masood and Khan (13) maintain that top executives frequently view CIM as just technology – a master computer controlling many robots and automated

machines They are wrong, if CIM were just technology, there would not have been as many companies having difficulty implementing it CIM is the management of technology rather than a technology itself Top management, manufacturing and industrial engineers must change their way of thinking and develop new skills Companies should appoint supervisors who are more skilled than the most skilled workers under their control (51) For CIM to be successfully implemented in an organisation, skilled leadership is a prerequisite (52)

Implementation of CIM must start from the top, with a commitment to provide the necessary money, time and other resources needed to make the changes CIM requires For Attaran (8), commitment through actions such as changing organisational culture and ensuring active support of middle management and front line staff is invaluable to a successful implementation The complexity of implementing CIM can be a great problem if there is not major and absolute commitment by management of the necessary time and resources (13) Because investment in CIM can be expensive, management must consider the investment as essential to achieve the company's long-term goals and objectives A long-term commitment to the investment must be made, and CIM funding should be part of the future planning because, as Foston et al (9) note, CIM is evolutionary

As far as Dowlatshahi (53) is concerned the design of integrated manufacturing systems poses one of the greatest challenges for manufacturing managers Therefore, some obstacles that can prevent the implementation of CIM in a company are related to the managers themselves such as (28)

- As cheaper alternatives to CIM implementation are available, many

managers see CIM as an expensive and complicated technology to implement

- When most managers look at the experiences of firms that have been successful with CIM, they see endeavours that may require four or five years before it yields any benefits
- For many managers, CIM represents a potential loss of management control

2 Lack of planning

In a recent survey 'inadequate planning or lack of vision', was mentioned as one of the principal reasons for the slow adoption of CIM A well thought out organisational plan must exist for CIM to succeed (8) Furthermore, CIM success requires deliberate and careful planning of the technical element in conjunction with training from day one (13) An integrative approach to training and skill upgrading coupled with careful planning and a high level of project management competencies reduces some of the problems and difficulties (4)

3 Integrated challenge

As the final objective of CIM is the integration of all parts of the organisation across the major functional boundaries, it is commonly agreed that the important issue to be addressed before CIM can become a reality is integration (13) According to Santarek (30), "Processes covered by integration include, first of all, production preparation and planning, manufacturing, control of material flow and inventory, quality control and others, which are not directly connected with the production process"

In this context CIM involves integration of advanced technologies in the different departmental units of an enterprise in an effective manner to achieve the overall objectives of the manufacturing enterprise (5) In conclusion, to take full advantage of the benefits of CIM technology, the complete manufacturing process from design of products to procurement, production scheduling, management, production and delivery must be integrated (13)

4 Organisational structure

The organisational structure of an enterprise has a vast impact on CIM development and the implementation processes As a result, changing from a traditional organisation structure to a non-traditional structure must involve top management and everyone below (9) According to Attaran (8), recent studies point to failures to achieve the promised benefits of AMT due to organisational structure Effective and comprehensive communications requires a flexible organisational structure Without this flexibility, future CIM systems cannot develop For truly effective CIM to work in practice there needs to be a detailed appraisal of organisational structure and processes

The appropriate development and reorientation of the organisation is needed to support and enable the technology to work for the maximum benefit of the business (29) McGuigan and Jun (1) also indicate one of the technological obstacles to implementing CIM is the lack of intercommunication capability within a company system Implementers of CIM have to take into account that as a strategic issue, CIM forces change, which, by implication, dictates a degree of demolition of the old system and rebuilding of the new one (4)

5 Strategic barriers

CIM is currently used to achieve strategic goals However, there are two

instances in which strategy can act as a barrier to the development of CIM The first is one in which the firm lacks a well-developed, comprehensive, complete, and feasible corporate strategy The result is a poorly focused and ineffective CIM system The second instance is one in which corporate strategy is inflexible Managers must recognise that CIM can influence corporate strategy (4)

6 Human Barriers

According to McGuigan and Jun (1) one of the non-technological obstacles to implementing CIM is the user's misunderstanding of the functions of CIM It is clear that the recognition of human resource factors will play an important role in the successful implementation of CIM A failure to recognise this may lead to unsuccessful implementation for a number of companies (46) In their study, McGuigan and Jun (1) indicate that a lack of expertise in data processing, system analysis and design experience, and in-depth knowledge of the CIM implementation process are the most common reasons for the failure of CIM implementation projects If CIM is to succeed and to evolve over time, it must be accepted and supported by the people who will use it

2 5 Justifying CIM

Hassard and Forrester (29) came to the conclusion that the benefits quoted from the adoption of CIM appear to offer companies, bold enough to develop the technology, the opportunity for attaining key competitive advantages

2 5 1 Why CIM?

Manufacturing enterprises play an important role in improving the economic situation of a country The ability to produce high quality products with shorter delivery times whilst responding to diverse customer demands have become vital characteristics for manufacturing industries The application of intelligent manufacturing systems and Computer Integrated Manufacturing (CIM) has, therefore, become necessary to overcome the above issues while maintaining the employment level and revenue of a country

Indeed, Nagalingam and Lin (5) argue that with the developments taking place in CIM and its related technologies, the application of CIM in manufacturing enterprises is now a necessity According to Hannam (7) the answer to the question 'Why CIM?' can be seen in the following points

To be competitive

The competitive pressure can be summarised partly in terms of reductions and partly in terms of increases Companies need to reduce the following items

- Costs costs reduction may apply to all aspects of operation but especially important are material costs and staff costs
- Lead-time lead-time is the time from when a new concept is introduced at the design stage to its delivery in the market place
- Inventory reduction in inventory is to save costs through reduced floor space, storage, material handling and the stuff associated with these activities

The increases required are in quality and responsiveness to customers

To combine and organise data

The main key to how CIM helps companies respond to these competitive pressures is by the best use of data. This firstly requires the data to be organised and coordinated, which can be achieved through databases. It secondly requires the data to be readily accessible. CIM can achieve this through its networks.

To reduce costs associated with using paper

Data and information have traditionally taken the form of paper documents and cards, distributed throughout the shop floor. Also, data and information often have to be copied, with the potential for error and any associated costs. CIM enables information to be stored electronically and displayed on terminals; transcription is not necessary.

To automate and speed up communication within a factory

A manufacturing organisation can only be controlled effectively if the controller knows what is going on. The networks of a CIM implementation permit the sending of massage, memoranda and documents by electronic mail over long distances. As with fax transmissions, the arrival of a message or document is almost concurrent with its dispatch.

Because of the advent of personal computers

The increased use of computers in all departments of manufacturing enterprises has led to a proliferation of computer-based systems. Networks and computer communications had been developing alongside PCs, so the two key ingredients for greater integration were in place (7). What is more, as Weatherall (18) argues, CIM is real. It takes advantage of a logical evaluation in computing technology to improve the products and profit of manufacturing

companies. In summary, enterprises tend to implement CIM for the following reasons:

- Improved Quality
- Increased flexibility
- Reduction of storage requirements
- Reduction of costs, resulting from shorter processing times (4).

2.5.2 Financial Justifications

One of the most difficult aspects of the adoption of Computer Integrated Manufacturing (CIM) for a company of any size, has been the question of financial justification of the investment required (54). What is more, Sharif (3) states that successful entry into the global market requires a large number of scientists and engineers and considerable investment in in-house Research and Development (R&D). As Foston et al (9) point out; the implementation of CIM is expensive. The expense is not easy to justify by using traditional financial yardsticks. The proposed cost of investing in CIM, in terms of hardware and software, education, training and implementation expenses can usually be estimated with reasonable precision.

However, as found by Weatherall (18) benefits will usually not accrue significantly until years two and three, since computer systems of any size usually take between six and twelve months to fully implement. Teicholz and Orr (36) agree, suggesting that a long-term technical implementation plan should not require the investment in CIM technology to be recovered in the traditional 2-to3-year time frames. Weatherall (18) goes on to argue that a CIM project with a seven-year payback period could give a better solution than one

with an expected two-year payback. The investment in CIM must be thought of as essential to achieve the company's long-term objectives. Since the implementation will be evolutionary, a long-term commitment to the investment must be made, and a company must include CIM funding in its forward planning (17).

Teicholz and Orr (36) found that to justify CIM technology successfully, additional benefits - both tangible and intangible will have to be included. Tangible benefits include, but are not limited to, shorter lead-time, reduced inventory and lower product costs. Examples of intangible benefits that may lead to increased market share and higher profitability are quicker response to market needs, improvement in on-time delivery and higher service level. In order to fairly justify investment for CIM, only focusing on tangible benefits will not be adequate (43).

Foston et al (9) concur with this view stating that *"Intangible factors normally not taken into account have now been incorporated into financial justifications for CIM systems"*. The problem however is that how well and when the intangible benefits will be realised cannot be easily predicted. In addition, as noted by Chen et al (43), not only do the effects of investing in CIM need to be evaluated, but also the effects of not investing in CIM require to be thought through. The results from an empirical investigation of the usage of Computer Integrated Manufacturing in German hardware manufacturing (55) indicate a large number of reasons that caused firms to invest in CIM. The most prominent of these reasons are a reduction in order processing time, an increase in scheduling effectiveness, and shorter delivery delays (55).

2.5.2.1 Return on Investment Analysis (ROI)

This method uses an evaluation of the average annual income generated during the life of the project, expressed as a percentage of the capital cost (54). The return on investment (ROI) analysis for a computer integrated manufacturing system is very difficult for several reasons. First, with a new installation there is no experience available, which will support the analysis. Second, the computer control system has numerous intangible benefits, which cannot be anticipated before it is installed and operated. Third, a computer controlled module may show no benefits if it is taken alone; however, it may bring substantial benefits when it interacts with other modules of the system. Fourth, a new technology brings structural changes to an organisation (19).

2.5.2.2 Payback Period

In contrast to the Return on Investment method, this approach evaluates the number of years before which the cumulative income from the project exceeds the original capital costs. This clearly excludes the benefits of longer-term advantages, and often, if used for comparison purposes, favours a project with high early returns rather than one with a higher overall earning potential but which requires more time to establish. Like the ROI method, however, it takes no account of the time value of money (54).

To conclude, few if any, CIM projects would satisfy Return On Investment (ROI) criteria. Payback and rate of return are essentially short-term criteria, and cost justification of CIM should not be approached on this basis alone, since it is a major business strategy (not just a cost reduction exercise) (9). Small and medium sized companies, which have had no or little experience

with the CIM technology, will have the greatest difficulty calculating a return on investment. They are used to making simple cost comparisons, without considering benefits obtained by system integration and the use of various manufacturing strategies (19).

2.6 Future Direction of CIM

At a time of ever increasing technological development, it is hard to predict the future research direction of CIM and related areas. However, some researchers have made an attempt to foresee the future direction, which will dominate the researchers' mind for the next decade, based on the current developments in CIM research (5). It is commonly expected that Computer Integrated Manufacturing (CIM) will ultimately determine the industrial growth of world nations within the next few decades (13).

It can be argued that today's competitive and agility requirements of the global market can be only met by virtual enterprises. To ensure a brighter future in the present market requirements research in virtual CIM and the application of it in worldwide manufacturing industries are beginning to emerge. Application of virtual CIM has been proposed as a necessary step towards the future of manufacturing to face competitive challenges. Research in robotics and automatic guided vehicles is predominant in the research direction of advanced tools and technologies for the application of CIM (5).

The move toward integration is an evolution of earlier computer systems. It is clear that computers will continue to increase in power and reduce in cost, allowing an increasing amount of data to be economically processed. Weatherall (37) notes that both individuals and companies want to be sure that

time and money invested in CIM will not suddenly be made obsolete by a newer technology. Furthermore, diverse developments in CIM components, which have been achieved need to be integrated into the CIM system in a cohesive manner to provide a complete and intelligent solution for manufacturing industries and help them step into the next decade with confidence and competitive ability (5).

2.7 Overview of Irish and Libyan Industries

"Companies (and countries) that emphasise CIM are likely to have significant competitive advantage over those that do not"(2).

Bolk and Manen (56) argue that technology is the most important resource for development. While Lister and Donaldson (57) claim that the growth of the manufacturing sector in so-called "developing countries" has long been seen as crucial for economic development. Sharif (3) progresses this further as he states that it is the management of technology that is indispensable for both the survival as well as the prosperity of productive enterprises in developing countries under the current trend of trade liberalisation and attempts to attract foreign direct investment.

According to Cyranek (58) the availability of Information Technologies (ITs) has reduced the size of the world to an extent that was impossible before. What is more, the required response time in the global community has been dramatically reduced. The implications of this phenomenon could offer new opportunities for developing countries. Small and Medium sized Enterprises (SMEs) play an increasingly important role in the competitiveness of many industries in the areas of product and process innovation, flexibility, and in the

development of innovative management methods, organisational conventions, and human resource practices. Gunasekaran et. al. (49) argue that one of the ways that SMEs can achieve a competitive advantage in manufacturing is through the implementation of CIM. Since almost all enterprises in developing countries are of small or medium scale, their capability to introduce technological change depends on the support provided by the national technological infrastructure. What can be bought and what can be locally developed depends on the status of this infrastructure, which is supposed to promote technological innovation through strong triangular linkages among (3):

1. Academic institutions involved in science and technology education and research (Academia),
2. a broad range of science- and technology-related Research and Development organisations (R&D Units),
3. and the engineering and industrial productive enterprises industry.

Small and Medium sized Enterprises (SMEs) have been forced to increase automation in their quest to produce parts faster and with greater consistency and conformity to quality specifications. Automation alternatives, such as CIM, have been crucial and instrumental in allowing SMEs to reduce lead times, and increase flexibility and reliability. Large enterprises, having an abundance of resources, qualified staff and computerised systems, are able to develop their own methods in the implementation of CIM (49). Erenay et. al. (59) point out that SMEs, on the other hand, need external assistance and technical recourses since they lack some or most of these facilities themselves.

A recent survey showed that almost 87% of SMEs in the USA are using or

planning to use CIM (49). With a wider basis of skills and infrastructure, more advanced developing countries may be in a better position to adopt IT and to increase their productivity and their international competitiveness (32).

Table 2.1: Classification of Industrialisation Level in Developing Countries (60)

Subdivision	Examples
Pre-industrial level	Most African countries concerned especially with agricultural production and public health
Beginning industrialisation level	Nations with demonstrable potentials to improve on the status quo, e.g. **Libya**, Egypt, Saudi Arabia and Pakistan
Relatively advanced industrialisation level	Nations heavily involved with technological adoption and industrial operations, e.g. Brazil, China, Mexico, Argentina, South Korea, Taiwan, India, South Africa and Israel

Education is vital in providing desperately needed skills for national development and appropriate suitable industrialisation in developing countries where there is a shortage of labour skills. Industrial engineers who are well educated with skills to lead, improve, adapt, innovate and be entrepreneurial are needed in greater numbers as the economies of these countries grow (57).

2.7.1 Libya

Oil export revenues in Libya account for over 95% of Libya's hard currency earnings (and 75% of government receipts) (61). Partly due to higher oil export revenues, Libya experienced strong economic growth during 2003 and 2004, with real Gross Domestic Product (GDP) estimated to have grown by about 9.8% and 7.7%, respectively. Real GDP is expected to grow 6.8% in 2005, with consumer price inflation of 4.0% (61). Petrochemical industries and Processing of foodstuffs continued to remain a high priority, and the largest numbers of plants built during the 1970s were in this area (62).

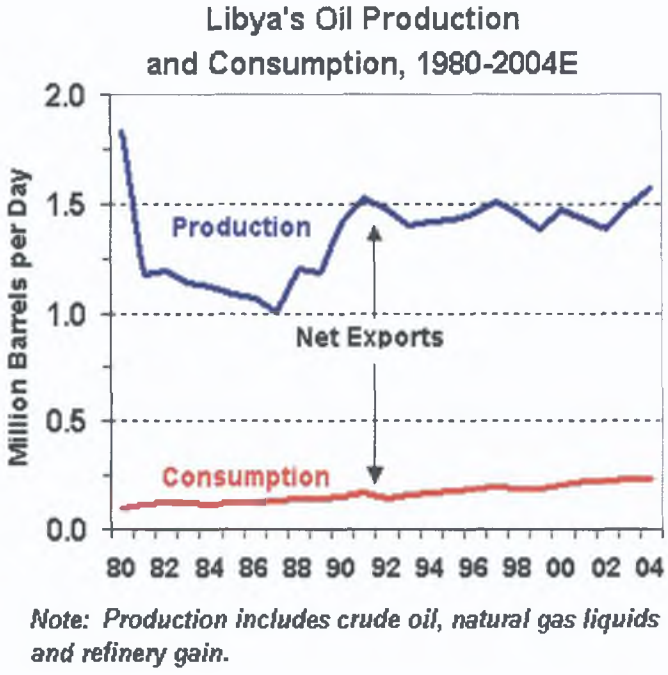

Figure 2.13: Libya's Oil Production and Consumption, 1980-2004E (61)

In the past, Libyan policy relied greatly on freeing industry, including manufacturing, from dependence on foreign ownership or control (62). All manufacturing and private-sector industries, including food processing, textiles, tanning and the production of traditional handicrafts were nationalised. (63). In terms of contribution to Gross Domestic Product (GDP), in 1983 manufacturing contributed only four percent of the total.

GDP-composition by sector (61)

agriculture: 7%

industry: 47%

services: 46% (1997 est.)

The non-oil manufacturing and construction sectors, which account for about 20% of GDP, have expanded from processing mostly agricultural products to include the production of petrochemicals, iron, steel, and aluminium (64).

Recently Libya has begun to implement new policies with regards to the industrial sector, including moving from public-sector to private-sector and encouraging overseas investment in manufacturing. Libya has launched an investment plan at a cost of USD 35 billion for 2002-2005. It is hoped that local and foreign capital will join it at the rate of 30 to 40 percent especially in the fields of oil and industry (65).

The Secretariat of the General Peoples Congress issued Law No. 5 for the year 1997, concerning the encouragement of foreign capital investment. This law aims to encourage foreign capital investment to set up investment projects within the frame of the general policy of the State and the aims of the economical and social development in particular:

- Transfer of modern technology.
- Building the Libyan technical personnel.
- Achieving location development.
- Participation in developing national products to help it enter the International Market.
- Variation of income sources.

The General Peoples Committee issued decision No. 21 for the year 2002, which allows investment of foreign capital owned by Libyan citizens and citizens of Arab and Foreign countries, in the fields of Industry, Agriculture, Tourism, Health, Services and other fields that the General Peoples Committee decides to add (66).

2.7.1.1 Libyan Government Industrial Strategy

It is becoming increasingly clear that Libya is moving towards a variety of

economic reforms and a reduction in the state's direct role in the economy. In June 2003, the President of Libya said that the country's public sector had failed and should be abolished (61). In same year, Libya unified its multi-tiered exchange rate system (official, commercial, black-market) around the IMF's (International Monetary Fund) special drawing rights, effectively devaluing the country's currency. Among other goals, the devaluation aimed to increase the competitiveness of Libyan firms and to help attract foreign investment into the country (61).

Government policy concentrates on the reconstitution of the internal marketplace in order to replace imports with domestic production that is growing, profitable and competitive, and that generates expanding tax revenues in a global market, with the following aims (66):

1. Increase the participation of the private sector in manufacturing industry.
2. Active participation of the government in the creation of an appropriate environment for private business.
3. Increase the productivity and capacity of industrial enterprises.
4. Attraction of direct foreign investment.
5. Creation of new jobs in the sector.
6. Concentration of industries in industrial development zones.
7. Modernisation of production with the purchase of new technologies and training of human resources.
8. Encouraging exports.

2.7.1.2 Why Libya?

Some of the mean reasons for choosing to study Libya as an example of a developing country include:

- A recent worldwide survey placed Libya as number one country for interest in new exploration.
- Libya is an emerging market, which has a real need for development in all sectors.
- Libya is often considered the gateway between Europe and Africa.
- Libya benefits from a long cost line on the Mediterranean Sea and the Sahara in the south (66).

2.7.2 Ireland

The application of AMT in Irish companies began in late 1980s (26). Companies emphasised their need for multi-disciplinary engineers and technicians who could deal with this type of work. It was deemed important that higher education establishments played an important role in this type of training and were also an important source of specialised technical support (26). Ireland is claimed to be the most globalised economy in the world and is also number one in Europe in the growth of creative capacity (67). It is believed to have the best education system in meeting the needs of a competitive economy. Ireland's workforces have proven themselves to be flexible when faced with new challenges (67).

It is interesting to note that Hashmi and Cuddy (26) have found that the majority of the larger manufacturing industries in Ireland that use new

technological developments in a move towards enhancing productivity and competitiveness are of overseas origin.

2.7.2.1 Reasons for Success

Economic success over the past decade in Ireland, was driven largely by the performance of the internationally traded goods and services sectors, and in particular by the growth of foreign direct investment. The reasons for Ireland economic success are well documented. The Department of Enterprise, Trade and Employment Review of Industrial Performance and Policy 2003 (68) summarised the key factors as follows:

External Factors

1. The growth of foreign direct investment globally in the 1990s, and in Europe following the stimulus provided by the single European market.
2. Generally favourable exchange rate trends until 2002.

Domestic Factors

1. The strategic policy decisions to improve human capital and encourage foreign investment started in the 1960s.
2. Improvements in the enterprise environment created by reforms to public finances, reductions in taxation and wage moderation under the national partnership agreements.

The foreign-owned sector was a major contributor to growth in output, exports and employment. Foreign-owned companies also produced a significant multiplier effect, with positive effects on the indigenous sector concerning employment creation, skills development and quality improvements (68). U.S. investment has been a particularly significant factor in the growth and

modernisation of Irish industry over the past 25 years, providing new technology, export capabilities, and employment opportunities (69).

2.7.2.2 Why Ireland?

The researcher has chosen Ireland as an example for the developing countries to follow because to some degree Ireland has faced the most important barriers to AMT innovation in the developing countries, which are:

- Economic entry barriers: Government policy in Ireland has provided financial inducements such as, direct grant aid, tax incentives, and training/infrastructural support, to potential electronics and software companies.
- Technological experience barriers: Ireland has faced a similar situation to that facing the majority of developing countries today.
- Market characteristic barriers: Ireland has also experienced the influence of market barriers and used the fact that it is a member of the European Union to attract investment from outside Europe.

All of these barriers point to the need for suitable government intervention in developing countries to support R&D activities, to encourage local firms, and to encourage collaboration across industries and between industries and academia (70). Ireland's economy has performed extremely well over the last decade and it has built a world class reputation across a range of technologies. It must now continue and enhance this performance (71). Ireland's education system has a strong reputation. Technological development and the complexity of business requires higher levels of academic achievement and increased links between education and enterprise sectors. All this make Ireland good model to

be followed by developing countries (71).

2.8 Chapter Summary

This chapter has addressed the first objective of this research and the following chapters will build on this to provide a clearer picture of the existing situation in Ireland and Libya.

Chapter 3 Methodology

3.1 Introduction

This chapter will outline the research design and methodology used to compile this thesis. Topics that will be addressed include research design, qualitative methods, quantitative methods, choice of research strategy, selection of the sample, research instruments, questionnaire and interview.

3.2 Research Design

Every research project should have a specified framework to ensure that the research will be carried out effectively. Research design is simply a plan of action for the collection and analysis of gathered information. It is important that the correct type of research is carried out in order to realise the objectives (72), (73). This research includes both qualitative and quantitative research. These different approaches need to be discussed before decisions can be made as to which type of research method is suitable for this dissertation.

3.3 Qualitative Methods

Qualitative research is defined as 'an unstructured, primarily exploratory methodology based on small samples, intended to provide insight and understanding' (74). Qualitative research methods were developed in the social sciences to enable researchers to study social and culture phenomena. Examples of this type of research methods are participant observation, interviews and case studies (75). This type of research is carried out when

trying to get information about sensitive issues, to uncover people's subconscious feeling and to understand complex feelings, which are difficult to glean from a questionnaire (74). From a psychological point of view the superficial answers the respondent gives in an interview have deeper meanings, which can be interpreted. From a sociological point of view, the researcher empathises with the respondents and tries to see the world from their point of view (74).

3.4 Quantitative Methods

'Quantitative research is a research methodology that seeks to quantify data and typically applies some form of statistical analysis' (74). Quantitative researchers collect facts and study the relationship between one set of facts and another. They are likely to produce quantified and if possible generaliseable conclusions. Typical examples include controlled experiments and questionnaires (76). Quantitative research is often carried out in a structured form. This means that questions are prepared and asked in a structured order. Respondents can be reached in several ways; through the post; by email; by telephone; or personal interviews (74).

3.5 Choice of Research Strategy

For the purpose of this study it was necessary to collect data from several companies in Ireland to generate enough information on the perceived benefits of CIM. The most appropriate method to glean this information was, therefore, through questionnaires. The managers' time in companies in Ireland is limited and it was thought that a questionnaire would be the best method to gain

accurate information and enable analysis of a wide range of that information. Through the use of questionnaires it is also possible to avoid interviewer bias and achieve an objective unbiased view of the CIM system.

The researcher also has conducted four interviews in Libya with manufacturing managers and production engineers. This facilitated a deeper insight into the manufacturing situation in Libya and the possibilities of adopting CIM in Libya. As mentioned before Libya is in the process of economic reform and industry is changing from the public sector to the private sector. Libya, as a developing country, can learn from the development of the Irish industrial sector. Therefore, it was necessary to gain statistical data on the benefits of the CIM system in Ireland to show the benefits for industry in Libya.

3.6 Selection of the Sample

A sample is 'a subgroup of elements of the population selected for participation in the study' (77). The first step in the sampling process is to define the target population (78). The target population can be defined as 'the collection of elements or objects that possess the information sought by the researcher and about which inferences are made' (77).

As the main aim of this dissertation is to estimate the benefits resulting from the successful implementation of CIM system in some companies in Ireland, the target population of interest was industrial companies in Ireland. The sample was selected from a website database of The Irish Times Top 1,000 companies 2004 in Ireland (79). Companies were randomly selected from the following sectors represented on the database:

- Food Processing
- Electrical Engineering
- Drink & Tobacco Industry
- Computer Software Development/Services
- Computer Hardware/Related Products
- Communications
- Clothing and Footwear
- Chemical Industry
- Instrument Engineering
- Metal production
- Rubber and plastics processing

In total, 267 questionnaires were distributed to manufacturing companies around the country. The closing date for return of the questionnaires was one month after the questionnaires had been distributed by post. At this stage there were 81 respondents. An additional 20 completed questionnaires were received after the closing date but the information contained in theses questionnaires was not included in the analysis that is presented in Chapter 4. The response rate before the closing date was 30%. Overall the response rate was 38%.

3.7 Research Instruments

Questionnaires were distributed to 267 different types of manufacturing firms in Ireland, and a series of interviews conducted with a number of working professional in Libya, were the instruments of this research. These two research methods provide a mean of being able to ask different questions and the data collected can be recorded quickly and accurately.

3.8 Questionnaire

A questionnaire is a tool to collect information. It is made up of items to which the user supplies answers or reactions. A well-designed questionnaire that is used effectively can gather information on both the overall performance of the test system as well as information on specific components of the system (75). Questionnaires are quick, relatively inexpensive to administer and can be sent to a wide number of people. They also allow the respondent to fill it out at their own convenience. But there are also some disadvantages. The biggest single disadvantage is that a questionnaire tells you only the user's reaction, as the user perceives the situation. Also, response rates are often low, and questionnaires are not the best vehicles for asking for detailed written responses (76).

The most common types of questionnaire are closed-ended questionnaires and open-ended. A *closed-ended questionnaire* is one that leaves no room for individual comments from the respondent. An *open-ended questionnaire* requests the respondent to reply to the questions in their own words, maybe even to suggest topics to which replies may be given. When producing this questionnaire both the reliability and validity were a matter for concern. The reliability of a questionnaire is the ability of the questionnaire to give the same results when filled out by like-minded people in similar circumstances (75). The validity of a questionnaire is the degree to which the questionnaire is actually measuring or collecting data on what you think it should be measuring or collecting data about (75).

3.8.1 Questionnaire Design

Questionnaire design is a long process that demands careful attention. A questionnaire can be a powerful evaluation tool and should not be taken lightly. Design begins with an understanding of the capabilities of a questionnaire and how they can help the research. In this work the researcher followed the next steps to design and administer the questionnaire:

1. Defining the Objectives of the survey
2. Determining the Sampling Group
3. Writing the Questionnaire
4. Administering the Questionnaire
5. Interpreting the Results

The major hurdle in questionnaire design is making it clear and understandable to the target group. A closed questionnaire format was used for the purpose of this research, as it 'provides a better response and is easier to answer and takes less time for the respondent to answer' (80). Careful consideration was given when choosing each question, to get the best possible return of information that was relevant to the research. The questionnaire was divided into sections. The first sections addressed the general background information on the companies. Section two addressed those companies who used CIM components. Section three was specific to companies that do not use the CIM component. The full questionnaire can be found in Appendix A.

3.8.2 Postal Questionnaires

Because the chosen sample is dispersed around Ireland, sending a postal questionnaire is the most effective way of reaching a large number of the target

population. It also allows the respondents to fill out the questionnaire at a time that is convenient to them so they do not need to change their busy schedule to do an interview for example. Every effort was made to maximise the response rate and minimise the respondent effort. This was achieved by:

- Ensuring that the questionnaire was sent to the general manager, technical manger or the production manager in all the sampled companies, as they would have the knowledge and experience necessary to complete the questionnaire.
- A covering letter accompanied all questionnaires. This letter explained the nature of the research and conveyed the importance of respondents' participation and thanked them in advance.
- The questionnaire was limited to four pages and the layout was clear.
- Close-ended questions were asked, according to the fact that the respondent would be more willing to answer 'tick the box' questions than questions that require a higher level of effort.
- A pre-test of the questionnaire was carried out to make sure that the questions were unambiguous and easy to understand. A pilot questionnaire was revised and adapted. It was then completed by two director managers and five postgraduate students from the school of Mechanical and Manufacturing Engineering in DCU and revisions were made in response to their comments.
- A pre-paid envelope was included to encourage respondents to reply.
- Telephone reminders were used 10 days after sending the questionnaire to urge some companies, which had not replied to complete and return the questionnaire.

3.8.3 The Questionnaire Response

As a result of these efforts, 81 completed questionnaires were received. This is equivalent to a response rate of 30%. There was no evident or consistent structure that caused the other companies not to participate. The questionnaire was divided into three sections. The first section addressed general information on the company and if the company used components of CIM. The second section addressed companies that used any component of CIM. It sought information on the benefits of using CIM, the timeline for implementing CIM and the perceived effectiveness of CIM in the company. The third section addressed companies that do not use CIM and the obstacles for implementing CIM components.

3.9 Interview

Interviews are generally conducted on individuals who are key players in the situation under investigation. There are three main types of interview. First, the structured interview has a set environment and questions that does not change from interviewee to interviewee. Second, the semi-structured interview where the questions are usually more open than the structured interview. Finally, the unstructured interview is the most flexible form of interview. Questions may or may not be predefined and are asked in no particular order (75).

In the course of this thesis the researcher carried out four in-depth structured interviews with people involved in and knowledgeable about their field from four sample Libyan industrial companies. Due to the confidential nature of some parts of the interview all interviewees are referred to only by their position in the company rather than by name. The following topics were

discussed in the face to face structured interviews. General questions such as the company size, the nature of the company's business and the current level of automation were asked, followed by questions, which focused on possible future implementation of CIM and any perceived obstacles to this. A complete list of interview questions appear in Appendix B.

3.9.1 Limitations

Once preliminary contact had been made with the companies, it was discovered that confidentiality was a major issue, which meant that less information could be received. Due to the fact that interviews are time-consuming only four people were interviewed. However the four interviewees were carefully chosen to represent a variety of sectors and expertise across the sectors.

3.9.2 Selection of the Interviewed Companies

The companies chosen where the interviews were conducted were from a range of sectors and were chosen to represent the main industries (Food and Beverage, Dairy Products, Plastics and Metals) in Libya. These companies are leaders in their fields and continue to experience high demand for their products. Petrochemical industries and foodstuff industries are also a high priority in Libya's industry sector. The photos featured on the following pages show some parts of the companies interviewed.

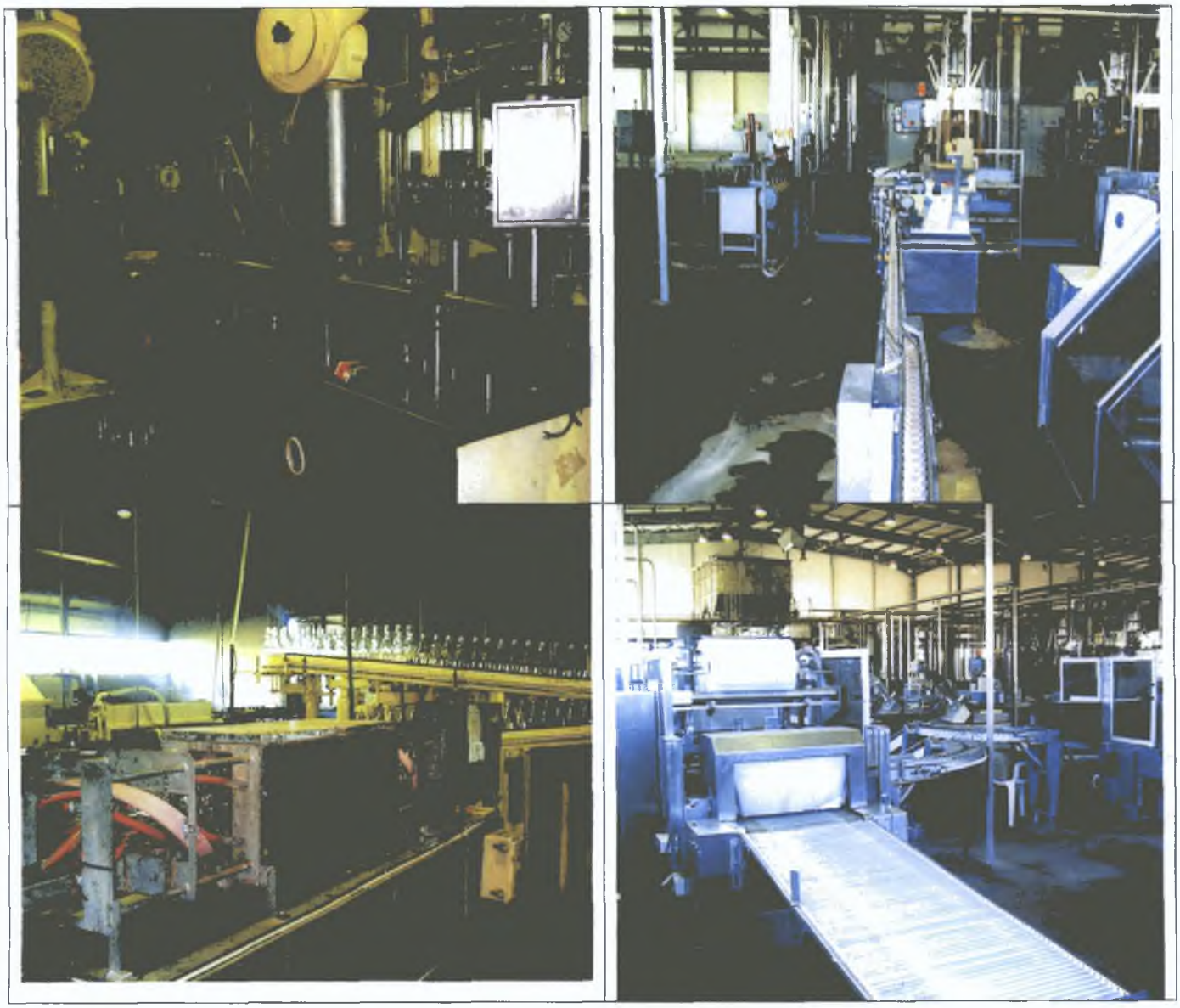

Figure 3.1: Manufacturing Equipment in Some Interviewed Companies in Libya

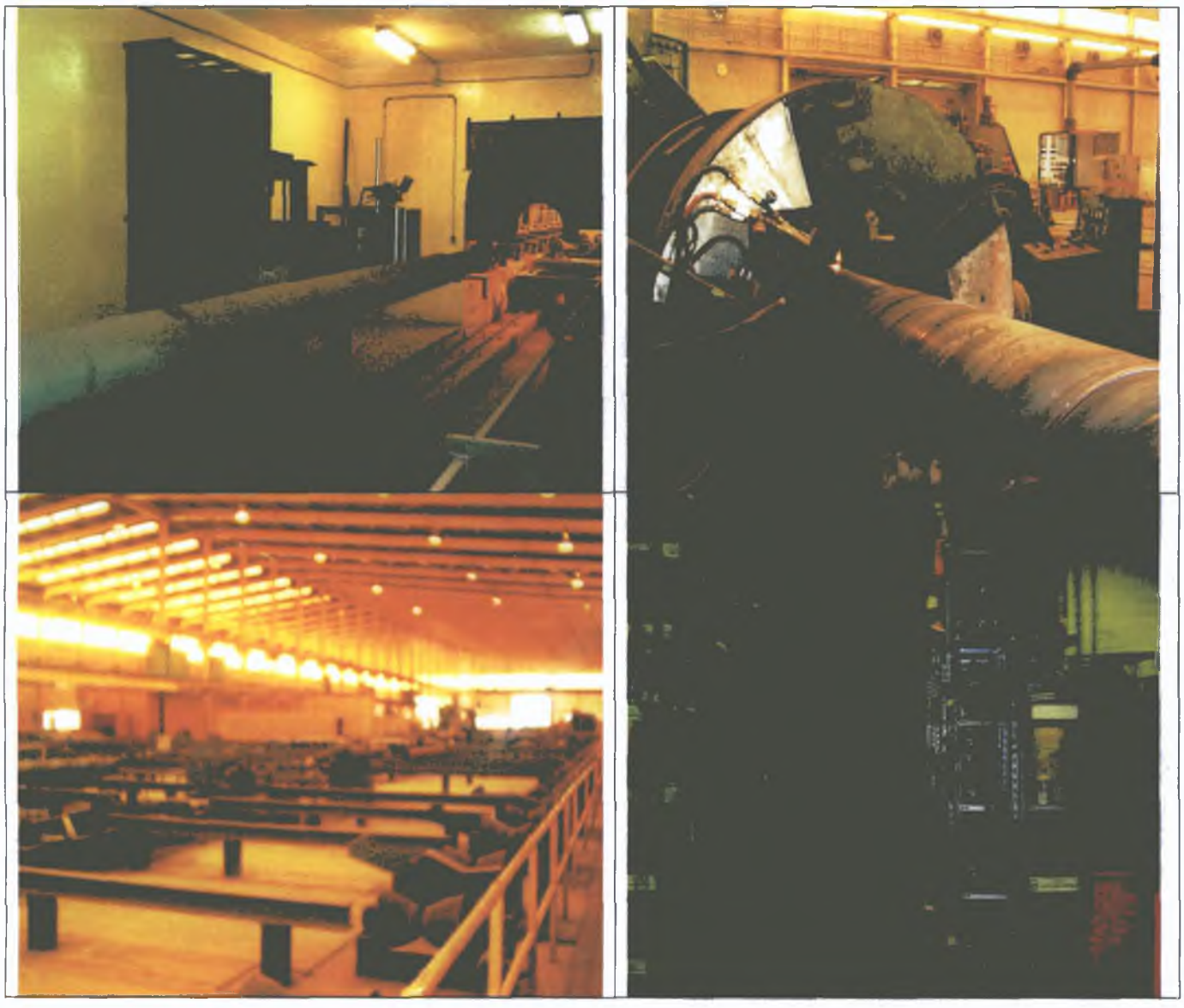

Figure 3.1 continued Manufacturing Equipment in Some Interviewed Companies in Libya

Figure 3.1 continued Manufacturing Equipment in Some Interviewed Companies in Libya

Chapter 4 Results

4.1 Interview Results

The aim of these interviews was to explore the current situation in some companies in Libya and to identify the main obstacles that they are likely to face when attempting to implement CIM. The first three questions sought general information about the companies surveyed. This included detail regarding the type of company, its size and the position of the person being interviewed within the company. The information from these questions is outlined in Table 4.1 below:

Table 4.1: Results for Q1, Q2, Q3

Interviewee	Position/department	Company	Sector	Company Size
1	Production engineer	Company A	Food and Beverage	Medium
2	Production manager	Company B	Dairy Products	Medium
3	Manager	Company C	Plastics	Large
4	Manufacturing engineer	Company D	Metals	Large

4.1.1 Using CIM and Automation Level

As a result of today's powerful technological trend toward Computer Integrated Manufacturing and its perceived large economic benefits, realisation of the importance of CIM implementation has now become a major goal for many manufacturing industries across the world. But the situation in Libya is different, as most interviewed companies do not use CIM. Some of them have some level of automation and some of these companies use traditional manufacturing systems. For example one interviewee from company A said

"No we don't use CIM, but we do have a high level of automation in some parts". He also said

" We will be able to integrate the machines together as a part of CIM but we need expert people and money and helpful management in order to do so".

He did recognise that CIM and similar high technology are important in today's industrial environment. Anther Interviewee from company B commented *" we have a very poor level of automation in the systems used in the warehouses and only some automation on the shop floor"*.

4.1.2 CIM Information

The literature review has highlighted the benefits of CIM in the manufacturing industry. The state of current CIM information highlights a major problem facing these Libyan industries i.e. poor CIM background. There is a lack of people with appropriate technical background, who are involved in design and implementation of CIM systems, and who are up to date on the latest CIM technologies. A production manager interviewed stated, *"We have very little idea about CIM. We know that to implement new technology is a complex issue and needs expert people"*. Alternatively, a manufacturing engineer in another company stated that *"we have heard of CIM and are aware of its benefits. We feel CIM will give our company competitive advantages"*.

The problem would seem to lie in the fact that there is discrepancy between engineer's beliefs regarding the benefits of CIM technology and manager's understanding of and willingness to invest time and money in its implementation.

4.1.3 Management Perception

Too many people still view the computer as an enemy, and costly, and do not see it as a competitive asset. Management education is very important in relation to the implementation of CIM technology. Companies run by management that has limited knowledge will face failure in this implementation. Management also must realise that although there is no quick return on investment in integrated automation, the acquisition of CIM technology will not be possible without the requisite long-term financial investment. From the interviewed companies we can see that management in Libya is slow to understand the need for this investment.

One interviewee from company B stated *"The main obstacles are the cost of CIM, the management's reluctance to invest in the implementation of CIM and the necessary training"*. He also suggested *"management do not have sufficient information about the benefits of CIM to the manufacturing industry"*. This was supported by another interviewee from company D who stated that *"management lack information and knowledge about CIM and there is a lack of cooperation between management and the shop floor"*.

4.1.4 Current Financial Situation

The financial justification of implementing a new technology was highlighted by some interviewees as a main problem. In an interview with a production engineer of a company, he said that *"there is no fixed budget for investment in AMT"*. He also commented *"I feel that the main obstacle is the change from public to the private sector and the consequent need for more investment*

and a higher budget". This was supported by another interviewee from company C who stated that *"there is a need for further funding".*

From the interviews in general it would appear that one of the main obstacles to the implementation of CIM is the lack of financial support. This may not simply be an indication of management's unwillingness but also highlights the need for further financial investment from both inside and outside the country.

4.1.5 Education and Training

The success of CIM system is very dependent upon its users and one interviewee from company C confirms this as he states that

"Employees would fear a loss of jobs due to the introduction of new technology and that this needed to be addressed as human resources are vital for the success of any activity".

Education, experience and consulting skills are going to be required to assist the implementation of CIM systems. The most common barrier when attempting to implement CIM is inadequate training on how to use computer systems and a failure to take account of the need to change peoples' attitudes through a programme of education.

One interviewee from company A felt that *"some employees would accept CIM and others would not, depending on the level of education and awareness."* As was noted in the literature review, having an in-house expert is very beneficial when implementing any new technology. It would appear from the interviews that there is a lack of people with the required expertise within the companies surveyed. One interviewee from company D commented that

"despite having a training department, there is a lack of experts and knowledge about implementing CIM".

Another interviewee from company B suggested the need for *"developing links with relevant third level institutions"* and another from company C stated that *"we have plans to create a research centre and a training department linked to a university in order to enhance personnel development within this company".*

The introduction of CIM into an organisation should be welcomed as an opportunity for personnel advancement and the necessary resources invested to enable this to happen.

4.2 Questionnaire Results

For the purpose of this research, it was decided to send out 267 questionnaires to Irish Industrial Organisations. There was an overall response rate of 30%. The data collected from the 81 returned questionnaires were entered into the computer package '*Statistical Package for Social Sciences'* (SPSS) in order to carry out a statistical analysis. SPSS is a statistical package that enables users to perform comprehensive statistical analysis and charting. SPSS is used to solve business and research problems using statistics. It provides the researcher with a wide range of statistics in order to get the most accurate response for specific data types (81). The results of this analysis will be described in detail in this section.

4.2.1 General Questions

Of the questionnaires returned, 41% of these were Irish and 59% were not Irish owned. Of the 59% of responding companies that were not Irish owned, there

was a broad ranging response to the country of ownership (see Figure 4.1). The majority of non-Irish owned companies had USA ownership (26%). Other companies were owned by Germany, the United Kingdom, Japan, Canada and Denmark. One company was owned by a partnership of Germany and the USA.

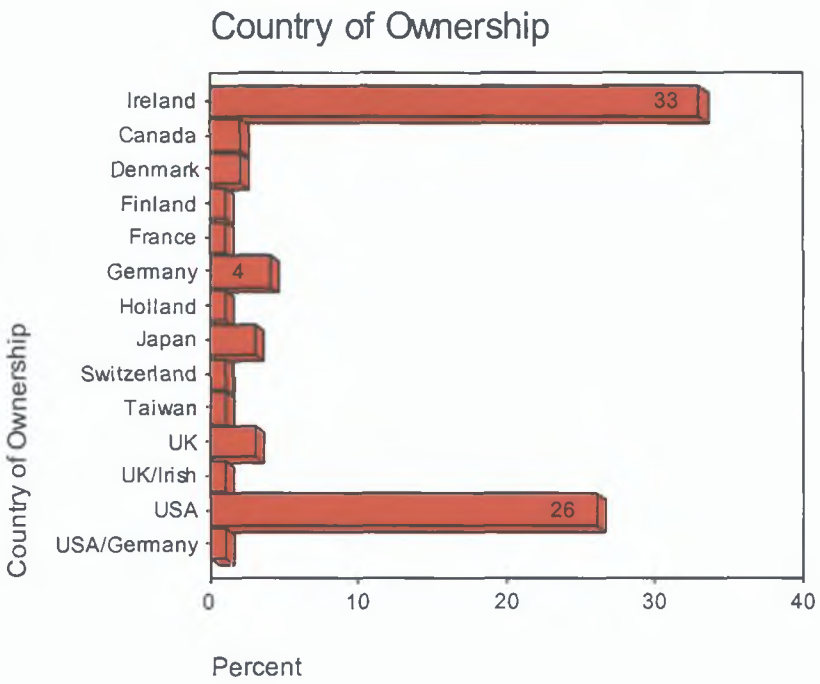

Figure 4.1: Country of Ownership

Of the respondents, 54% described these companies as a medium size organisation (more than 50 and less than 250 employees), 37% were larger companies (more than 250 employees) and 9% were small companies (less than 50 employees).

4.2.2 Companies that use components of the CIM system

69% of the respondents to the survey use CIM components and 31% do not use any components of the CIM system.

Figure 4.2 includes the most important components of the CIM system. It can be seen from the companies using CIM that, 76% are using the CAD element, 68% are using CAM, 41% are using CAQ, 48% are using CAPP, 25% are using CNC, 45% RAC, 63% CSPC, the other components are not as widely used in these companies and 12% of companies are using other components of the CIM system.

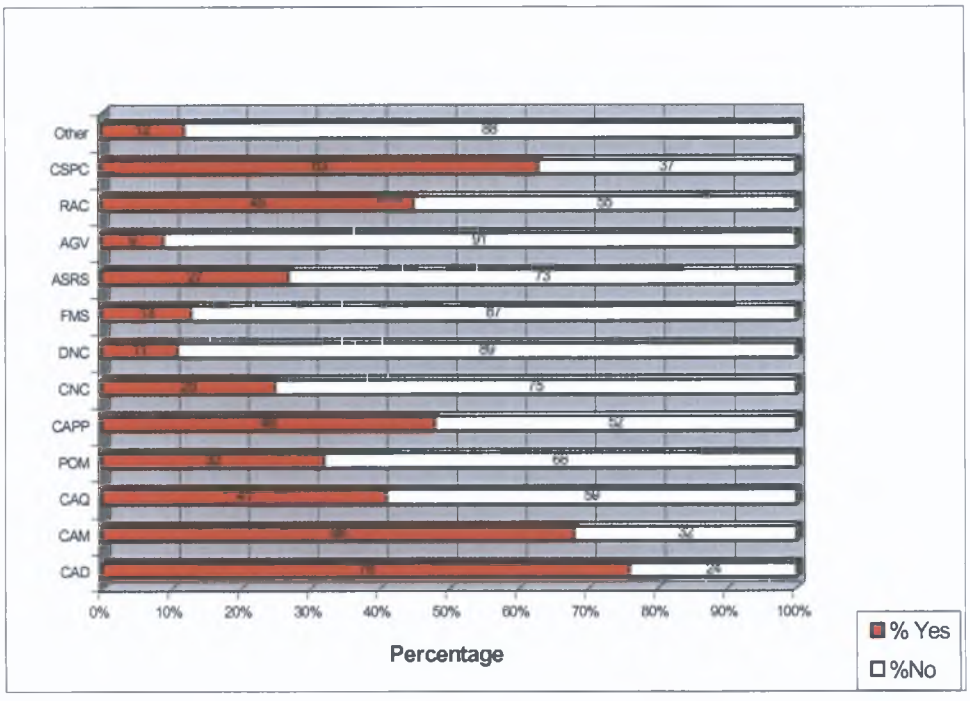

Figure 4.2: Components of CIM Used

The results of the survey indicate that 56% of the companies surveyed are using CIM components in their industries between 5 to 10 years, 16% from 4 to 5 years, 7% from 3 to 4 years, 7% from 2 to 3 years, 5% from 1 to 2 years, 5% from 6 to 12 months, 4% from 3 to 6 months (see Figure 4.3).

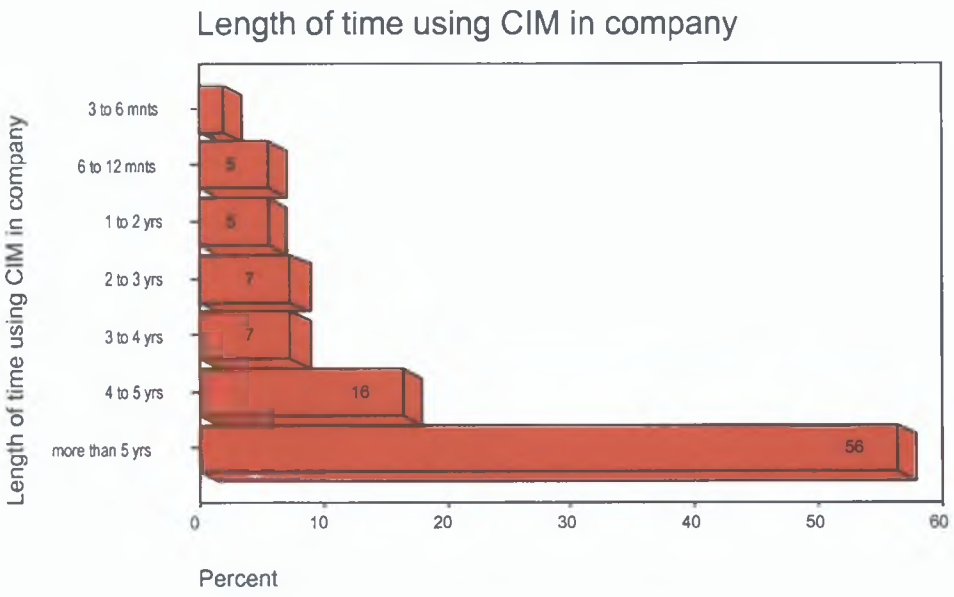

Figure 4.3: Length of time using CIM in Company

When cross tabulation was used to analyse the numbers of small to medium sized companies using CIM compared to larger companies, it revealed that a far greater percentage of larger companies were using some components of CIM (86%), in comparison to medium (60%) or smaller (50%) sized companies.

Table 4.2: Size of Company * Use of Components of the CIM System

	Companies that use CIM		
Size of company	**Yes**	**No**	**Total**
Small	3 50%	3 50%	6 100%
Medium	26 60%	17 40%	43 100%
Large	25 86%	4 14%	29 100%
Total	**54** **69%**	**24** **31%**	**78** **100%**

The majority of the companies surveyed (54%) considered implementing CIM as quite expensive. On the other hand, only 1% of the respondents see CIM as a very cheap system to implement. 19% stated that implementing the CIM

system is neither cheap nor expensive. Another 19% of the companies surveyed see implementing CIM system as very expensive. While 5% could not decide about this issue.

77% of the companies felt that they can decide within 3 years time whether a CIM system is a success or a failure. Whereas, 11% need between 3 to 10 years to decide. 12% of the sample did not know the trial period for implementing CIM in their company.

In relation to the required time to implement CIM the results from Figure 4.4 show that 46% of the companies surveyed need between 6 months to 1 year, 25% stated that they need from 1 to 2 years, 14% need more than 2 years, and 10% said that they implemented CIM system in less than 6 months.

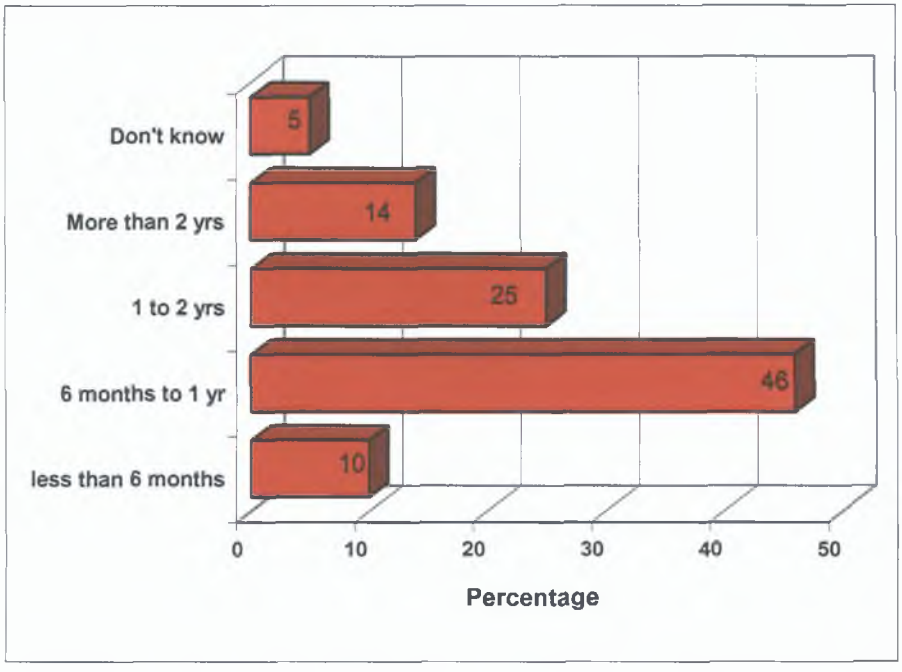

Figure 4.4: Time for Implementing CIM

From Figure 4.5 it can be seen that the majority of the companies (83%) stated that implementing CIM has improved their productivity, and this is the main benefit from implementing a new technology. 80% of the sample stated that implementing CIM

has reduced the production time. 72% of the companies surveyed, stated that implementing CIM has reduced administration costs, another 75% stated it has reduced overall costs, and 70% stated it has reduced indirect labour costs. 59% of the sample stated that implementing CIM has reduced inventory, 57% stated that it has increased accuracy of forecasting, and 67% said it has increased their profits, and that is one of the targets from introducing and spending money on a new technology.

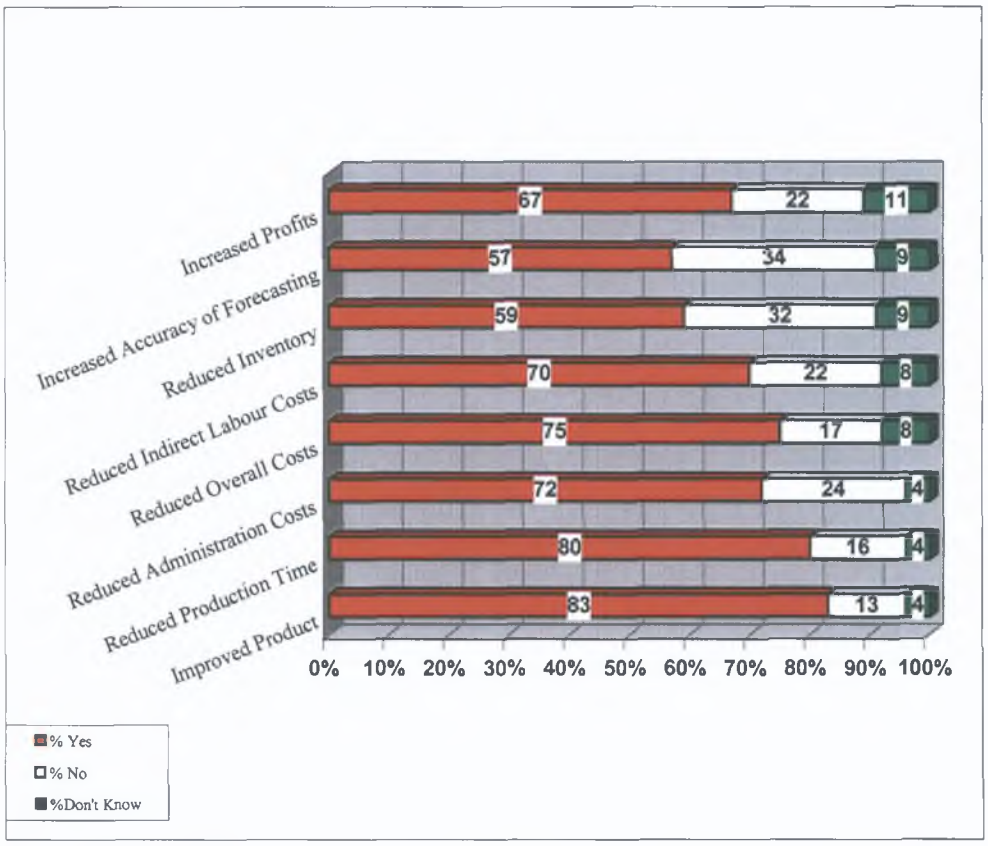

Figure 4.5: Outcomes from Implementing CIM

Companies were then asked about the areas in their companies where components for the CIM technology have had the most impact. Figure 4.6 shows that Human Resources (30%) and Marketing & Sales (33%) were the two areas where the CIM technology was judged least effective. It was

perceived that CIM had the most effective impact in Manufacturing (90%), Material Management (81%), Warehouse and Distribution (81%).

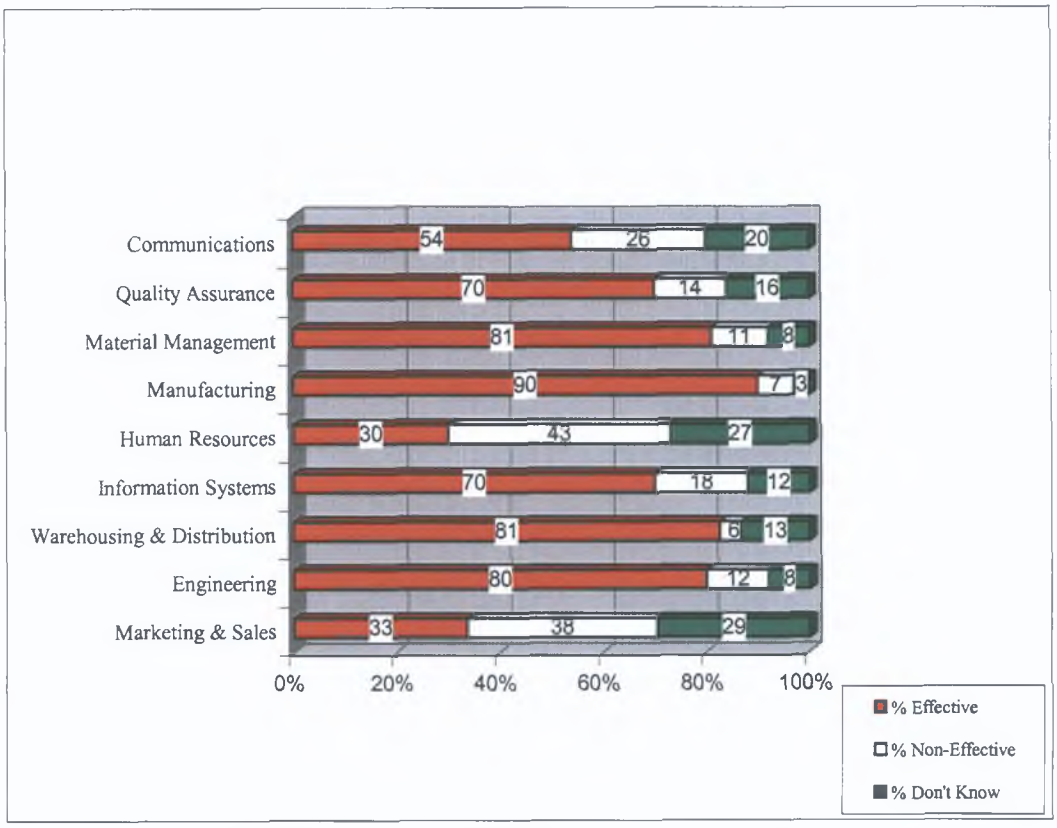

Figure 4.6: Areas where CIM has had the Most Effective Impact

The majority of companies agreed that introducing the CIM technology increased demand on technical knowledge (93%) and skills (90%). When respondents were asked if they thought that CIM is an effective tool for management within their company, 82 % agreed that it was effective, 6% found it was not effective and 12 % did not know.

58% from the companies that use CIM stated, that using CIM has reduced the number of employees, whereas, 28% said it does not, and 14% of them said they did not know.

Overall, 57% of the respondents using CIM admitted that CIM components have improved the communication between all parts of their companies. While

only 29% said it does not make any deference and 14% said they did not know.

When companies were asked what impact they expected from implementing CIM in their companies, 43% responded that they expected better positioning on the market, 59% expected faster product development and 79% expected a higher quality product (see Figure 4.7).

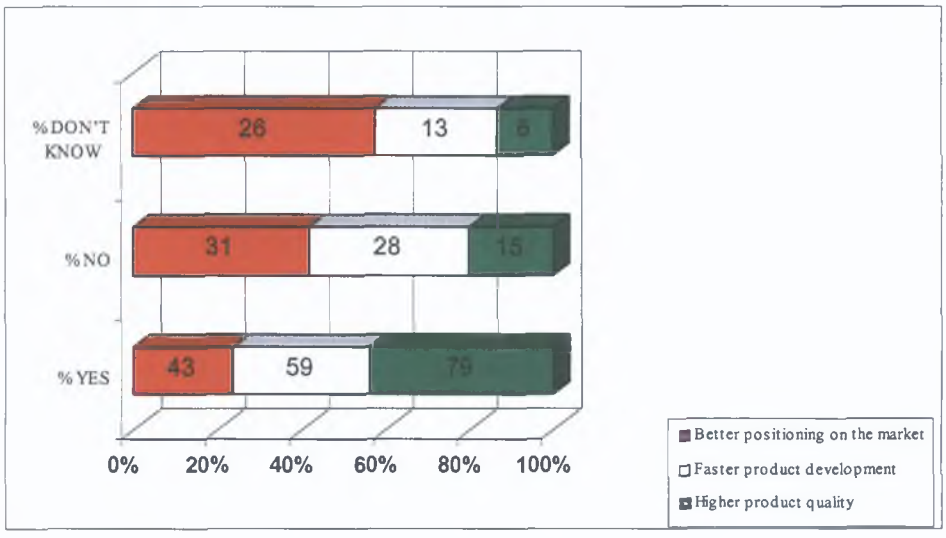

Figure 4.7: Expected Impact on Company after Introducing CIM

91% of the companies using CIM technology reported that their employees were open to the idea of CIM, while only 9% stated that employees did not accept CIM in their company.

From Figure 4.8, it can be seen that the majority of companies surveyed were using the full warehouse system. Although, we can see that some components are used more that others. Inspection was the component used the least (55%) and Inventory was the system used the most (84%).

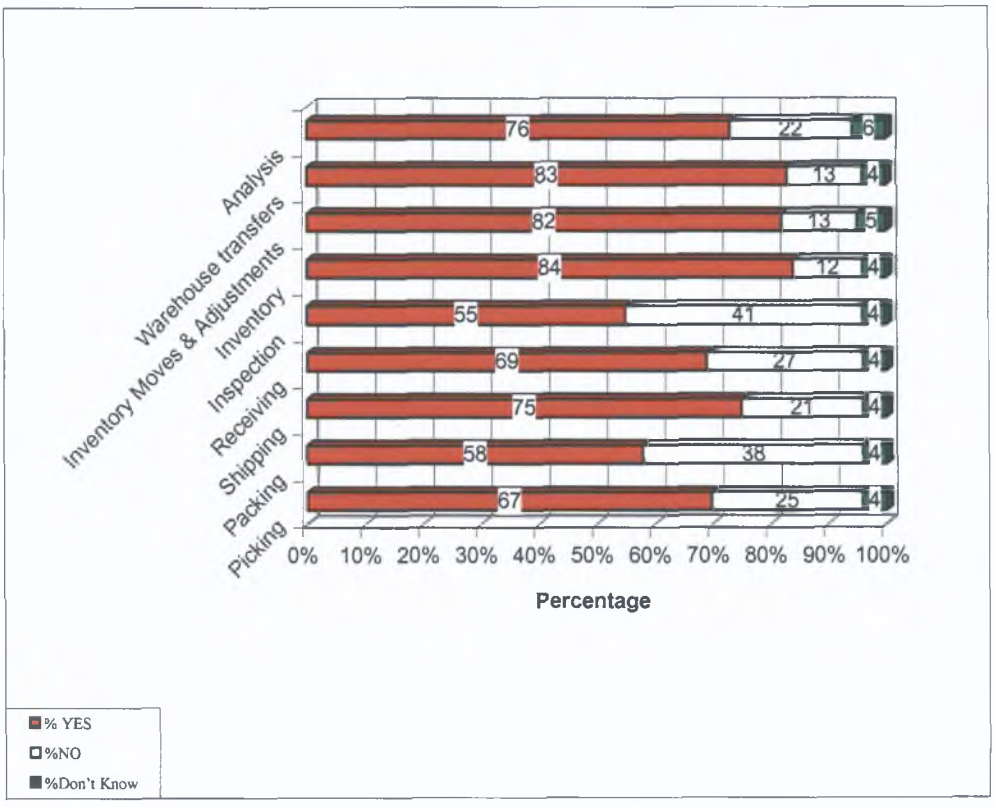

Figure 4.8: Components Included in Complete Warehousing System

Of the respondents 67% agreed that a CIM system is cost effective, in addition to 18% who strongly agreed. Only 14% of companies using CIM were undecided and 1% disagreed that CIM is cost effective.

Of the companies surveyed that use CIM, 54% considered implementing CIM as a worthwhile undertaking and 19% of the respondents rated CIM as an excellent undertaking. 25% stated that the results achieved from implementing the CIM system were reasonable. Only 2% stated that implementing CIM was poor undertaking.

4.2.3 Companies that do not use CIM

The majority of the companies that responded to the survey indicated that they had previously heard about CIM (83%). Only 17% said they were unaware of CIM.

65% of companies that do not use CIM stated that they have not considered implementing CIM in the future. Only 15% said they will implement some components of CIM in the future and 20% said they did not know.

As can be seen in Figure 4.9, regarding the main reason for not implementing CIM, the majority of the companies did not give an answer. Of those who did provide an answer, a large percentage of companies cited all three obstacles as the reason for not implementing CIM. While technical obstacles were seen as the main reason for not implementing CIM, it is obvious that Finance and Organisational obstacles are also important.

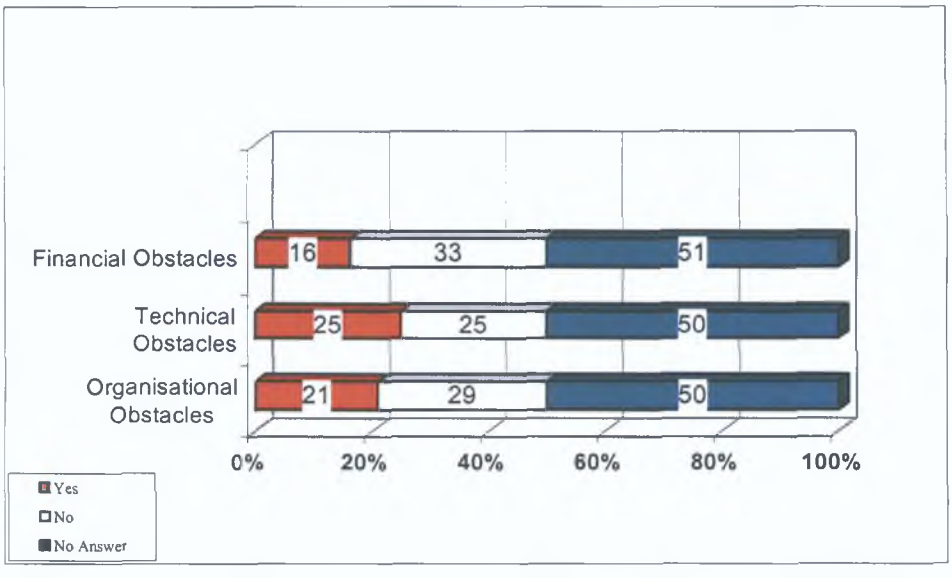

Figure 4.9: Main Reasons for not Using CIM

Chapter 5 Discussion

5.1 Introduction

The primary aim of this research is to estimate the benefits gained from the successful implementation of components of a Computer Integrated Manufacturing (CIM) system in some companies in Ireland and demonstrate the importance of these benefits to overcome today's industrial problems. This research also aimed to review the evidence of CIM effectiveness and efficiency in helping industry to survive in today's competitive global market. This research explores the possibility of encouraging developing countries' industries (for example Libyan industries) to start investing and implementing CIM. The purpose of this research was to critically analyse CIM technology in the Irish manufacturing economy and establish if CIM technology is cost effective, reduces production time, improves quality, reduces cost and if it is an efficient tool for management.

Manufacturing is fundamental to economies around the world. Today's industry competes in a truly international marketplace. For any country to compete in this market, it must have companies that provide high-quality products to their customers in a timely manner. The global competition, which exists today, not only from developed industrial countries, but also from low labour cost countries such as China, forces manufacturing managers to consider and adopt innovative and advanced technologies (13). Implementation of CIM could help companies achieve their competitive goals to survive in the global market environment as long as the technologies chosen are appropriate

to meet their objectives. Application of CIM has been proposed as a necessary step towards the future in manufacturing to face competitive challenges.

This research emphasises the significant role of Computer Integrated Manufacturing (CIM) to a country's economy. Also, the results of the literature survey indicate that introducing a new technology in any enterprise can lead to reduced costs, and this is the main target of any manufacturing management in today's competitive global industry and market, such as decreased labour cost and consequent decrease in unit costs. Considering the costly, complicated and lengthy processes of CIM implementation, it is necessary to gain a comprehensive and reliable picture of CIM implementation in a country where CIM technology is already being implemented. A total of 267 industrial companies in Ireland were questioned. As mentioned before, the research aimed to establish the following:

- The current status of CIM implementations in Irish manufacturing companies.
- The main benefits gained from implementing CIM, in companies where it has been introduced.
- The reasons for not implementing CIM in companies where it has not been introduced.
- The possibilities of implementing CIM in developing countries, where it was also necessary to conduct interviews with manufacturing managers and production engineers in Libya, to analyse the level of awareness of the benefits of CIM technology.

By establishing the benefits of CIM technology to Irish manufacturing companies, it may be possible to use this example to encourage Libyan

companies to evaluate the benefits for their own companies. It is vital that Libyan companies consider this question now as Libyan industries move from the public to the private sector and foreign investment in Libya is increasing. Recent Government decisions in Libya show a commitment to national investment in many sectors including manufacturing and increased international cooperation and foreign investment (66).

The research into Irish companies showed varied results and a multitude of benefits and limitations for implementing CIM technology in Irish industry. The results of this study show that 59% of the sample was not Irish owned companies. This shows that, just as Libya is currently encouraging foreign investment, Ireland has already opened the door to foreign investment to develop its industries. Moreover, it is commonly accepted that most of the industrial expansion of Ireland was due to the new foreign owned companies in Ireland. Based on the review of the literature, Ireland is trying to keep its industries competitive and establish strategic research programmes to develop Irish industries and to address the current and future needs of them. Irish industries have developed collaboration with Irish colleges to conduct research programmes to aid them in achieving their objective.

The links between Irish industries and Irish colleges are strong and mutually beneficial. For example Science Foundation Ireland provides grants for researchers from around the world and based in Ireland, for outstanding research visitors, for conferences and symposia, and for collaboration with industry (82). A number of companies specialising in CIM also offer consultant services to manufacturing companies across Ireland to achieve maximum value

and competitiveness in the areas of manufacturing efficiency, material and supply chain management and business information systems (83), (84).

This shows the importance of research for Irish industry for achieving competitiveness in the global market. From the interviews conducted with Libyan companies it can be deduced that there is very little collaboration between Libyan colleges and Libyan industry. It is vital that Libya should encourage direct relationships between third level research and industry and manufacturing. It is essential that links between colleges and industry are increased and that there is research support for companies using CIM.

5.2 CIM and Cost

"Although the cost of such a totally automated system is still unacceptably high, some companies have made considerable steps toward CIM with the goal of gaining a competitive advantage in the world market place"(16).

The results showed that implementing CIM components is an expensive undertaking. Of those who use CIM, 54% chose quite expensive and 19% chose very expensive. 33% of those not using CIM who answered the question chose financial obstacles as a reason for not using CIM. So cost is one of the major obstacles toward implementing CIM. This is also true for companies in Libya. Most of the interviewees stated that the cost of CIM was a reason for not considering the introduction of CIM. Implementing CIM components requires a big budget or a large investment from a company. Libya and other developing countries should consider investment from foreign sources as an effective way in helping to implement CIM in a country that cannot offer this

kind of initial investment.

The results of the survey showed Ireland has huge foreign investment especially from developed industrial countries. For example 26% of the companies surveyed are USA owned. This supports the finding of Hashmi and Cuddy (26) that the majority of the larger manufacturing industries in Ireland who use new technological developments towards enhancing productivity and competitiveness are of overseas origin.

'U.S. investment has been particularly important to the growth and modernisation of Irish industry over the past 25 years, providing new technology, export capabilities, and employment opportunities' (69).

It is evident from the interview results that Libya's industry needs investment from inside and outside to achieve competitiveness in the market place. Despite the high income generated in Libya through the oil industry, there is a low level of inside investment in the broader industrial sector. In Libya, there is little foreign investment due to the political nature of the country to date. In recent times, Libya's industry has diversified from public sector to encouraging private investment and ownership. At present there are several foreign owned industries competing to invest in Libya and take advantage of the incentives offered (66).

Once investment is secured it is important for all managers to take into account the overall costs of implementing CIM including the cost of new equipment and skills training. These costs may result in some managers resisting the implementation of CIM technology. Small to Medium sized Enterprises (SMEs) need external assistance and technical recourses to implement CIM as they may lack some or most of these facilities themselves. When cross

tabulation was used to analyse the numbers of small to medium sized companies using CIM compared to larger companies, it showed that a far greater percentage of larger companies were using some components of CIM (86%), in comparison to medium (60%) or smaller (50%) sized companies.

Considering the high cost of implementing CIM components, a sequential implementation strategy is an important approach. Investment in CIM can be, or perhaps even should be, started with one or only a few components at a time. Further elements can be added on a step-by-step basis, as production facilities require, or financial and human resources permit the investment. Most of the CIM components can be implemented individually, thus allowing CIM to be approached in a step-by-step manner (16).

This makes CIM both attractive and feasible for smaller and medium sized companies. Due to this sequential implementation strategy option, the benefits of CIM are not restricted to large companies. It is important however, that companies continue to add to the components they use. It can be seen from the results of this research that some companies in Ireland are not using CIM to its full potential as they currently limit their use of CIM to only one or two components. They should continue to invest in the other CIM components to gain the full benefits of CIM. As Milling (55) has confirmed, investment in isolated CIM components- CAD equipment, for example, that is used as a stand-alone tool will have limited effect on productivity. Only if it is connected to and shares its data with other equipment, can an over proportionate return on investment be expected.

5.3 CIM and Management

Of the respondents, 82% of companies using CIM stated that CIM is an effective tool for efficient management. From the literature review it can be seen that CIM technology helps managers to make quick decisions and implement necessary changes to satisfy the needs of the market and their customers. This enables more efficient management.

"CIM is a strategic investment, it must be sponsored from the top of a company and implemented as a management policy" (7).

The organisational structure of an enterprise has a vast impact on CIM development and implementation processes. As a result, changing from a traditional organisation structure to a non-traditional structure must involve top management and everyone below (9). Therefore management plays a significant role in implementing advanced technologies such as CIM. Based on the literature review, proper management of technological change, particularly at the productive enterprise level, has become the most important consideration for development. Results from the interviews conducted with the four companies in Libya, showed that people in management positions in those companies are afraid to implement CIM technology either because of the cost of this implementation or misconception in relation to the actual meaning of CIM technology.

5.4 CIM and Company Size

Automation alternatives, such as CIM, have been crucial and instrumental in allowing Small to Medium sized Enterprises (SMEs) reduce lead times, and

increase flexibility and reliability. A recent survey showed that almost 87% of SMEs in the USA are using or planning to use CIM (59). Therefore, CIM is not restricted to large companies. This is confirmed from results of the survey present in Chapter 4, as 54% of the companies using CIM components are medium sized. While it is difficult for SMEs to secure initial funding to implement CIM, the results showed that it is possible for SMEs to implement it successfully. SMEs in Ireland should learn from other SMEs experiences in implementing CIM and Libya should encourage and initiate the adoption of CIM by companies of all sizes.

5.5 CIM and Skilled Technicians and Technical Knowledge

According to Ghosh (10), Kenaroglu (32) and Gunasekaran (25), Advanced-Manufacturing Technology (AMT) can today be properly implemented only after stronger focus on training and improving employee motivation, satisfaction and productivity. Human resources play a significant role in CIM technology. Human motivations have as much influence over the success or failure of implementing CIM as finance and technology. Therefore, more attention must be given to educating and retraining workers in the company. From the interviews it can be seen that engineers are willing to improve themselves to cope with advanced technology. It is perhaps only the perception of management that employees will not be willing to accept computerisation.

According to Lee Yong *"Implementation of CIM can result in significant improvements in productivity and product quality and a stronger presence in the global marketplace. To achieve these benefits, there is a need to educate and motivate practising engineers, managers and information technologists*

regarding CIM methodology, planning and implementation" (85). This is supported by the results of this research, as 90% of the companies that use CIM stated that having skilled people is a very important point. That means training to understand the new technology and having expert staff who have the relative knowledge are crucial issues to the successful implementation of CIM.

From those surveyed, 93% also confirmed the importance of the technical factor in implementing CIM. It is clear, therefore that Libyan industries should pay more attention to both factors while implementing CIM. All the interviewees expressed worries about a lack of expertise and training. Most stressed the need to improve links with universities and relevant institutes to fulfill the needs of industry. Indeed, from conducting the interviews, it became clear that there is a general lack of knowledge about CIM in Libya and none of those interviewed had a clear idea of what kind of benefits should be aimed for or even what benefits could be achieved from implementing CIM.

However, it can be seen that 91% of the companies using CIM in Ireland said that employees are not anti-computerisation and they do accept the implementation of CIM. It is therefore vital that employees have a positive attitude to the introduction of CIM. The interviews showed a fear on the part of management that employees would not accept computerisation was a real barrier.

5.6 Expected Benefits of CIM

There are several issues arising from the literature review and the primary research conducted during the course of this dissertation. Based on the literature review it is evident that companies need to reduce Lead-time, Costs

and Inventory. While, companies need to increase quality and responsiveness to customers. Based on the literature review there is evidence to suggest that implementing CIM can produce an increase of productivity of some 40-70%. Both design costs and the in-shop time of a part can also be reduced by 15-30% and 30-69% respectively. Scrap can also be reduced by 20-50%, leading to better product quality (19).

Results from an empirical investigation into the use of Computer Integrated Manufacturing in German (55) hardware manufacturing indicate a large number of reasons encouraging firms to invest in CIM. The most prominent of these reasons are a reduction in order processing time, an increase in scheduling effectiveness, and shorter delivery delay (55). These findings are supported in the results of the primary research conducted in this dissertation. This research showed that Irish companies using CIM have identified four clear benefits of using CIM:

- Improved product.
- Reduced production time.
- Reduced inventory.
- Cost reduction and cost effectiveness.

When considering whether or not to implement CIM, companies in Libya and Ireland should bear in mind these obvious benefits of CIM.

5.7 Cost Effectiveness of CIM

As stated in the literature review, some of the previous studies have highlighted that one of the barriers to implementing CIM is the difficulty in justifying investment in CIM. This study confirmed that CIM is a cost effective system as

67% of the surveyed companies using CIM, stated that CIM is cost effective. Other results from the questionnaire support this finding. For instance, 83% of respondents using CIM emphasised that using CIM has improved their product and 80% stated that it has reduced production time. Product improvement and reduced production time are important aims for most industries.

Chapter 6 Conclusions and Recommendations

6.1 Conclusions

From this research the following points can be concluded,

1. Due to the fact that CIM would reduce costs and increase competitiveness, the successful implementation of CIM is essential in today's global market.
2. Although they may take some time to be seen, successful implementation of CIM has wide-reaching benefits for companies.
    - Operational – reduced costs, reduced cycle time, improved quality and productivity.
    - Managerial – Better resource management.
3. The successful implementation of CIM is dependant on adequate investment.
    - Implementing CIM is costly, but cost-effective.
    - Investment can be a combination of national and foreign investment.
    - Where funds are limited step-by-step investment and implementation can be a highly successful method.
4. Investment in CIM is quite expensive, so a long-term commitment to the investment must be made and management must consider the investment as essential to achieve the company's long-term goals. CIM funding should be part of the future planning because CIM is evolutionary.

5. The successful implementation of CIM is dependent on sufficient expertise and skilled workers.
    - Raising awareness of CIM is dependent on research and sufficient links between industry and relevant third level institutions.
    - Employees accept new technologies if they have access to sufficient training.
    - Adequate training depends on sufficient investment in this area.

6.2 Recommendations

This research highlighted the need to look at CIM more in-depth and to analyse the barriers that face industries that would benefit from CIM technology. The following recommendations present some suggestions that may contribute to improving the status of the utilisation of Computer Integrated Manufacturing in the Libyan industry and further increase its use in Ireland.

1. The introduction of new technology, as well as advanced CIM programmes, should be encouraged, particularly in Higher Education.

2. In Libya there is a need for a national programme for diffusing new technologies in collaboration with universities, institutes, and committees related to IT or Computer Integrated Manufacturing. Ireland can be used as a model as it is also relatively new in this field and provides a good example.

3. Libyan companies should adopt the sequential implementation strategy when implementing CIM technology.

4. Training professionals in the use of IT tools, especially in Computer Integrated Manufacturing, is an essential step in the process of implementing CIM technology.

5. Companies should organise conferences, meetings, seminars and workshops on different topics related to Computer Integrated Manufacturing and the development of the IT industry.

6. Developing countries such as Libya should hold national conferences to address the issue of CIM technology and to address methods of reducing the barriers of implementing CIM in Libyan industry. Experts in CIM technology should be invited to discuss their experiences and suggest possible solutions that they have found effective to reducing barriers.

7. Because Libya is in the first stages of CIM technology development, Libya needs to raise the awareness of the development capacity in the field of CIM technology.

8. Libyan industries should allow investment in new technologies and CIM technology from foreign sources.

9. Irish companies currently using only a limited number of CIM components must be encouraged to use more in order to improve their efficiency.

10. Irish companies not using CIM must be encouraged to use CIM by raising the awareness of its benefits. Further research into why those companies are not using CIM is necessary.

6.3 Suggested Areas for Further Work

The literature review and the research conducted for the purpose of this thesis highlighted several areas that require further research and development. These include:

1. The significance of the human role in developing the CIM system. There is limited research exploring the nature or significance of this role. It is important that future research should address this vital role in Computer-Integrated Manufacturing (CIM).

2. The issue of quality management in CIM has been highlighted as an important factor in the successful implementation of CIM. It is important then that this factor is acknowledged.

3. From the research into the current status of CIM implementation in manufacturing companies in Libya, it is evident that there is a real need for investment justification in the future for CIM in developing countries in general.

4. The scope of this research into Libyan industries was limited in its capacity to address all issues. Therefore an in-depth investigation into Libyan industry would be essential.

5. It became evident during the course of this research that the globalisation of manufacturing has an impact on the applications of CIM. It is important then to explore this impact further.

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List of Publications arising from this work

Current publications:

[1] Khaled A.Saeed, A.G. Olabi and M.S.J.Hashmi "CIM implementation in developed and developing countries" International Conference on Manufacturing Research 2005, Cranfield University, UK, 6th -8th September 2005

[2] Khaled A.Saeed, A.G. Olabi and M.S.J.Hashmi "Justifying CIM implementation in developing countries" ATDC 2005, Advanced Technologies for Developing Countries, Slavonki Brod, Croatia, September 21-24, 2005

Appendix A

Questionnaire No. | | | |

PLEASE TICK THE APPROPRIATE ANSWER FOR EACH QUESTION…e.g..

YES	✓
NO	

A

Q1. (A) Are you an Irish Owned Company?

YES	☐
NO	☐

(B) If you answered **NO**, please state the country of ownership _____

Q2. Please state your company size according to the number of employees….

SMALL (LESS THAN 50)	
MEDIUM (MORE THAN 50 LESS THAN 250)	
LARGE (MORE THAN 250)	

Q3. Do you use any components of the computer integrated manufacturing (**CIM**) system in your company?

YES	☐
NO	☐

If you answered **NO** - PLEASE continue to **Section C** on page 4.

B

THE FOLLOWING QUESTIONS SHOULD BE ANSWERED BY COMPANIES THAT *USE* THE CIM components ONLY!

Q.4 Which components of the CIM system do you use in your company?

	YES	NO
CAD (COMPUTER AIDED DESIGN)		
CAM (COMPUTER AIDED MANUFACTURING)		
CAQ (COMPUTER AIDED QUALITY)		
POM (PRODUCTION ORDERING MONITORING TECHNOLOGY)		
CAPP (COMPUTER AIDED PROCESS PLANNING)		
CNC (COMPUTER NUMERICAL CONTROL)		
DNC (DIRECT NUMERICAL CONTROL)		
FMS (FLEXIBLE MANUFACTURING SYSTEMS)		
ASRS (AUTOMATED STORAGE AND RETRIEVAL SYSTEMS)		
AGV (AUTOMATED GUIDED VEHICLES)		
ROBOTICS AND AUTOMATED CONVEYANCE		
COMPUTERISED SCHEDULING AND PRODUCTION CONTROL		
OTHER		

Q.5 How long have you been using the CIM components in your company? _____MTHS _____YRS

Q.6 Would you consider the cost of implementing CIM as…..,

VERY CHEAP	
QUITE CHEAP	
NEITHER CHEAP NOR EXPENSIVE	
QUITE EXPENSIVE	
VERY EXPENSIVE	
DON'T KNOW	

Q.7 In your company, how long is the trial period for the CIM components before determining it a success or a failure?

LESS THAN 3 YEARS	
3 TO 10 YEARS	
MORE THAN 10 YEARS	
DON'T KNOW	

Q.8 What is the time-line for implementing CIM components in your company?

LESS THAN 6 MONTHS	
6 MONTHS TO 1 YEAR	
1 TO 2 YEARS	
MORE THAN 2 YEARS	
DON'T KNOW	

Q.9 Do you think using CIM has…

	YES	NO	DON'T KNOW
IMPROVED YOUR PRODUCT			
REDUCED PRODUCTION TIME			
REDUCED ADMINISTRATION COSTS			
REDUCED OVERALL COSTS			
REDUCED INDIRECT LABOUR COSTS			
REDUCED INVENTORY			
INCREASED ACCURACY OF FORECASTING			
INCREASED PROFIT			

Q.10 In which area has the CIM had the most effective impact in your company?

	EFFECTIVE	NON EFFECTIVE	DON'T KNOW
MARKETING & SALES			
ENGINEERING			
WAREHOUSING & DISTRIBUTION			
INFORMATION SYSTEMS			
HUMAN RESOURCES			
MANUFACTURING			
MATERIAL MANAGEMENT			
QUALITY ASSURANCE			
COMMUNICATIONS			

Q.11 Do you think introducing new technology in your company means increased demand on ….

	YES	NO	DON'T KNOW
SKILLS			
TECHNICAL KNOWLEDGE			

Q.12 Do you think the CIM components is an effective tool for efficient management?

YES	
NO	
DON'T KNOW	

Q. 13 Do you think implementing the CIM components reduces the number of employees?

YES	
NO	
DON'T KNOW	

Q.14 Do you think the CIM enables more effective communication between all departments in your Company?

YES	
NO	
DON'T KNOW	

Q.15 After introducing the CIM components, do you expect to achieve…

	YES	NO	DON'T KNOW
BETTER POSITIONING ON THE MARKET			
FASTER PRODUCT DEVELOPMENT			
HIGHER PRODUCT QUALITY			

Q.16 Do you use a complete warehousing system that includes?

	YES	NO	DON'T KNOW
PICKING			
PACKING			
SHIPPING			
RECEIVING			
INSPECTION			
INVENTORY			
INVENTORY MOVES & ADJUSTMENTS			
WAREHOUSE TRANSFERS			
ANALYSIS			

Q. 17 In general, have the employees accepted the CIM components?

YES	
NO	
DON'T KNOW	

Q. 18 Do you think the CIM is a cost-effective system?

Strongly Agree	
Agree	
Undecided	
Disagree	

Q. 19 Overall would you rate your CIM system as…

EXCELLENT	
GOOD	
REASONABLE	
POOR	
VERY POOR	

THE FOLLOWING QUESTIONS SHOULD BE ANSWERED BY COMPANIES THAT *DO NOT USE* THE CIM SYSTEM ONLY

Q. 20 Have you ever heard about the computer integrated manufacturing (CIM) system?

YES	☐
NO	☐

Q. 21 (A) If **YES**, have you ever considered implementing it in your company?

YES	
NO	
DON'T KNOW	

(B) If **YES**, when do you intend to implement the CIM components _____

(C) If **NO**, what are the main reasons for not using the CIM components in your company?

	YES	NO
ORGANISATIONAL OBSTACLES		
TECHNICAL OBSTACLES		
FINANCIAL OBSTACLES		
OTHER (*Please State*)_____		

Q.22 Any Further Comments?

_____

_____

_____

_____

_____

_____

_____

Thank you for your Assistance

Address of DCU
Mechanical & Manufacturing
Engineering School

5th August 2004

Contact Number
00353 17005749

Dear Sir/Madam,

I am currently undertaking a Masters postgraduate in the School of Mechanical and Manufacturing Engineering of Dublin City University. For the purpose of this Masters I am focusing on the benefits of the Computer Integrated Manufacturing (CIM) system in manufacturing companies in Ireland.

Please find attached a copy of the questionnaire designed to analyse the benefits if the CIM system in companies throughout Ireland.

I would appreciate if you could take some time to complete this questionnaire and return it in the freepost envelope as soon as you can.

All information supplied is specifically for the purpose of this research study and is confidential.

Thank you for your co-operation.

Regards,

Khaled Saeed

Appendix B

Interview Questions

Q1: What is your position in the Company?

Q2: What would you consider the size of your Company to be in relation to the number of people employed?

Q3: What is the nature of the business or industry in which you are employed?

Q4: Can you tell me about the level of automation currently at use in your Company?

Q5: Do you use Computer Integrated Manufacturing? If not, have you ever heard about Computer Integrated Manufacturing (CIM)?

Q6: Do you think the Management intend to introduce CIM in the future or are at least willing to consider doing so?

Q7: In your opinion do you think the workforce / employees would be willing to accept CIM technology if it was introduced?

Q8: What would you see as the main barriers and obstacles to the introduction of CIM technology?