Automation and Computer Integrated Manufacturing in Food Processing Industry: An Appraisal

By

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Dedication

This thesis is dedicated to my beloved parents, my wife, my kids, and my brothers and sisters who are always wished me to be a successful engineer, thank you very much

Ayad Khalifa Mohamed

Declaration

I hereby certify that the material presented in this thesis is entirely my own work, except where specific references have been made to the works of others

Signed ______________________ I D 51183404

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December 2003

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Automation and computer integrated manufacturing (CIM) in food processing industry: an appraisal

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Abstract

This study is concerned with a research programme on automation and computer integrated manufacturing (CIM) in food processing industry, culminating in an implementation framework detailing the extent of automation and application of computer based technologies in Irish food processing industries

This work involved with designing of a postal survey questionnaire and mailing it to 221 manufacturing companies, and designing a web-based survey and emailing it to 31 manufacturing companies in the Republic of Ireland Questions were designed to capture information about the level of automation, envisaged level of automation, motivation and obstacles to implement computer-based technology, and the extent of implementation of CIM environments at plants

The key findings point to the existence of a linear relationship between practice and performance From the perspective of competitive advantage, the traditional postal survey gives a higher response rate than web-based survey, but on the other hand the web based survey takes shorter response time and cost s less than a traditional postal survey

The results of this study show variable levels of automation A large number of the manufacturing plants are applying automation, and are trying to increase the automation level in their plants
This work has demonstrated that the manufacturers have the desire to adopt CIM systems at different levels, despite the cost obstacle of implementing them

AUTOMATION AND COMPUTER INTEGRATED MANUFACTURING IN FOOD PROCESSING INDUSTRY AN ECONOMIC APPRAISAL

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Chapter 1

Introduction

1 1 Historical developments in industrial automation and control

Around the year 1900, factory mechanization 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 mass production This resulted in the development of programmable automation By the year 1950, numerical control (NC) was developed as an innovative approach to programmable automation With the developments in commercially available computer technology, the application of computers in manufacturing started to emerge by producing a variety of new technologies By the year 1955, the introduction of computer aided design (CAD) and developments of NC resulted which led to the evolution of systems like computer NC (CNC) and direct NC (DNC) By the year 1970, developments in CAD applications and computer aided manufacturing (CAM) based systems introduced the concept of CIM, which are collectively named as AMTs [1] AMTs provide flexibility as well as data driven computer integration for a manufacturing organization, in which the manufacturing technology utilized is intelligent enough to process the activities with less human intervention The need for integration became a necessity by the advanced systems in CAM, computer aided process planning (CAPP), computer aided quality control (CAQC), flexible manufacturing system (FMS) and CIM in the 1980s, in response to the problems faced by traditional manufacturing processes of industrial automation Individual automation leads to islands of automation These islands of automation did not facilitate communication between the functional units and plagued the manufacturing industry [2]

In order to integrate islands of automation, the United States Air Force initiated the Integrated Computer Aided Manufacturing (ICAM) programme in 1983 [3] European Computer Integrated Manufacturing Architecture initiated the computer integrated manufacturing open system architecture (CIMOSA) concepts in 1983 [4] As discussed by Sergarra [5], the advanced information technology (AIT) road map for the European manufacturing industry initiative was launched by Daimler Benz in 1993, for technological integration through the development of integration platforms, and the usage of generic networked enterprise (re)engineering methodologies

The generic Internet based utility hooks up host computers (which handle high-level decisions) and dedicated process controllers This gives the controllers various facilities to interact, report, query, and coordinate activities with computers located anywhere in the Internet [6, 7] The new possibilities for connectivity, sharing and coordination have shifted the way manufacturing enterprises are run [5] Client/server architecture and groupware tools attempt to coordinate the anarchy created by the PC revolution, and provide means for travelling users who want to connect their own Web from anywhere in the world, for storing, analysing, and coordinating their activity [8] Distributed computing technologies motivate scientists and industries to develop modular architectures, distributed and linked through specific networks in contrast to centralized and rigid organizations Advances in software technology have been transforming the world of integration into compatible systems and devices by establishing an open connectivity standard, agreed by the manufacturers, which will provide plug-and-play communication and interoperability between field devices, control systems, and enterprise-wide business applications [9]

In the year 2000, the Venture Development Corporation reported that PC-based control application products are forecasted to have double-digit growth rates through 2005 The Siemens Automation and Drives group, forecast that the number of PC-based automation solutions will grow rapidly by 20% each year [9]

1 2 Importance of food industry

The food industry constitutes a major part of the world economy and is, of course, a truly international business [10] In the US an advanced manufacturing country, the food industry became one of the important sectors in the American economy Whereas, in 1995, the food manufacturing sector accounted for 14% of the total US manufacturing output In that same year, the processed food market represented $372 billion in value added Clearly, the food manufacturing industry represents a dominant force in the US economy [11]

In Republic of Ireland the food industry is considered as central and important to Ireland's "psyche" and economy [12] The department of agriculture and food announced that the Food Industry in 1999 accounted for 3% of total employment, over 6% of Gross Domestic Product (GDP), and for 9 6% of total exports, they also estimated output of £11 1 billion in 2000 [13]

1 3 Computer automation and food industry

In today's competitive global market, for the survival of any industry, manufacturing companies need to be flexible, adaptive, responsive to changes, proactive and be able to produce a variety of products in a short time at a lower cost [1] The food industry is facing increasing global competition and consumer demands These require new technologies and practices for competitive advantages in the market The needs for increased automation in the food industry is due to [2] (1)the elimination of extremely repetitive and monotonous tasks, which resulted in repetitive strain injury to workers, (2)better quality control, needed because of consumer sophistication, regulatory labeling requirements, and narrow quality boundaries, (3)the elimination of off-line quality control due to the need for more rapid correction of deviations from process and quality standards/specifications, and (4)the detection of foreign and contaminant material in food [14] CIM is the term used to describe the total automation of a manufacturing system under the control of computer and digital information [15]

CIM involves all of the functions in the organization related to production including design, engineering manufacturing, production scheduling, inventory control, quality control, maintenance scheduling, materials handling, order processing, and finance and accounting CIM systems are supported by a network of computer systems tied together by a single set of integrate databases This integration facilitates the communication between different areas as well as the sharing of manufacturing information data [16] However, little is actually known about computer applications and extent of CIM implementation in food industry Clayton (1987) discussed the concepts, experiences, and potential contribution, and future development of CIM [17] Beaverstock (1987) analyzed the role of automation in food manufacturing and it's effect on both company employees and company strategies [18] Aly [19] determined the level of implementation of CIMs in food processing companies and discussed the obstacles that were facing the manufacturers to implement CIM systems in their plants Zhanhui et al (1999) discussed The needs for increased automation in the food industry and CIMs [14] Sasha et al (2001) has conducted a nationwide scientific survey of US food manufacturers to better determine the current state of automation in the food industry His survey also included system integrators and equipment suppliers that sell goods and services to food manufacturers, and also discussed the obstacles to implement new technologies [11]

1 4 Aim of study

The general aim of this research is to assess the level of Automation and Computer Integrated Manufacturing in the Irish Food Processing Industry A survey is the heart of this research, with the main objectives being summarised as following

1 To determine the level of current automation in the food industry

2 To determine the desire to adopt automation technology over the next five years

3 To determine the current status of CIM implementations in the food industry

4 To determine the reasons that caused the decision to invest in CIM

5 To determine the obstacles to the adoption of CIM system in the food industry

6 To compare traditional post and web based survey feed back from industry

1 5 Method of approach

The method of approach adapted in this research work, is schematically shown in Figure 1 1

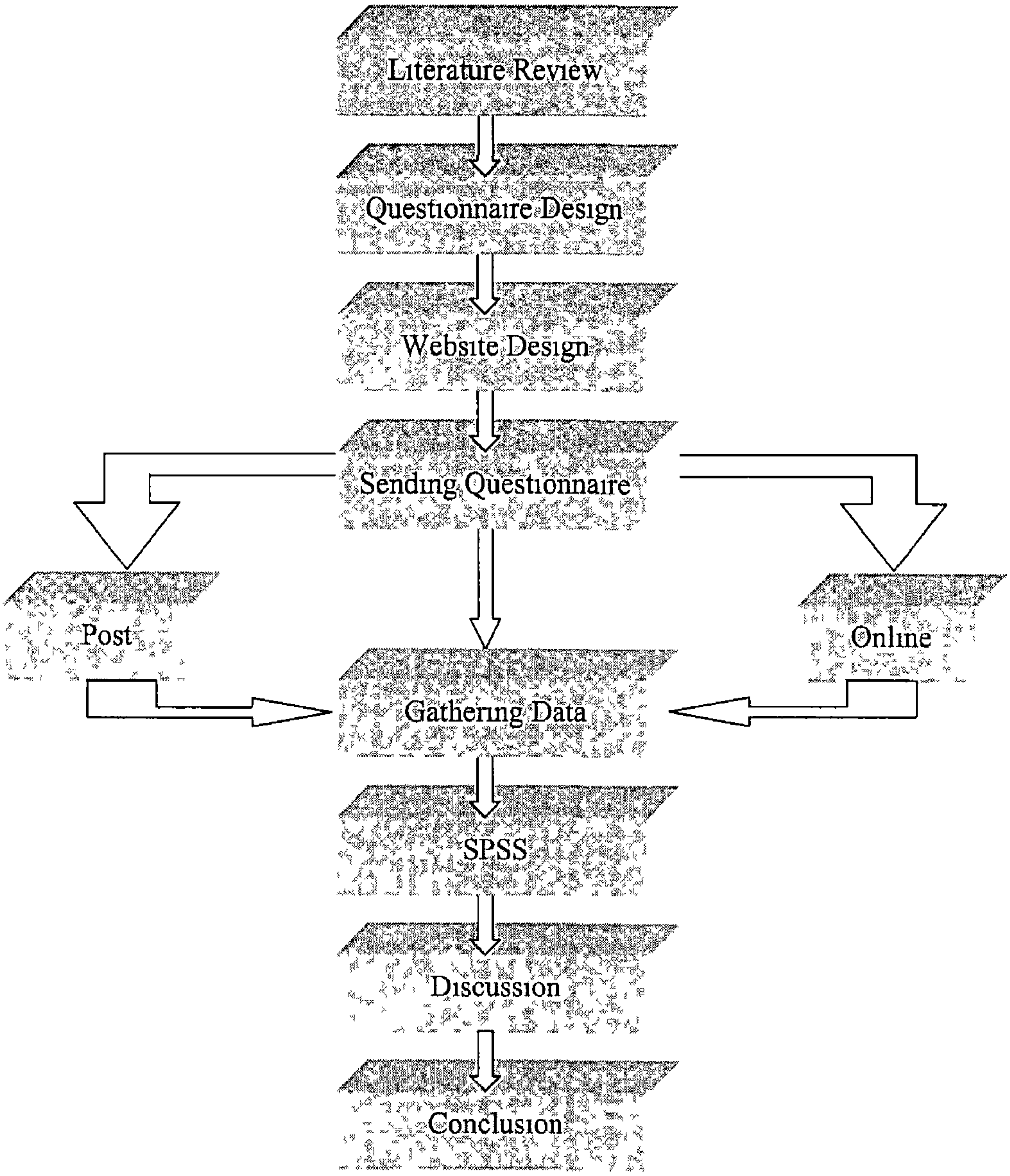

Figure 1 1 Schematic diagram of research outline

1 5 1 literature review

It is the starting point of the research A continuous literature search in the university's library on the subject automation and computer integrated manufacturing in food processing industry was actively conducted throughout the research programme This topic will be covered in Chapter 2

1 5 2 Designing the survey

The preliminary research effort assisted in determining the areas those need to be addressed in designing of the implementation framework Following this, the most important phase of the research work was the design of the survey Two kinds of survey have been used in this work, 1) web based survey, which required a web page on the net, and 2) a traditional postal survey During this stage a pilot test of the survey was conducted Chapter 3 will cover in depth this topic

1 5 3 Survey analysis

Data collection has been carried out by the two survey methods and some statistical analysis has been completed for the data, including, frequency chart, pie chart, bar chart, mean, variance and correlation SPSS software has been used for this task, and some discussion has followed the results of the analysis Chapter 4 will cover in detail this topic

1 6 Overview of the thesis

This thesis is divided into 5 chapters Following this introductory chapter, chapter 2 gives a back ground about the automation and computer integrated manufacturing and reviews some related work Chapter 3 covers in detail the heart of this work "designing the survey", which includes two methods 1) traditional postal survey and 2) web-based survey, andalso gives full coverage of the objectives of the survey, population of the survey, scaling of response, questionnaire design and analysis, pre-test and pilot survey, and some details about the methods of the web based survey and web site design The results of the survey are presented and discussed in Chapter 4 Finally, conclusions based on the present work are presented in Chapter 5

Chapter 2

Lıterature Vıew

2 1 Developments ın manufacturıng technology

The modern age of manufacturıng began ın England ın the 18^{th} century wıth the first ındustrıal revolutıon

Durıng the 19^{th} century the ındustrıal revolutıon entered the Unıted States wıth the ıntroductıon of powered machınery ın mechanıcal fabrıcatıon and the standardızatıon of product desıgn for component ınterchangeabılıty These technologıes are taken for granted today, but at the tıme they revolutıonızed manufacturıng [20]

In a classıc study of the causes of mechanızatıon ın Unıted States over the perıod up through World War II, Seymour Melman of Columbıa Unıversıty [21] documented the ımpact of mechanızatıon on the rısıng rate of worker output Some results of hıs study are shown ın Fıg 2 1 Over the perıod 1900-1949, the level of ınstalled horsepower per productıon worker grew at a relatıvely constant rate The effect of that growth ın mechanızatıon was a parallel ıncrease ın worker productıvıty, also shown ın fig 2 1 Hıs study further shows that the ıncrease ın mechanızatıon ıs caused by the changıng relatıve cost of machınery to workers over that perıod In partıcular, as worker wages rose faster than the cost of machınery, the use of more machınery as an offset to labour was cost – justified However, ınstead of observıng a reductıon ın the factory workforce, by 1949 there were over twıce as many people employed ın US manufacturıng than ın 1900 Thıs was due ın part to the ıncrease ın demand for manufactured products, made possıble by theır low cost from the use of mechanızatıon and mass-productıon technologıes

In the early 1980s the Natıonal Academy of Scıences proclaımed 'The modern era of electronıcs has ushered ın a second ındustrıal revolutıon Whereas the first ındustrıal revolutıon was characterızed as replacıng muscle power wıth mechanıcal power, the second ındustrıal revolutıon ıs characterızed as replacıng braınpower wıth computer power ın the decısıon and control functıons of manufacturıng

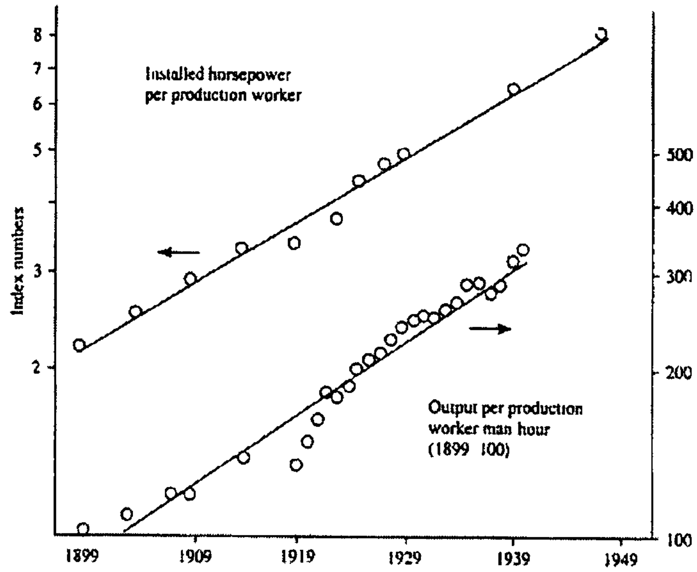

Figure 2 1 Mechanization and productivity in the manufacturing industries of the US, 1899 -1950 [21]

At the heart of this revolution lies the computer, which could possibly be the foremost technological development in manufacturing of the latter 20th century The idea of a computer has to be credited to Charles Babbage, an English mathematician In 1812 he proposed an automatic calculator that could solve different equations Although Babbage developed workable designs, his machine was never built

Modern computing can probably be traced back to the 'Harvard Mk I' and Colossus (both of 1943) Colossus was an electronic computer built in Britain at the end 1943 and designed to crack the German coding system - Lorenz cipher The 'Harvard Mk I' was a more general purpose electro-mechanical programmable computer built at Harvard University with backing from IBM These computers were among the first of the 'first generation' computers [22]

The Harvard computer had many features of a modern computer an input unit, an output unit, a memory and an arithmetic unit All instructions had to be programmed and input using a punched tape reader The Harvard computer had a competitor In 1944, the Princeton mathematician John von Neumann collaborated with engineers at the University of Pennsylvania in the development of a computer that worked on the binary number system and that had operating instructions built into the machine itself Underlying principles for this work appeared in a master's thesis written by Claude Shannon of the Massachusetts Institute of Technology in 1937 This thesis demonstrated the parallel between electrical switching circuits and mathematical logic, which is based on the binary number system

The invention of the transistor at Bell Laboratories in 1948 helped in supporting and advancing the practical implementation of electrical switching circuits and mathematical logic After replacing the vacuum tube the transistor make it more economic in the fabrication of binary circuits which then called (logic gates) Further development and advances lead to and succeeded in combining several of logic gates on the single fabricated chip This work was carried out and developed by the Texas Instruments Corporation by 1960 the relatively dense packing of electronic logic was to become known as small scale integration By the end of the 1970s it was not uncommon to put 50,000 logic gates on a single chip This brought hardware costs down dramatically It has been estimated that a computer having hardware costs of $30,000 in 1960 would have costed about $1,000 by 1980

But automation does not live by hardware alone Paralleling the advances in hardware were advances in the understanding of how to model manufacturing processes for automatic control During the 1930s and 1940s, scientists and mathematicians were developing a theory of electromechanical control The theory of control provides basis for the design of self- regulating devices

This is the act of continuously monitoring the output of a process and comparing it to a desired output The controller alters the input to the process to bring the actual output of the process into conformance with the desired goals By the 1940s there were several analog devices that performed on this basis

Since digital computers are discrete devices that monitor a process by taking samples at discrete instances of time, the use of computer technology in the control function needed a control theory based on the sampling of feedback information This theory began to develop during World War II, when scientists were working on radar systems A radar system is a naturally sampled system because of the time delay between successive detection of object position The first important theoretical work on sampled systems began to appear around this time [20]

The marriage of computer and manufacturing process also began in the late 1940s The first commercial machines did not employ the concept of feedback They were programmed using a punched tape that contained instructions for directing the motion of the motors driving the axes of the machine tool Starting from a known registration point, the bed of a milling machine would be moved through various positions beneath the milling tool in accordance with the instructions on the tape There was no continuous feedback of positional data, but a proper initial registration of the work piece, combined with correct instructions, would result in the correct component being manufactured This process was termed 'numerical control' and it ushered in a great deal of expectation about the potential control in manufacturing

The idea of an automatic factory was seriously being entertained in the period just after World War II 1946, two radar engineers proposed a prototype automatic factory design in an article that appeared in fortune, a prominent business periodical With the development of numerical control, expectations increased and, in 1953, 'the automatic factory' became the topic of discussion at The Fortune Round Table, an annual meeting of academic and industrial experts and business executives The article reporting the discussion at that meeting is interesting to read today in that many of the ideas those are widely discussed today were discussed at that time [20]

2 2 Automation in Manufacturing Environment

2 2 1 Automation Objective

According to Adler et al [23], automation aims to maximize value-cycle opportunities by blending together knowledge and automation technologies This will extend the company's capabilities and promote global collaboration by providing continuous access to information To achieve this requires special attention to the career development of automation professionals, more leverage of existing automated facilities and partners, and development of best practices in delivery and maintenance

2 2 2 Definition of Automation

Automation [24] is a technology concerned with the application of mechanical, electronic, and computer based systems to operate and control production This technology includes

- Automatic machines tools to process parts
- Automatic assembly machines
- Industrial robots
- Automatic material handling and storage systems
- Automatic inspection systems for quality control

- Feedback control and computer process control
- Computer systems for planning, data collection, and decision making to support manufacturing facilities

2 2 3 Type of Automation

Automated production system [24] can be best classified into three basic types

2 2 3 1 Fixed automation

Fixed automation is a system in which the sequence of processing (or assembly) operations is fixed by the equipment configuration The operations in the sequence are usually simple It is the integration and coordination of many such operations into one piece of equipment that makes the system complex

The typical features of fixed automation are

- High initial investment form custom-engineered equipment
- High production rates
- Relatively inflexible in accommodating product changes

2 2 3 2 Programmable automation

In *programmable automation,* the production equipment is designed with the capability to change the sequence of operations to accommodate different product configurations The operation sequence is controlled by a program, which is a set of instructions coded so that the system can read and interpret them New programs can be prepared and entered into the equipment to produce new products

Some of the features that characterize programmable automation include

- High investment in general-purpose equipment
- Low production rates relative to fixed automation
- Flexibility to deal with changes in product configuration
- Most suitable for batch production

2 2 3 3 Flexible automation

Flexible automation is an extension of programmable automation which is capable of producing a variety of products (or parts) with virtually no time lost for changeovers from one product to the next There is no production time lost while reprogramming the system and altering the physical setup (tooling, fixtures, machine setting) Consequently, the system can produce various combination and schedules of products, instead of requiring that they made in separate batches

The features of flexible automation can be summarized as follows

- High investment for a custom-engineered system
- Continuous production of variable mixtures of products
- Medium production rates
- Flexibility to deal with product design variations

Owen [25] wrote, at the beginning of the automation century, the robot appeared Lights-out assembly hasn't become the norm because automation itself isn't reliable and flexible enough The things that must drive automation are throughput, consistent production, and quality Each module consists of equipment and personnel They lay out assembly areas, decide on maintenance, and look for ways to avoid repetitive motions, maximize use of existing equipment, and improve work flow or quality Each operator in a module does quality checks, cleanup, and preventive maintenance, tracking breakdown histories to identify problems for engineers, supervisors, or maintenance staff

2 2 4 Computer Integrated Manufacturing

Computer-integrated manufacturing (CIM) is frequently considered as [26] a technology enabling companies to compete in today's market that requires great flexibility and responsiveness Some of the benefits realized from successful implementation of CIM technology include Improved quality, greater flexibility and responsiveness, improved competitiveness, reduced lead time, increase productivity and decreased work-in-process The large, completely automated and integrated environment is a Computer Integrated Manufacturing (CIM) operation [27]

2 2 4 1 Definition of CIM

CIM is more than 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 [28] According to Ranky [29], computer integrated manufacture is concerned with providing computer assistance, control and high level integrated automation at all levels of manufacturing and other industry, by linking islands of automation into distributed processing system The technology applied in CIM/ Agile/ Lean and Intelligent Manufacturing makes intensive use of distributed computer networks and data processing techniques, Artificial Intelligence and data base management system (Figure 2 2)

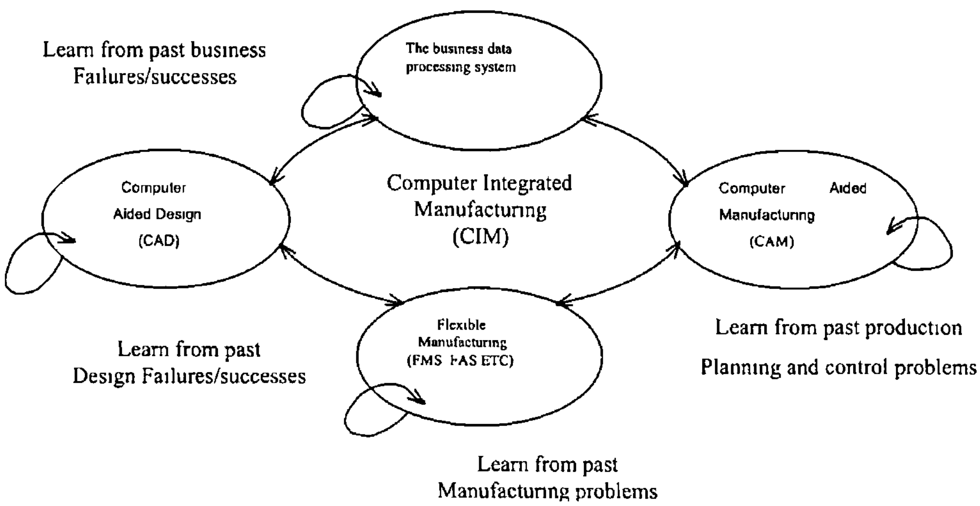

Fig 2 2 computer integrated manufacturing (CIM) system concept [29]

Therefore CIM is a broad term describing the computerised integration of all aspects of design, planning, manufacturing, distribution, and management Computer integrated manufacturing systems consist of subsystems that are integrated into a whole These subsystems consist business planning and support, product design, manufacturing process planning process control, shop floor monitoring systems, and process automation, (Fig 2 3) [30]

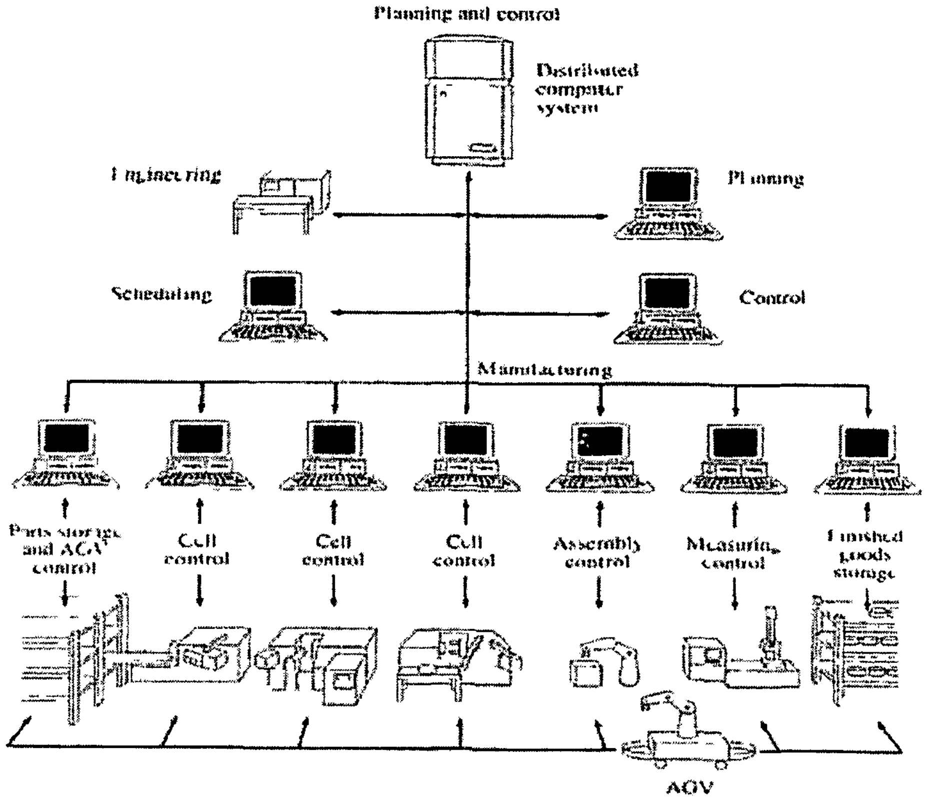

Figure 2 3 A schematic illustration of a computer integrated manufacturing system [30]

The American organisation, "the Computer and Automation Systems Association of the Society of Manufacturing Engineers(CASA/SME) has defined CIM as follows

CIM is the integration of the total manufacturing enterprise through the use of integrated systems and data communications coupled with new managerial philosophies that improve organisation and personnel efficiency [31]

The Manufacturing Enterprise wheel (CIM wheel) illustrates the integration called for in definition and shows the interrelationship among all parts of an enterprise The CIM concept model (Figure 2 4) is an update from the original SME/CIM wheel and has six areas

- First area is the hub of the wheel, titled Customer, who is the main target for marketing, design, manufacturing, and support efforts in the enterprise A clear understanding of the marketplace and customer desires is the key to success
- The next layer focuses on the role of people and teamwork in the organization Included here are the means of organizing, hiring, training, motivating, measuring, and communicating to ensure teamwork and cooperation The techniques used to

achieve this goal include self-directed teams, teams of teams, the learning organization, leadership, metrics, rewards, quality circles, and corporate culture

- Third section on the wheel focuses on the shared corporate knowledge, systems, and common data used to support people and processes The resources used include both manual and computer tools to aid research, analysis, innovation, documentation, decision-making, and control of every process in the enterprise
- This section of the wheel focuses on three main categories of processes product/process definition, manufacturing, and customer support Within these categories 15 key processes complete the product life cycle
- The enterprise has resources (inputs) and responsibilities (outputs) Resources include capital, people, materials, management, information, technology, and suppliers Reciprocal responsibilities include employee, investor, and community relations, as well as regulatory, ethical, and environmental obligations
- The manufacturing infrastructure, make up the final part of the wheel This infrastructure includes customers and their needs, suppliers, competitors, prospective workers, distributors, natural resources, financial markets, communities, governments, and educational and research institutions [31, 32]

Computer integrated manufacturing [29] covers all activities related to the manufacturing business, including

- Evaluation and developing different product strategies
- Analysing markets and generating forecasts
- Analysing product/ market characteristics and generating concepts of possible manufacturing systems
- Designing components for manufacturing (i e machining, inspection, assembly, maintenance and all other processes relating to the nature of the component and/or product, such as welding, cutting, presswork, painting, etc
- Evaluating and/ or determining batch size, manufacturing capacity, scheduling and control strategies relating to the design and fabrication processes involved in the particular product
- Analysing and feeding back certain selected parameters relating to the manufacturing processes, evaluation of status reports from the DNC (Distributed Numerical Control) system

- Analysing system disturbances and economic factors at (CIM/ Agile/ Lean/ Intelligent Manufacturing) component level as well as at total system level
- Analysing and providing data at the appropriate level and time and in the appropriate format

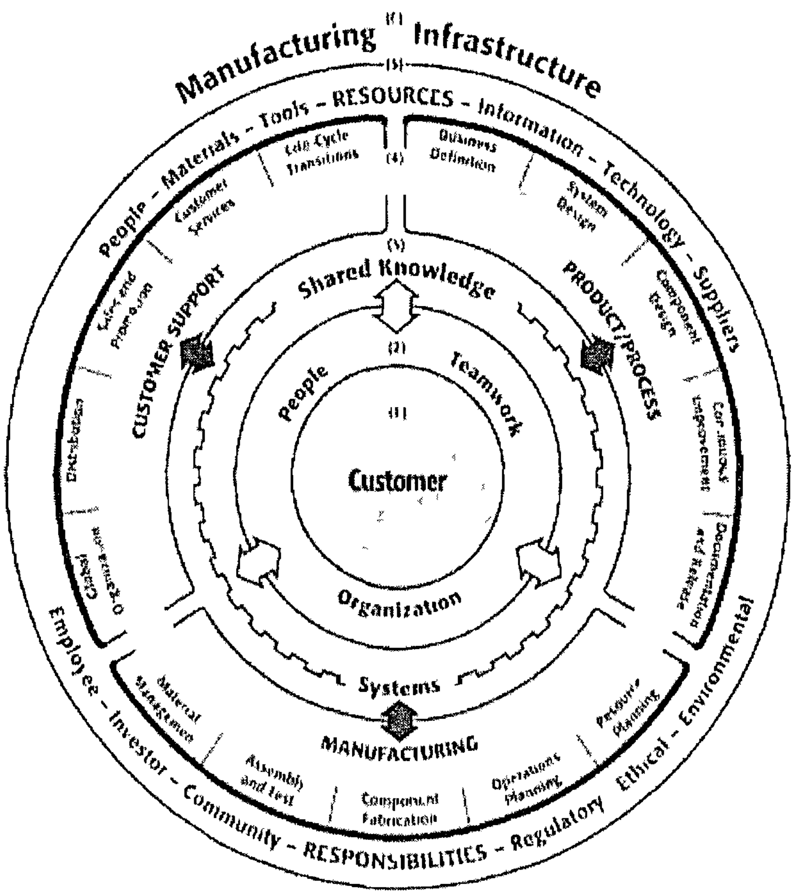

Figure 2 4 New manufacturing enterprise wheel (CIM wheel) [31, 32]

In comparison with FMS, CIM is mainly concerned with the information processing tasks at all levels of the factory and its management, including humans and technology, such as CAD, CAM and the business data processing system, whereas FMS provides the essential computer controlled manufacturing tools and shop floor control system for CIM to execute the computer generated plans and schedules that take account of a total system rather than just one machine, one cell or shop [29]

2 2 4 2 The benefit of CIM

There are several answers to the question "why CIM?"
Roger Hannam 1996 [32] discussed this question and has illustrated some general benefit of CIM as flowing

- **To co-ordinate and organize data**

The main key to how CIM helps companies respond to these competitive pressures are the better use of data The CIM wheel should functional relationship in a company, but most companies do not have central cores of data and integrated systems architecture Their structures and their data organization are traditionally based on specialist groups of staff

A company is often accurately represented as a hierarchy " Figure 2 5"

The branches of the structure contain the groups of specialists, who carry out their activities under a supervisor The specialist groups have their own "function data" their own information and knowledge (perhaps still in handbook form)- which may be described as part of a company's knowledge base The second type of data is the data these specialist groups generate about their function For a design department this will be data on products and their parts It can be classed as "product data"

A third type of data is required to control the operations of the company and often takes the form of plans or instructions This can be classed as "operational data" The fourth type of data is reported back to confirm that instructions have been carried out or standard achieved This can be classed as "performance data"

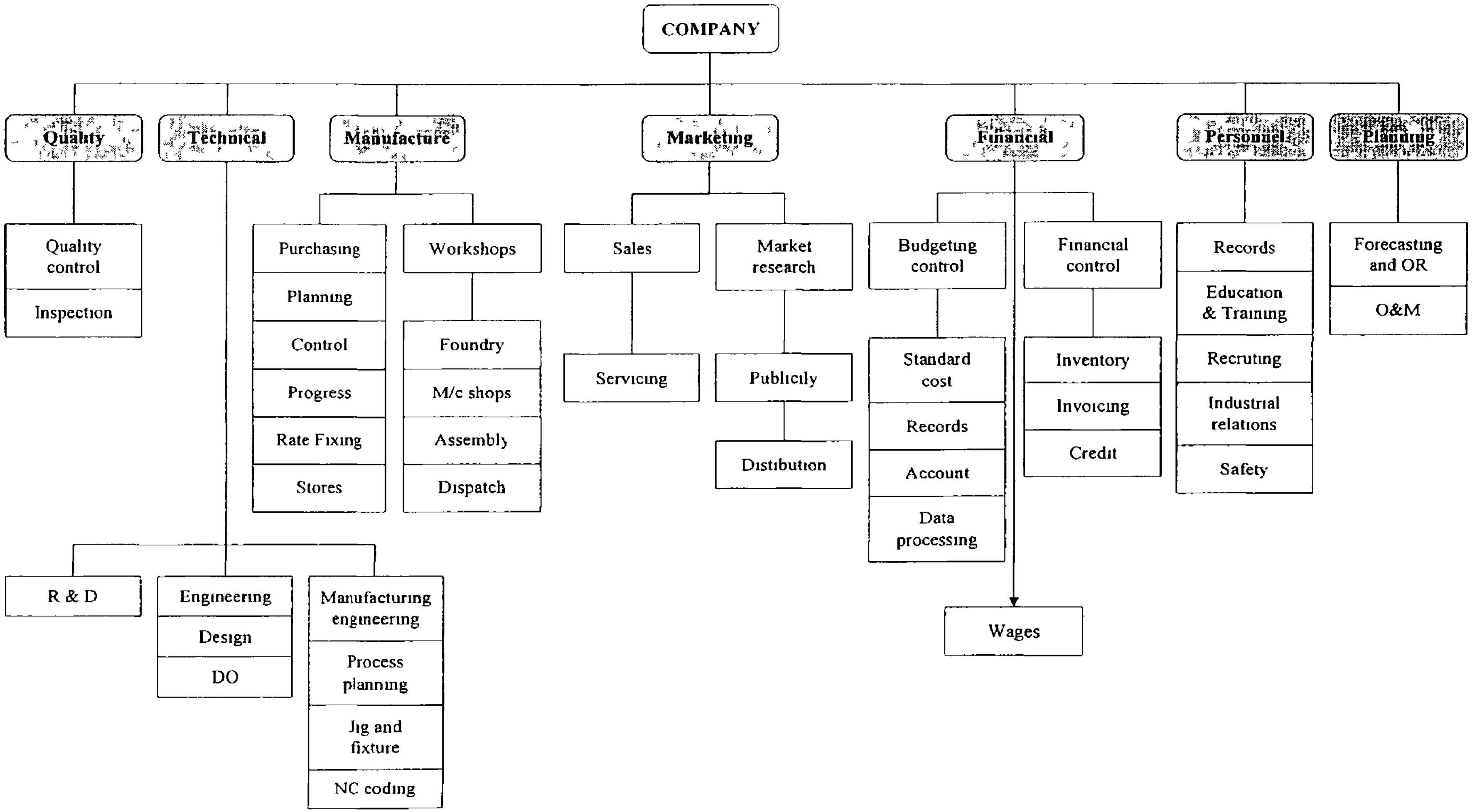

Figure 2 4 The hierarchical structure of company [32]

- **To eliminate paper and the costs associated with its use**

Manufacturing engineering and manufacturing planning generates significant operational data and information for the manufacturing of products and their parts Data and information have traditionally taken the form of paper documents and cards distributed throughout the shop floor The jobs of creating the paper work, handling the paper work managing the distributing of the paper work Besides the cost, misplaced information can be a source of delay CIM enables information to be stored electronically and displayed on terminals Thus, with document imaging and document management techniques, the elimination of paper and its associated costs is a second reason for CIM

- **To automate communication within a factory and increase its speed**

A manufacturing organization can only be controlled effectively if the controller knows what is going on Many control systems within companies are effectively open loop because of the time it takes to collect and feed back the data For example with manual shop floor data collection system, by the time the scheduler receives data on the state of production, some of it may be two weeks old and entirely unrepresentative of what currently is happening The networks of a CIM implementation permit the sending of messages, memoranda and documents by electronic mail over long distances Communication between customers and suppliers by EDI (electronic Data Change) is a specialised application

- **To facilitate simultaneous engineering**

The 1980's saw competitive pressures and companies to improve processes and systems, to reduce lead times, to carry out operations more quickly, to improve the quality of functional performance, etc The 1980's particularly concentrated on reducing both lead times and inventory Interest in these two aspects of operation developed from Japanese just in time practices In the later 1980's one approach to reducing lead time, which computerization had started to facilitate, was called "simultaneous engineering" or "concurrent engineering" These two terms are synonymous and they refer to carrying out tasks in parallel rather than sequentially Especially suited to design and manufacturing engineering tasks, simultaneous engineering was seen as a means of shortening their combined lead times Simultaneous engineering can easily be implemented with computers All those workıng on a project must be able to access the work beıng done by others Hence the need to lınk together computers and the data they are holdıng [32]

2 2 4 3 CIM Network of the Model Factory

Communıcatıon plays a central role ın computer-ıntegrated manufacturıng (CIM) The choıce of a communıcatıon system largely determınes the capabılıty and productıvıty of a factory Moreover, ın the ımplementatıon of CIM systems, the costs assocıated wıth the ınterconnectıon of the ındıvıdual CIM components are very ımportant The varıous devıce technologıes used ın CIM and the dıfferent demands ın the ındıvıdual areas of computer-ıntegrated manufacturıng necessıtate dıfferent communıcatıons networks to meet these requırements In addıtıon, office communıcatıon networks ımpose dıfferent requırements than factory communıcatıon networks In the office area, communıcatıon ıs prımarıly used for ınter-computer file access and transfer In such a communıcatıon system there are also hıgh data- protectıon requırements In computer-ıntegrated manufacturıng, communıcatıon ıs largely used to control programmable manufacturıng equıpment Here, the tıme requırements are hıgh, and error-free data transmıssıon ıs a necessıty In the 1970s, the broad range of communıcatıon devıces used and the numerous manufacture- and system-specıfic ımplementatıons (mostly ıncompatıble) led to the cooperatıon of varıous ınternatıonal standardızatıon bodıes wıth the goal of a systematıc analysıs of the requırements for open communıcatıon systems and suggestıons for standardızatıon Open communıcatıon trıes to provıde standard data lınks between both manufacture specıfic and technology-specıfic data termınals [33] A sıgnıficant advance ın communıcatıon technology are the Local Area Network (LAN), and the wıde area network (WAN) In thıs hardware and software system, logıcally related groups of machınes and equıpment communıcate wıth each other [30] The processıng and flow of the data ın the conceptual factory ıs controlled by a hıerarchıcal computer system The computers are ınterconnected by varıous types of communıcatıon networks, as ın Fıgure 2 6 [33]

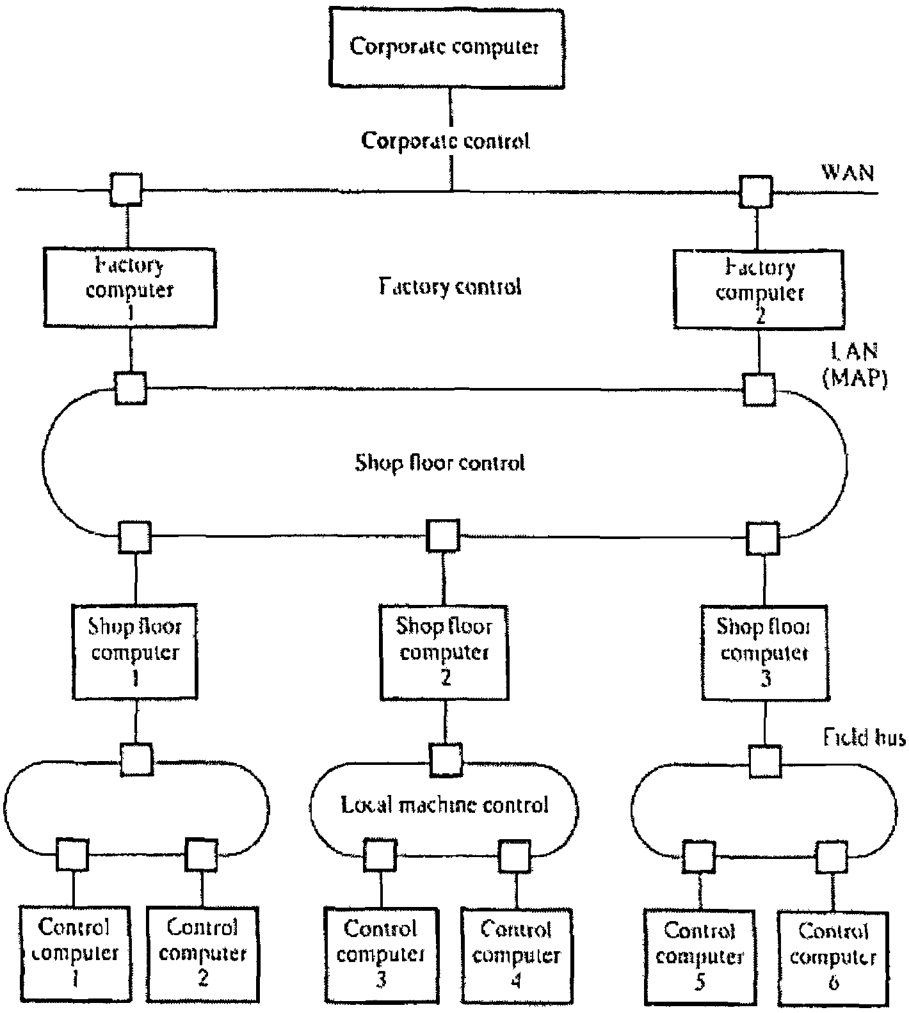

Figure 2 6 A computer network for CIM [33]

Each hierarchical level has specific requirements regarding the data rate, communication distance, communication speed, number of the participants, configuration of network structure and real-time behaviour The computers of the corporate level are interconnected by a wide area network (WAN), which allows communication over long distances This is an open communication system where various types of communication media, such as copper cable, fibre optic line, radio link or satellite transmission maybe used The communication system allows online connection of new participants during the operation of the network It is possible to communicate with other factories, vendors or even with overseas partners On the plant control level, a local area network (LAN) interconnects the various computing systems which co-ordinate and control the factory operations A (LAN) net may use a copper cable or optical fibres over a distance ranging from a few meters to as much as 30 km

The topology of a LAN may be configured according to a star, bus or ring structure, as shown in Figure2 7

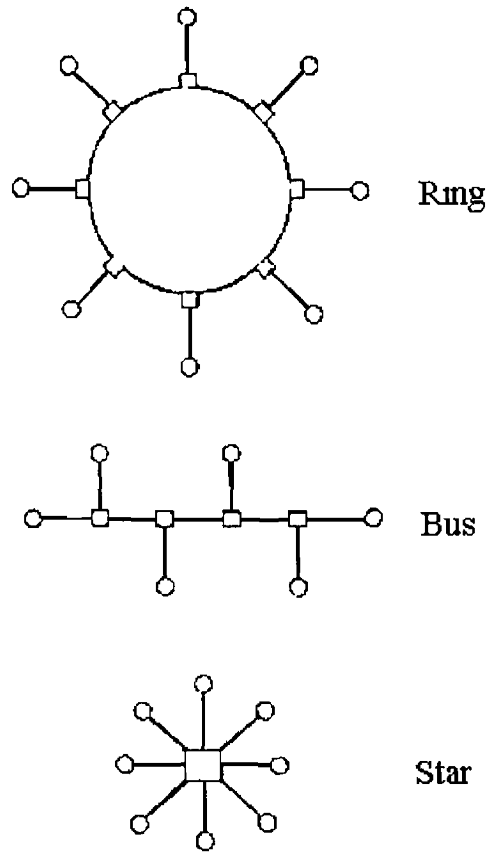

Figure 2 7 Basic types of topology for LAN [30]

- **Star topology**

The star topology is suitable for situations that are not subject to frequent configuration changes All messages pass through a central station Telephone systems in office building usually have this type of topology

- **Ring topology**

In the ring topology all individual user stations are connected in a continuous ring The message is forwarded from one station to the next until it reaches its assigned destination

Although the wiring is relatively simple, the failure of one station shuts down the entire network

- **Bus topology**

In the bus topology all stations have independent access to the bus This system is reliable and is easier to service As its arrangement is similar to the layout of machines in a factory, its installation is relatively easy and can be rearranged when machines are rearranged The connection access method is known by the initials CSMA/CD which stands for carrier sense multiple accesses with collision detect Different types of networks can be linked or integrated together through "gat-way" and "bridge" Access control to the network is important, otherwise collisions can occur when several workstations transmit simultaneously Thus continuous scanning of the transmitting medium is essential In the 1970s, a carrier sense multiple access with collision detection (CSMA/CD) was developed and implemented in Ethernet Used by a majority of workstations and minicomputers, Ethernet has now become the industry standard Other access control methods are *token ring* and *token bus* in which a token is passed from device to device, and the device that has the token is allowed to transmit while other devices receive [30, 33]

Communication standard

Typically, a manufacturing cell is built with machines and equipment purchased from one vendor, another cell from another vendor, and yet another from another vendor Thus a variety of programmable devices are involved, driven by several computers and microprocessors, purchased at various times from different vendors and having various capacities and levels of sophistication Each cell's computers have their own specifications and proprietary standards and cannot communicate beyond the cell with others unless equipped with custom-built interfaces This situation has created "islands of automation", and in some cases up to 50 percent of the cost of automation has been related to difficulties in communication between manufacturing cells and other parts of the organization

The existence of automated cells that could functioning independently from each other and without a common base for information transfer led to the need for a communications standard to improve communication and the efficiency of computer integrated manufacturing The first step toward standardization began in 1980 After considerable effort, and on the base of existing national and international standards, a set of communications standards known as manufacturing automation protocol (MAP) was developed Its capabilities and effectiveness were demonstrated in 1984 by the successful interconnection of devices from a number of vendors As a result, the importance of a worldwide communications standard is now recognized, and vendors are designing their products in compliance with this standard The international Organization for standardization (ISO)/Open System Interconnect (OSI) reference model has now been accepted worldwide The ISO/OSI model has a hierarchical structure in which communication between users is divided into seven layers (Figure 2 8) Each layer has a special task such as mechanical and electronic means of that transmission error detection and correction, correct message transmission, controlling the dialog between users, translating messages into common syntax, and ensuring that the data transfer is understood The operation of this system is complex Basically each message or data from user A is transmitted to user B sequentially through successive layers Additional message are added to the original message as it travels from layer 7 to layer one The complete message (packet) is then transmitted through the communication medium to user B, through layer 1 to layer 7 The transmission takes place through coaxial cable, fiber-optic cable, microwaves, and similar devices Communication protocols are being extended to office automation as well, with development of technical office protocol (TOP) based on the ISO/OSI reference model In this way total communication (MAP/TOP) is being established among the factory floor and offices at all levels of an organization [30]

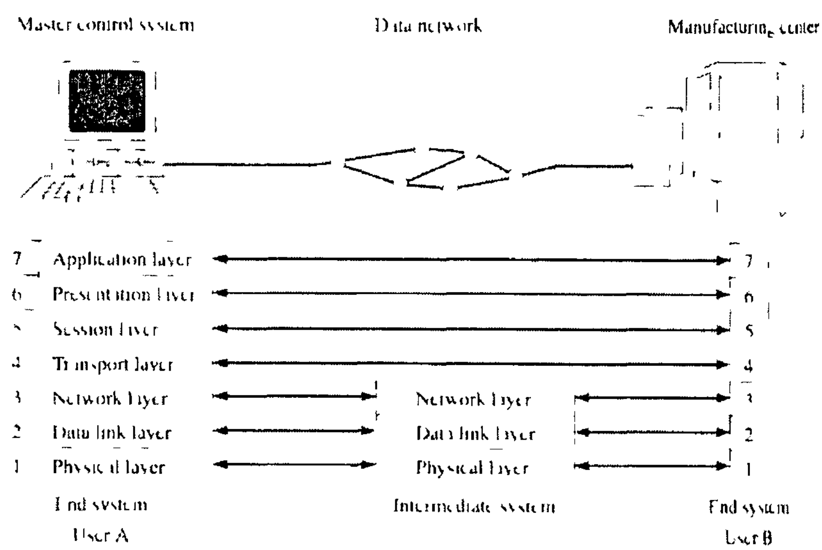

Figure 2 8 The ISO/OSI reference model open communication [30]

2 2 4 4 CIM database

2 2 4 4 1 The Management Information System

The heart of a computer-integrated manufacturing system is a management information system which process, handles and controls the shared data needed for administration, design, planning, scheduling and control The efficiency of operating a computer-integrated manufacturing plant depends on the quality and integrity of a well-designed management information system There is a close relationship between data, which is being processed and used in the various manufacturing activities For example, design information is needed for planning, scheduling, machine programming, quality control and so on For this reason, an information system must be designed as an entity, which comprises all manufacturing activities The components of the information system are the planning and control modules, the common database, the computer network and the communication system The data handled and processed by the management information system comes from external and internal sources of the enterprise Figure 2 9 gives a global picture of the data, which is entered into the system from the world in which the enterprise operates The outer ring shows activities, which project out into the future, to make forecasts, which are needed to secure the position of a company in its competitive environment The inner ring represents the activities of the ongoing manufacturing process Manufacturing takes much data from the outer ring, but it also generates its own data The management information system must process and store data from all levels of a manufacturing operation Most of the information maintains its value for a longer time period, thus it is necessary to provide ample storage capacity Within the context of a generic model of a manufacturing system, the activities of the inner ring are of particular interest

To get a feeling for the magnitude of the problem, the most important planning and control activities needed to channel a product through a plant are shown in Figure 2 10

The text in the boxes explains the activities The database contains the master files and temporary order-related data for all activities There are various master files on the customers, suppliers, and products, manufacturing processes, personnel and so on These files should be located in a common database as seen in Figure 2 10 Access to the master files must be provided for all activities requiring the data Information is located in the master files is of a more permanent nature and need not be changed often The order-related information is composed of data, which has a temporary value to manufacturing It is usually activated with the order entry and can be deleted with the delivery of the product, if it is not needed for future reference [34]

2 2 4 4 2 Data Models

Manufacturing information entered into a database can basically be represented by three classical data models

1 The hierarchical data model
2 The network data model
3 The relational data model

The use of a particular mode in a system depends on the required representation scheme, the available memory, and the ease of accessing and manipulating data The relational database is increasingly getting attention because it offers the user a very natural way of communicating with the stored manufacturing information [34]

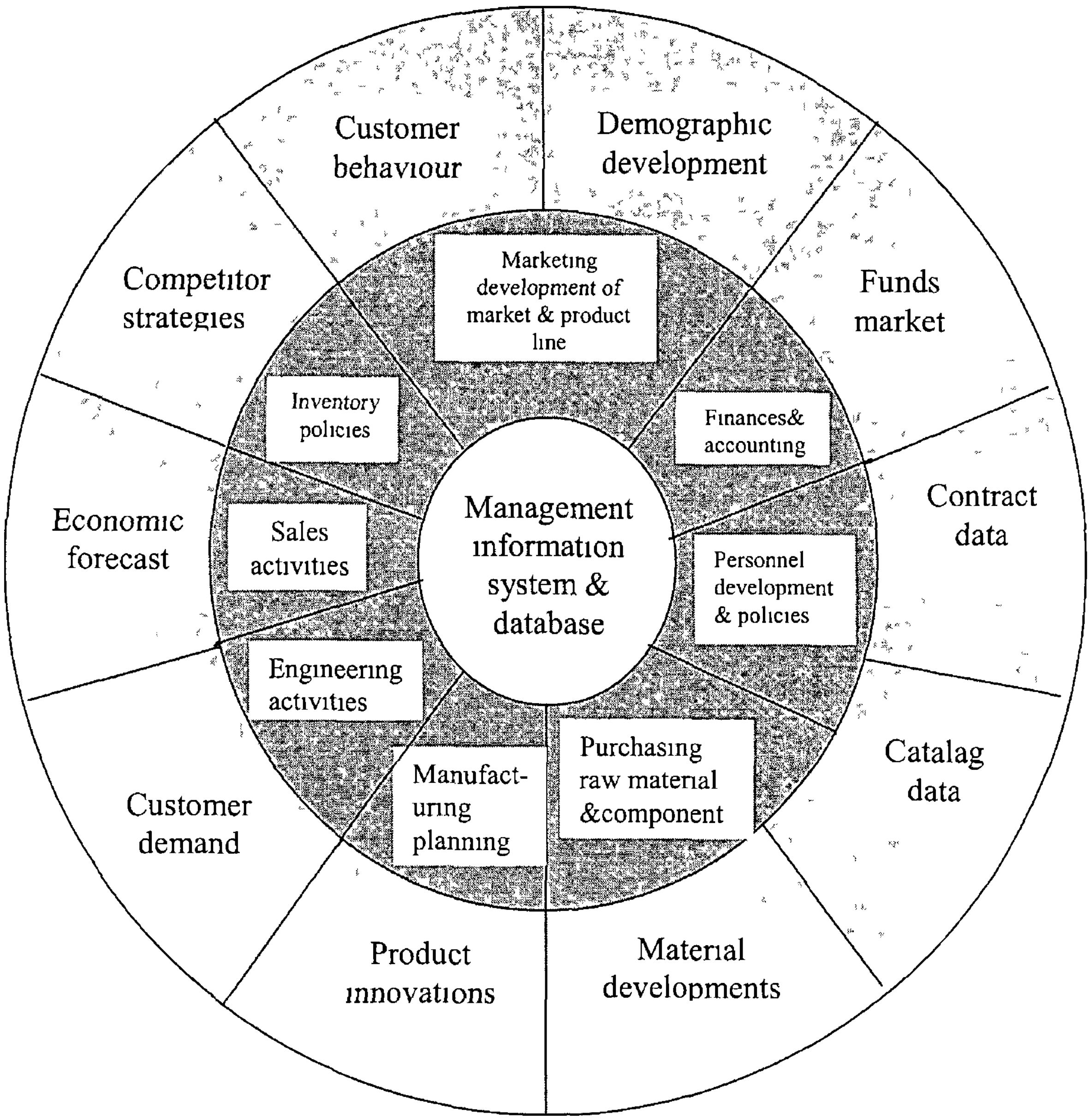

Figure 2 9 Comprehensive management information system of a firm, [34]

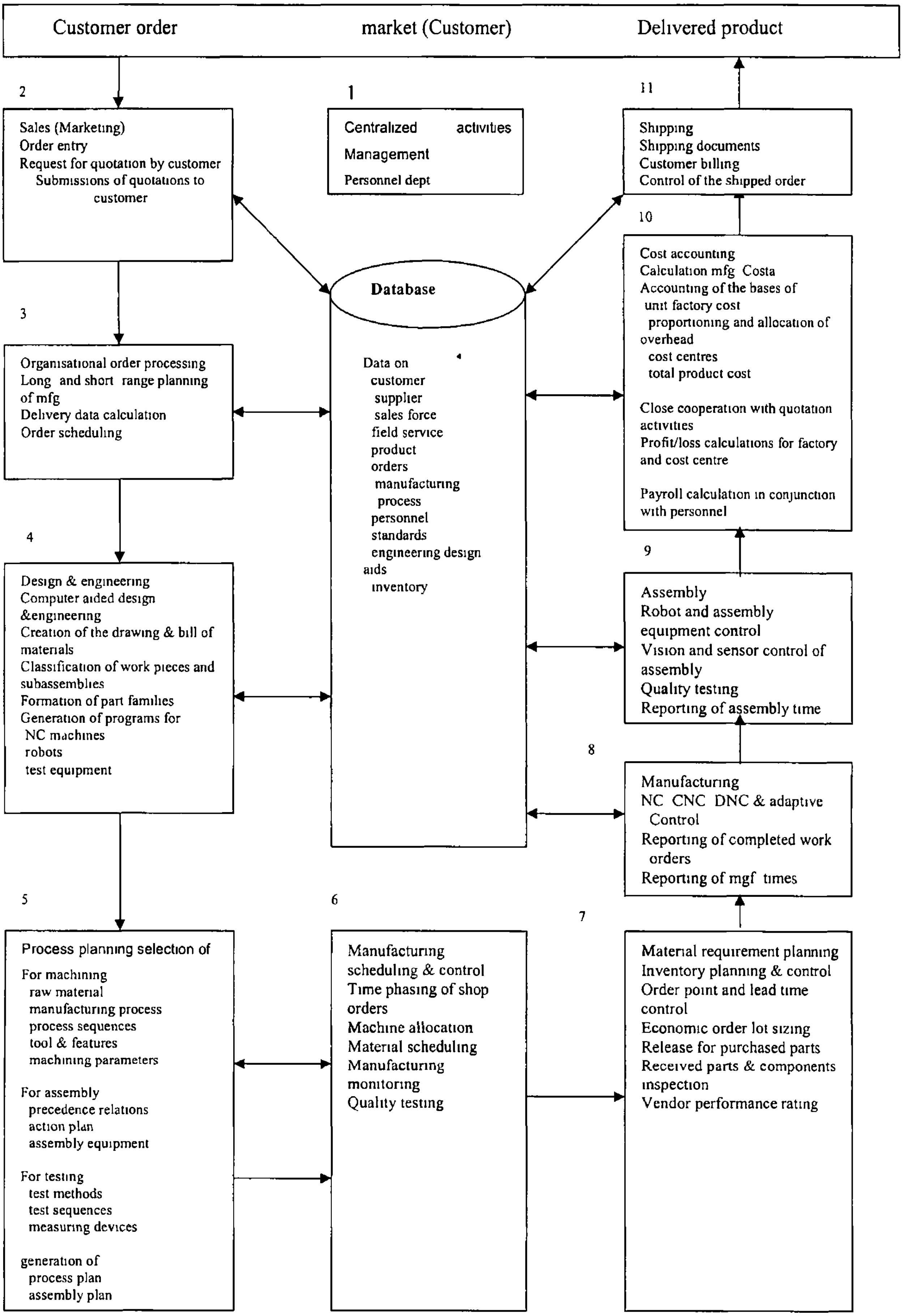

Figure (2 10) A CIM database must flow of an order through a factory, [34]

2 3 Food processing industry

Commercial food processing is the branch of manufacturing that transforms raw animal, vegetable, or marine materials into intermediate foodstuffs or edible products through the application of labour, machinery, energy, and scientific knowledge

Various processes are used to convert relatively bulky, perishable, and typically inedible food materials into ultimately more useful, concentrated, shelf-stable, and palatable foods or potable beverages Heat, cold, drying, chemical and biological reactions, and other preservation techniques are applied to enhance storability Containers and packaging materials confer portability as well as extended shelf life Changes in product forms often reduce preparation time for consumers Increasing palatability, storability, portability, and convenience are all aspects of "adding value"

In other words, food processors utilize factory systems to add economic value by transforming products grown on farms or fished from the sea [35]

2 3 1 Classification of food industry

According to Connor and Schiek [35], food industry has classified as following

- Meat, fish, and eggs
- Dairy products
- Grain milling and baking
- Breakfast cereals
- Pasta
- Canning
- Freezing
- Drying
- Sweeteners and sweets
- Vegetable oils and margarine
- Malt Beverages
- Wine
- Spirits
- Tea, Coffee, and Spices
- Snacks

2 3 2 The development of food processing

The contemporary food manufacturing industries are the culmination of over a century of technological evolution Man has since the origins of civilization, always processed food The basic technical purposes of food processing have remained unchanged for an eon Animal, vegetable, and marine raw materials are transformed from relatively bulky, perishable commodities to products that are more palatable, nutritionally dense, stable, and portable Processing separates what is regarded as most valuable from waste or by-products Processing usually enhances palatability (for example baking flour into bread), digestibility (brewing coarse into beer), and sensual appeal Processing makes foods more portable and tradable by increasing the value to weight ratio, in ancient Hellenic times, long-distance trade developed in bottled oils and wines that would never have occurred with there unprocessed forms olives and grapes

Most food manufacturing techniques were discovered long ago Slaughtering domestic animals predates written history, and in cold climates meat and fish were frozen Sun and air drying grains, beans and fruit wee ancient practices Meat drying methods were known to the North American Indians, fish drying to the prehistoric peoples of Japan, and egg drying to the prehistoric Chinese The curing of meats (and vegetables) with salt or smoke is at least pre-Christian and possible of Greek origin by the middle ages over 200 varieties of processed meats were being made commercially by European craftsmen Milling and baking are also ancient methods of food preparation Cakes over 5,000 years old have been excavated in Europe Leavening and the baking of wheat breads were known to the Egyptians by 2600B C The Romans baking industry was well developed ,they invented mechanical dough mixers and their bakers were organized into disciplined guilds The earliest processed dairy products were cheese and yoghurt, both first developed in west Asia Most other processing methods are relatively modern Canning, freezing, and chemical preservation (except salting) have all been invented since 1800 The first U S meatpacking house was established in Boston in 1662, and there was thriving pork-canning industry centred around Cincinnati beginning in 1818, The Midwest meatpackers first began to use refrigerated railroad cars to transport beef to Eastern markets in the early 1880s, and in about 1900 mechanical disassembly and conveyors came into use in meatpacking methods In the 1950s major improvement were made in sanitation and packing methods Mechanical refrigeration also made possible the commercial (wholesale) ice cream industry, which appeared about 1890 until that time, ice cream was made in small batches in retail establishments for daily sale Continuous ice cream freezer-makers were introduced after 1950 Similarly, continuous butter churns were first sold after 1945 both of these inventions increase markedly the size of the most efficient plants Pasteurisation, homogenisation, and the advent of automated high-speed bottling lines also raised the optimal output size of fluid milk plants

Some food processing techniques were very recently developed and still are in limited commercial use In addition, developments in food machinery industries may make possible the wider introduction of more fully automated continuous flow methods in food processing Replacement of batch continuous-flow equipment makes for fuller utilization of capital, simplified control, less labour, and more uniform products [36]

2 4 Related work

In food processing the main objectives are food safety, minimal processing, and high quality products good instrumentation, appropriate fault detection and reliable real-time on-line control techniques are required [37] Intelligent computer systems capable of modelling and real-time simulation of entire food processing operations from production planning to process control are visualized for the future Unfortunately, there are few means of real-time measuring and monitoring of key food process variables, and of food quality attributes Non-uniformity and variability in raw materials, and high-volume low-added-value production has limited investments in sophisticated food control systems Furthermore, most food processes are highly non-linear, often with time-varying dynamics, which complicates food automation and control even in the current computer era [38-40]

Consequently, subjective human expert knowledge in the form of 'rules of thumb' is invaluable and still widely used However, the recent developments in artificial intelligence-based advanced control tools such as fuzzy logic and neural networks, and their introduction to food processing have opened up novel possibilities for food process control When conventional control systems do not work satisfactorily, a fuzzy expert controller could well replace the human operator [41]

Nevertheless, the replacement of the human expert by advanced computer-aided systems in the food industry has been slower than in other process industries And related publications are scarce

John McCarthy first introduced the artificial intelligence paradigm in 1956 as a concept of data processing that would mimic human problem-solving behaviour [42] About a decade later, in 1965, Lofti Zadeh [43] published the principle of fuzzy (continuous) logic, which today has found numerous practical applications from household appliances to industrial process control In 1991 Matsushita alone in Japan sold over US$1 billion worth of fuzzy logic-based products [44]

And in 1996 Japan exported about US$90 billion worth of fuzzy logic-based goods [45] Although most fuzzy food applications have been in the control area [46], Lincklaen-Westenberg *et al* [47] at Unilever demonstrated the superiority of fuzzy food classification over statistical treatment as used in sensory evaluation

K Ting 1998 [48] has discussed robots as automation tool in the food industry He enhanced that robotics is fairly new to the food processing industry Ting has pointed that harvesting and grading of fruits and vegetables are most suitable tasks for robotics applications in the food industry Purnell et al, [49] reported that a robotic system has been developed to remove meat from a beef forequarter Robot technology plays an important role in food packaging, (Jerney, 1994) [50] pointed out that there have been many examples that demonstrate successful implementation of robots with machine vision capabilities in replacing human touch labour, examples included the use of commercially available robots to transfer bakery items from cooking process to consumer packages, to pack ground beef patties, chicken, or fish filets, sausages, or bagged products into cases, and to prepare airline meal Belforte et al, (1991) [51] studied various automated and robotic devices and methods to be used in sweet products manufacturing and packaging An air nozzle was developed as a robot end-effector for cutting puff pastry into any shape

In general by the last decade automation in the food industry has increased and computer technology has become adopted in food plants but in limited ways compared to other industries

A recent survey carried out by the Leatherhead Food Research Association suggests that the food industry has been surprisingly slow to take up many useful technologies that have emerged in recent years [52]

Sasha et al, [11] in their survey on automation practices in food industry figure out that there has been a significant increase in food process automation over the last decade, also this survey determined the level of automation in food industry, (Figure 2 11) They found that about 59% of food manufacturers indicated that their plants was mostly automated As for the level of automation that food manufacturers envision for the next five years, they found that about 41% of respondents desire to implement full automation of their facility, and 18% would still expect to have only limited number of operations automated, finally about 35% of respondents indicated that they have no desire for further automation in next five years (Figure 2 12)

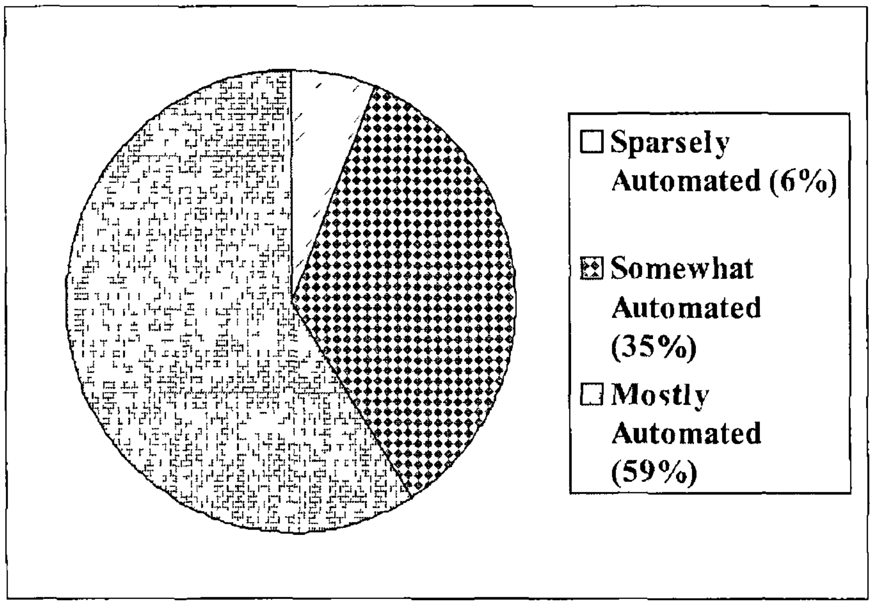

Figure 2 11 Current level of automation in US food industry [11]

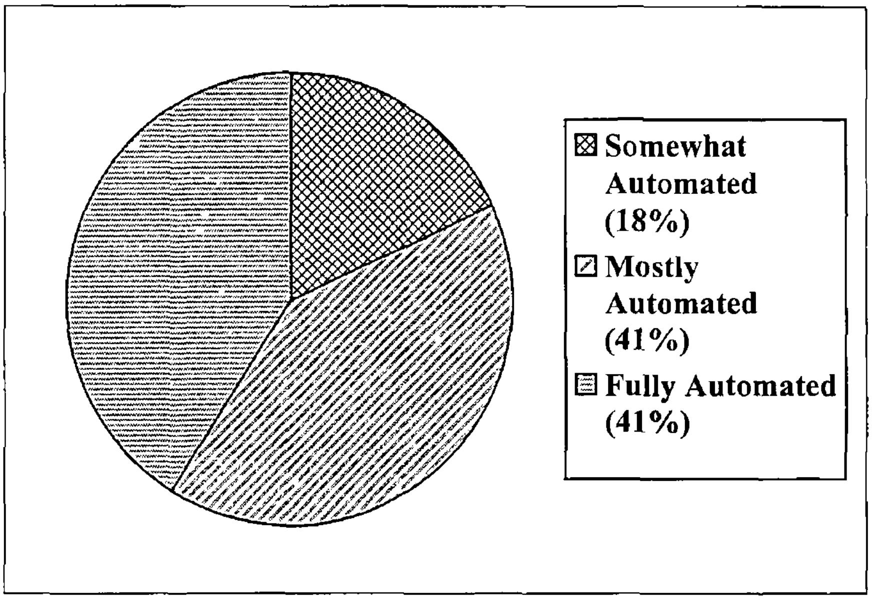

Figure 2 12 level of automation expected by the next 5 years in US food industry [11]

Maria A [53] has conducted a survey on the top 10 manufacturing trends The result of the survey indicated that only 3 2% of the processors surveyed have a truly top-to-bottom integrated manufacturing operation a slight increase over last year when 2% reported a truly integrated operation Although most processing facilities are not totally integrated, the majority of food plants report some level of integration In year (1999) 55 7% of those surveyed reported "scattered islands of control "This is up from last year's 52 percent In 1998, 22 percent reported implementing distributed process control, while this year's sample was 19 percent The percentage of respondents reporting central process control declined from 11 3 percent in 1998 to 9 5 percent this year (1999) Those having little or no process control remained constant at 12 percent

Sasha et al, [11] studied the level of use of computer integration manufacturing in various parts of food manufacturing process They found that the majority of food manufacturing companies (94%) indicated the computer-aided manufacturing Distribution management and computer-aided design are each integrated in 47% of cases Electronic HACCP programs are used among 24% of respondents, as shown in Figure 2 13

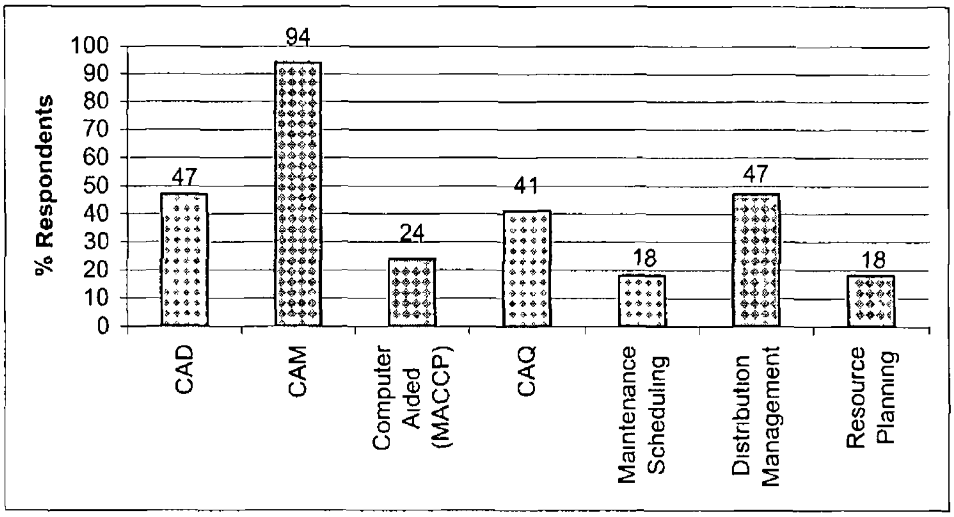

Figure 2 13 The use of CIM technology in food manufacturing [11]

Chapter 3

Designing The Survey

3 1 Definition of survey

Surveys are an important means to learn about people's attitudes, behaviours, and characteristics and to assess any activities in any field Every day, the results of polls and surveys are used by policy-makers, the media, and market researchers to describe the population, to make critical decisions, to analyse how various groups feel about a range of topics According to Whitman [54] a survey is a systematic method used to collect data from more than one source to answer one or more questions typically arranged on a form called a questionnaire

3 2 Objectives of Survey

Computer Integrated Manufacturing is distinguished by the use of computer control in place of hard automation usually found in food industry CIM provides high flexibility to produce multiple part types regardless to the production volume of each part Market forces are driving the food industry toward the generation of automatic devices with more effective process control strategies A considerable body of research literature has accumulated in implementing CIM in food industry since the late 1980s However, these reviews focused on specific perspectives such as automation technology, or implementation methodology This study attempts to survey, "Automation and computer integrated manufacturing in the food processing industry" having wider practical perspectives while concentrating on the impact of the automation and CIM implementation on enhancing the food industry performance A list of the survey objectives follows -

- To determine the level of current automation in the food industry
- To determine the desire to adopt automation technology over next five years
- To determine the current status of CIM implementations in food industry
- To determine the reasons that caused the decision to invest in CIM
- To determine the obstacles to the adoption of CIM system in food industry

3 3 Coverage of Survey

The taiget population of this survey is the Irish manufacturing companies within food piocessing industry sectoi This list of companies can be obtained fiom the Bord Bia (Irish Food Board) [55], and Irish Seafood Trade Directory [56]

Bord Bia (Irish Food Board) is the agency charged with the promotion of Irish food at home and abroad It is the organisation behind this site and further information on it can be found at www bordbia ie

Irish seafood Trade Directory has been developed by the market development division in order to promote the Irish seafood sector

In the database of Board Bia (Irish Food Board) and Irish Seafood Directory there are hundreds of companies registered as companies working in this sector (food industry) as manufacturing companies, supplier and marketing companies etc In this study the companies, which have been selected were just manufacturing companies This has been done by searching in the database of Board Bia and Irish Seafood Directory

In this survey two methods have been employed, 1) postal survey, 2) and web-based survey A total of 252 companies were identified and contacted The questionnaire surveys were sent to 221 manufacturing companies, and an e-mail message including a hyperlink of the online survey has been sent to the remaining 31 manufacturing companies Both techniques, the traditional post and on-line survey comprises of the same questionnaire The traditional postal survey involves posting questionnaires to the selected companies While the online survey involves designing a web page as an online form that consisted of radio buttons, check boxes, text boxes, and submit button

3 4 Scaling of responses

Scales are ways of ordering possible responses to a question There are four types of scales that may involve numbers, each with different characteristics that determine the suitability of applying statistical tests, the types of scales are [54, 57]

- Nominal scales
- Ordinal scales
- Interval scales
- Ratio scales

A nominal scale is simply a set of categories, which may or may not be numerically coded There are many questions in this survey, which take this form or type of scale Example Question no 1 What kind of food produced by your company? And the possible responses offered are Infant formula, Human food other 1, Animal food, Food ingredients, and others It is possible to code these responses using letters or numbers There is no relationship between the types or codes used except to represent the names of the possible respondents

An interval scale has equal units of measurement that makes it possible to interpret not only the order of the scales but also the magnitude of the distance between them Example Question no 13 (refer Appendix A)

Ordinal scale use numbers, but only to represent an order or sequence to the responses, not to imply that there is an evenly spaced interval between sequential numbers

Ratio scales use numbers that start with a zero as a base, so that all the numbers are defined in an identical way relative to zero and the first number Therefore, the number 2 means exactly twice the value between zero and one, the number 9 means exactly 9 times the value between zero and one, and so on

3 5 Response Errors and Rates

This is very important topic in any survey based research that relates to reliability and validity According to Sudman [57] the different types of errors fall into four factors

Memory material may be forgotten or may not remembered clearly

Motivation respondents may want to present their companies in a better light

Communication inability to understand the questions asked

Knowledge respondents may not know the answer

Apart from the problem of response errors that have a bearing on the reliability and validity of the survey and consequently the research study, the problem of low response rate has always been a major cause of concern to any researcher

According to Moser and Kalton [58], it is not the loss in sample numbers that is serious, but the likelihood that the non-respondents differ significantly from the respondents

There are various types of non-response and some will be mentioned below

- Companies outside the population
- Companies refusing to co-operate
- Change of addresses or wrong addresses

3 6 Pre-tests and Pilot Survey

Within the framework of the general principles and guidelines for administrating a sound survey, and in order to be sure that the questionnaire is understandable, to get any suggestions for improvements, to avoid any difficulty, to observe that the instructions and questions work as expected, pre-testing and pilot survey are necessary In this study, pre-testing of the survey questionnaire was carried out on a number of occasions Sample questionnaires were given to peers, academic staff, who are familiar and have experience in the industry field, and revised by the project supervisor

3 7 The postal survey

The postal survey materials were printed in booklet form, on A4 paper The questionnaire was 4 pages long A cover letter (refer to Appendixes B & C) was printed on the official letterhead of Mechanical and Manufacturing school, and signed by the supervisor, and a reply-paid envelope was included in the packet The envelopes were individually addressed and delivered to the mail office of the school for distribution using mail Reminder questionnaires were distributed after a month of the first questionnaire Returns were collected directly from the school office for check-in and data entry A postal survey coverage about 221 manufacturing companies in Irish food industry
Similar procedure was used for the web-based survey Section 3 10 will discuss web-based survey in details

3 8 Questionnaire Design

The research employed in this study involved designing of a postal survey questionnaire and web-based survey and mailing them to manufacturing companies in food industry in the Republic of Ireland Whitman [54] and Czaja and Blair [59] identified several important factors and procedures any questionnaire design should take into careful consideration when designing questionnaires, which are 1) question is clear and unambiguous, 2) wording of questions, 3) formatting the questionnaire, 4) and length of the questionnaire Certain guidelines were also proposed by Sudman [57] and Frink [60] In designing the questionnaire all the above guidelines have been taken into considration A Draft questionnaire, which relates to the survey's objectives, was prepared Some questions from similar survey have been used (a survey carried out on the automation practices in the US food industry in 2001 [11]), and some ideas have been taken from other surveys (a survey on computer integrated manufacturing in Germany industry carried out on 1997 [61], and Survey of Advanced Technology in Canadian Manufacturing carried out on 1999 [62]) The questionnaire has been divided into three sections

Section 1 General Information

This section contains four questions (Questions 1 to 4) It covers the information concerning the kind of food produced, the production volume, number of years in business and the number of employees

Section 2 Automation

This section contains six questions (Questions 5 to 10) It covers the information concerning the level of automation in present and in future, type of operation and automated areas, the obstacles as well as the motivation for implementing advanced new technology in the factory

Section 3 Computer Integrated Manufacturing

This section contains four questions (Questions 11 to 14) It covers the information concerning the current CIM technology and networking used, the objective of CIM investment and finally the obstacle of CIM implementation

All questions are in multiple choices format and a number of them have some space to make comments This will save time for respondents and make questions more understandable

In order to least interrupt the respondent's train of thought and at the same time not influence his or her response, the questions have been ordered in logical sequence, for example question 5 sought information about the current level of automation in the plant, next question sought information about the expected level of automation, and question 7 sought information about automated areas and so on Therefore this order of questions (where to place questions on the questionnaire) made the questionnaire in logical sequence form By taking the comments on the pilot test in consideration, reviewing and eliminating problem questions, the final questionnaire was developed in form that can be characterised as all questions are clear, understandable, in logical sequence, and the length of the questionnaire is reasonable (answering time of the questionnaire is about 25 mints)

3 9 Questionnaire analysis

Question 1

Sasha et al [11] in there study " a survey of automation practices in the food industry, classified food industries into five groups

- Infant formula
- Human food, other than (1)
- Animal food
- Food ingredients
- Others (specify)

In this question the name of the kind of food follows the checkbox The respondent should tick just one of the five options

Question 2

There is more than one factor affecting the volume of production Implementation of advanced manufacturing technology in the industry has a big effect on the volume of production Therefore a large volume of production will be an indicator of the use of advanced manufacturing technology for any company In this question there are four choices

- < 1,000 tons
- 1,000 – 100,000 tons
- >100,000 – 1,000,000 tons
- >1,000,000 tons

The respondent should tick the appropriate one

Question 3

This question inquires how long the firm has been established It is generally believed that the longer a firm has been in operation the more difficult it becomes to accept changes Whereas for new ventures or fresh start firms, the chances of meeting resistances are minimal since there will be little or no established work culture that may hinder the introduction of automation and efficiency improvement initiatives In this question, there are six options

- Less than 10 years
- 10-20 years
- 21-30 years
- 31-50 years
- More than 50 years

And the respondent should tick the most appropriate option

Question 4

Some experts believe that the size of employment plays a crucial role in the development of quality, efficiency and productivity Also it is generally believed that the relation between the size of employment and the level of automation is inversely proportional Large organizations with a high level of automation should have a low employment level compared to the same size of organization with a low level of automation In this question, there are five options

- Less than 25
- 25 to 50
- 51 to 100
- 101 to 200
- 200+

Respondents should tick the appropriate one

Question 5

In general the level of automation in industry plays an important role in the productivity process Automation has a direct effect on the efficiency, quality and productivity High levels of automation in the food industry or in general industry should increase quality and productivity- at the same time decreasing costs and cycle time This question inquires about the level of automation or the lack of it in relation to the amount of products and number of employees of the organization Five objective answers are provided expressing five level of automation, as below

- No automation
- Sparsely automated
- Somewhat automated
- Mostly automated
- Fully automated

The respondent should tick the appropriate one

Question 6

Normally the implementation of automation will increase gradually in line with the growth and development of the organization This question seeks information on the future level of automation within the next five years Again five objective answers are provided expressing five levels of automation as below

- No automation
- Sparsely automated
- Somewhat automated
- Mostly automated
- Fully automated

The respondent should tick the appropriate one

Question 7

Food industries consist of various type of operations starting from raw material handling to actual processes to quality inspection to packaging This question seeks information on the number of operations automated using microprocessor/computer based control system The five objective answers are

- None
- Very small number of operations
- Some operations
- Most operations
- All operations

The respondent should tick the appropriate one

Question 8

Each factory or plant consists of several parties or units, and each one of these has a role in the productivity process The decision of automating any unit depends on several factors for example time, cost, value of production, staff skills etc This question seeks information on the current situation of automation of units in the plant In this question, six important units are identified in the plant

- Raw material receiving and inspection
- Raw material preprocessing
- Processing/ filling / wrapping
- Post process handling and inspection
- Packaging
- Warehousing and storage

The respondents must tick any unit which has been automated

Question 9

There are many obstacles facing manufacturers in implementing new technology systems, this question seeks information on the obstacles of implementing microprocessor/computer-based control system in the food industry Five general obstacles are identified, which usually face manufacturers when implementing new technology, these are

- Time is an important factor m deciding to implement new technology systems such as microprocessor/computer-based control systems The implementation of new technology needs time for planning, designing, installations, testing, and operating the system
- Cost is also an important factor affecting the decision maker when implementing new technology such as microprocessor/computer-based control system The implementation of microprocessor/computer-based control systems needs equipment and expertise These cost manufacturers a substantial amount of money, so if the capital of the firm or organization does not allow implementation of new technology, then cost is a major obstacle
- Technical skills of support staff is one of the major obstacles for implementation of microprocessor/computer-based control system if the organization lacks competence and technically skilled staff In order to overcome this obstacle, the

decision maker in the organization has to organize training courses for staff before implementing new technology Another alternative that company recruit 'ready-made' skilled workers to operate new technology Both options imply high investment in the company or organization

- Management commitment the implementation of new technology such as microprocessor/computer-based control system needs full support and commitment from management in terms of money allocation, time, and opportunity Other wise the implementer will encounter major difficulty
- Nature of business normally automation is needed for manufacturing businesses where repeatable processes and large volumes are involved Not all food industries are of this nature Obviously, this affects the suitability of the business for implementation of automation
- Others the respondents are requested to specify other obstacles which are not included in the list above

For all the obstacles listed above, the respondents are required to identify the severity of the obstacles from scale 1 {not an obstacle) to scale 5 (major obstacle)

Question 10

Theory of diffusion of innovations suggests that the presence of motivation to implement new technology positively affects the rate of adoption

This question sought information on motivation factors on the implementation of microprocessor/computer-based control technology in food plants Various reason and benefits are identified by implementing microprocessor/computer-based control technology as motivations for manufacturers to implement this kind of technology Among the reasons identified are

- Access to process information
- Lower production cost
- Improved personnel safety
- Improved product safety
- Better quality
- Obsolescence of older technology

The respondents are required to check all the motivation factors, which apply, in implementing this kind of technology

Question 11

This question is one of the most important questions It seeks the core information of the study The computer integrated manufacturing has pictured as an umbrella that covers modern technologies CIM technologies are divided into three groups The first group are management techniques, and technologies that support the integration of the company's functional departments The second group of technologies support the shop floor activities by designing, planning and controlling the process and products The third group are computer-based technologies that are used directly on the shop floor for the production, handling and transport of parts and products In this question it has been tried to select the useful technologies in food industry, which are part of component of CIM technology The technologies selected are

- Computer-Aided Design (CAD)
- Computer-Aided Engineering (CAE)
- Computer-Aided Manufacturing (CAM)
- Computer-Aided Quality (CAQ)
- Computer-Aided Planning (CAP)
- Production Planning and Control (PPC)
- Production Program Planning (PPP)
- Volume Planning (VP)
- Capacity Planning and Scheduling (CPS)
- Production Ordering (PO)
- Production Ordering Monitoring (POM)

The respondent should indicate which of the above technologies they are currently using, plan to use (within five years), or have no plan to use

Question 12

Communication network is a very important part in computer integrated manufacturing, it links all departments and units in the plant, and allows the managers to communicate and to access to the units in the plant via computers The communication networks have been classified in four kinds

- Local Area Network
- Wide Area Network
- Wireless Local Area Network

- Wireless Wide Area Network

This question seeks information on the kind of communication network, which is employed in the company The respondent is required to indicate which kind of network is in use in the company

Question 13

Any company or investor when implementing any new technologies has to have planning and objectives of the new technology investment, in this question some important common objectives of the CIM investment are indentified, which are

- Reduction of the order processing time
- Increased delivery scheduling effectiveness
- Shorter delivery times
- Increased procedure and information transparency
- Increased product quality
- Reduced inventory level
- Increased production flexibility
- Increased calculation and planning accuracy
- Reduced administrative expenses

The respondent should indicate the percentage of the actual goal, which has been achieved if they implemented CIM technology in their company, also they can specify and indicate the percentage of achievement for any other objectives not be listed above

Question 14

As mentioned in Question 9, there are many obstacles facing manufacturers to implement new technology systems, this question sought information on the obstacles for implementation of computer integrated manufacturing system in food industry Five general obstacles usually facing manufacturers for implementation new technology have been identified, which are time, cost, Technical skills of support staff, Management commitment, Nature of business and others These five general obstacles have been discussed in Question 9

3 10 On-line survey

3 10 1 Introduction

Survey research has traditionally played an important role in many areas of the social sciences and business, such as policy development, marketing and consumer research, health issues, educational practice, media polling, and political polling [63] There are several methods that can be considered in order to collect data in survey research Each has advantages and disadvantages *Diem* has classified methods of collecting data in survey research into mailed survey, telephone survey, personal interview (face-to-face), and web-based survey [64]

Over the last decade, electronic surveys have evolved from disk-by-mail surveys, to e-mails with embedded or attached surveys and finally to web-based surveys posted on the Internet [65] With web-based surveys, participants are usually notified by e-mail to participate in the survey The e-mail generally includes a link to the URL (uniform resource locator) web address of the survey [66] Internet based technology such as the World Wide Web (web) is fast becoming accessible to large segments of society Usage is doubling every year with a current estimate of 1 in 6 people using the Internet in North America and Europe [67]

In this research in the field of automation and computer integrated manufacturing in food processing industry, both paper questionnaire and web-based surveys as a method to collect data have been used As part of this study a comparison between the two methods (paper questionnaire and web-based survey) will be conducted

3 10 2 Brief history of on-line survey

Beginning in the late 1980s and early 1990s, prior to the widespread use of the Web, e-mail was explored as a survey mode As with the Web today, e-mail offered the possibility of nearly instantaneous transmission of surveys at little or no cost Unlike the Web, however, early e-mail was essentially static, consisting of a basic ASCII (text- only) message that was delivered via the Internet E-mail surveys tended to resemble the linear structure of a paper survey and were generally limited in length Furthermore, because e-mail surveys were primarily text-based, document formatting was rudimentary at best The only significant advantage they offered over paper surveys was a potential decrease

in delivery and response time and cost, although some observers also hypothesized that the novelty of the new medium might actually have enhanced response rates [68, 69]
The Web started to become widely available in the early- to mid- 1990s and quickly supplanted e-mail as the Internet survey medium of choice Whereas early e-mail was all ASCII-based, the Web offered the possibility of multimedia surveys containing audio and video, as well as an enhanced user interface and more interactive features [70]

3 10 2 Coverage of on-line Survey

The target population, that is the population for which the results are required are some Irish manufacturing companies within food processing industry sector this list of companies can be obtained from the Bord Bia (Irish Food Board) and the Irish seafood Trade Directory
Bord Bia (Irish Food Board) is the agency charged with the promotion of Irish food at home and abroad It is the organisation behind this site and further information on it can be found at (www bordbia ie) [55] Irish seafood Trade Directory [56] has been developed by the market development division of the Irish seafood sector This survey is a part of a research study, which covers some Irish manufacturing companies within food processing industry sector Whereas the other part of study has been conducted by a traditional postal survey A total of 31 companies were selected for the on-line survey Both techniques, the traditional postal and on-line survey comprises of the same questionnaire The traditional survey involves posting questionnaire to the selected companies, which has been designed in Microsoft Words While the online survey involves designing a web page as an online form that consisted of radio buttons, check boxes, text boxes, and submit button
In order to ensure that the survey was easy to complete, a pilot study was undertaken by the Department of Mechanical & Manufacturing Engineering with 6 participants During the pilot-testing phase, the average time to complete the on-line survey about 20 -25 minutes

3 10 3 Methods of onlıne survey

In the few years sınce ıts ınceptıon, the World-Wıde Web, or WWW or Web, (Berners-Lee et al , 1994) has grown dramatıcally ın the number of users, servers, and ıts geographıcal dıstrıbutıon [71] MacElroy [72] has classıfied current methods/technologıes for conductıng on-lıne research projects ınto seven methods These range from the most basıc, least costly methods (e g , text e-maıl) through hıghly sophıstıcated, and relatıvely expensıve forms

- E-maıl (text),
- Bulletın boards,
- Web HTML,
- Web fixed-form ınteractıve,
- Web customızed ınteractıve,
- Downloadable surveys,
- Web-moderated ınterviewıng chat ınterviewıng and other dıscussıon formats (qualıtatıve)

3 10 3 1 E-maıl (text)

One of the earlıest methods for conductıng surveys over the Internet or over a company's ınternal system (ıntranet) ıs the sımple text-based e-maıl survey These surveys can be generally thought of as on-lıne paper-and-pencıl surveys [72]

3 10 3 2 Bulletın boards

Specıfic web sıtes were used ın ınvıtıng dıscussıon topıcs or where dıscussıon topıcs are posted Thıs onlıne research ıs relatıvely easy and fast It ıs also consıdered as ınexpensıve category of bulletın board research where responses are collected over tıme The user responds to the orıgınal topıc and what other users wrıtten ın responses Thıs way the ınformatıon ıs fed back and forth between users the task of formıng a bulletın board ıs not dıfficult but ıt would be requıred to have more skıll than formıng an e-maıl survey

3 10 3 3 Web HTML

The most common form of on-lıne surveyıng ıs the flat HTML survey form Characterıstıcally, these surveys take the shape of a long, sıngle page on whıch the respondent clicks buttons and boxes, fills in text boxes, and eventually submits the information all at once

3 10 3 4 Web fixed-form interactive

Another new form of on-line research is being driven by survey authoring tools Many of these tools have been developed from previous generations of software used to conduct computer-assisted telephone interviews (CATI) or disk-by-mail (DBM) studies They have been adapted to "play" questions on the Web the same way they would play for an interviewer at a tele-polling station

The big innovation is the option of allowing the individual researcher to construct highly sophisticated studies for the on-line environment These software packages put many of the sophisticated controls that have been available for phone studies since the late '70s directly into the researchers' hands Most of these tools exist as packaged software programs that the researcher uses on his or her own PC As an alternative, several interesting new Web sites have emerged which allow the author to design the research on-line without the need for loading the design software

3 10 3 5 Web customized interactive

The most powerful and flexible of all on-line surveying options are those that involve the custom programming skills of highly skilled technical people They also tend to be the most expensive Like the fixed-form tools, custom programming provides all of the modern technical controls (screening, skip-patterns, logic, error-checking, etc), but also offers many other tricks and options that allow the researcher the highest level of flexibility currently available for design and functionality

3 10 3 6 Downloadable surveys

Another on-line survey method attracting attention are surveys that are downloaded from the Web and run on previously installed software provided by the researcher This shifts the computing tasks from the on-line server to the respondent's PC Once pre-loaded, the survey software can then read much smaller files that the respondent downloads from the Internet The result is surveys that run in a very similar manner to the fixed-form interactive surveys Once the survey has "played" on the respondent's PC, a data file is created which can then be uploaded the next time the Internet is accessed [72]

3 10 3 7 Web-moderated interviewing chat interviewing and other discussion formats (qualitative)

In these chat interviews, the logic and control mechanisms are supplied by a highly skilled human moderator People enter the interviewing chat session and then type the answers to questions posed by the moderator While the results from traditional focus groups can be highly influenced by the skill of the moderator, these on-line chat sessions are doubly tricky Just as the traditional moderator must control the overly enthusiastic participant, the on-line moderator must control the "tyranny of the fastest typist " [72]

3 10 4 The Web HTML

Most Internet surveying is now being done using HTML forms with potential respondents often contacted via email cover letters While some developers still directly code these forms in HTML, there are dozens of HTML editors available, and they are becoming increasingly sophisticated and easy to use There are two general methods of capturing the data entered into an HTML form The form can be programmed to email the data back to a specified email address or captured by a program on the server called a common gateway interface (CGI) script Using CGI scripts is more robust, offers more flexibility and is the far more commonly used method of capturing data There are several HTML development packages that both provide HTML editing capabilities and automate the process of developing the CGI scripts necessary to capture data from HTML forms developed with the package Two widely used examples of these packages are Microsoft's FrontPage and Macromedia's ColdFusion

While these packages are general purpose Web development tools, there are also a growing number of software development systems designed specifically for Web-based surveying Examples include Perseus's, "Survey Solutions" for the Web, Creative Research System's, "The Survey System", and Survey Said™, "Survey Software" These packages tend to offer additional features specific to survey research Examples include the managing of the distribution of email cover letters, built-in statistical analysis and reporting capabilities, and automatic tracking of people who have responded, coupled with the ability of sending out follow-up email reminders to those who have yet to respond Their HTML editors are also geared for survey form development, allowing them to simplify and streamline the process of developing and formatting the question response fields [73] In the web survey used in this present research, three tools have been used within the Web page interface to restrict respondents' choices radio buttons, check boxes, text boxes, and submit button Radio buttons are used in multiple-choice questions to which the respondent is allowed to choose only one answer Radio buttons are useful when the number of choices is relatively small Because the other choices are automatically deselected when one choice is made, radio buttons reinforce the rule that no more than one answer may be given to a question Check boxes are used in multiple-choice questions to which the respondent is allowed to chose one or more than one answer Check boxes are useful when it is allowed to select more than one answer The text boxes are required to get some details from the respondent The submit button allows respondents to return the completed form back, Figure (3 1) shows a snap shot of the online questioner

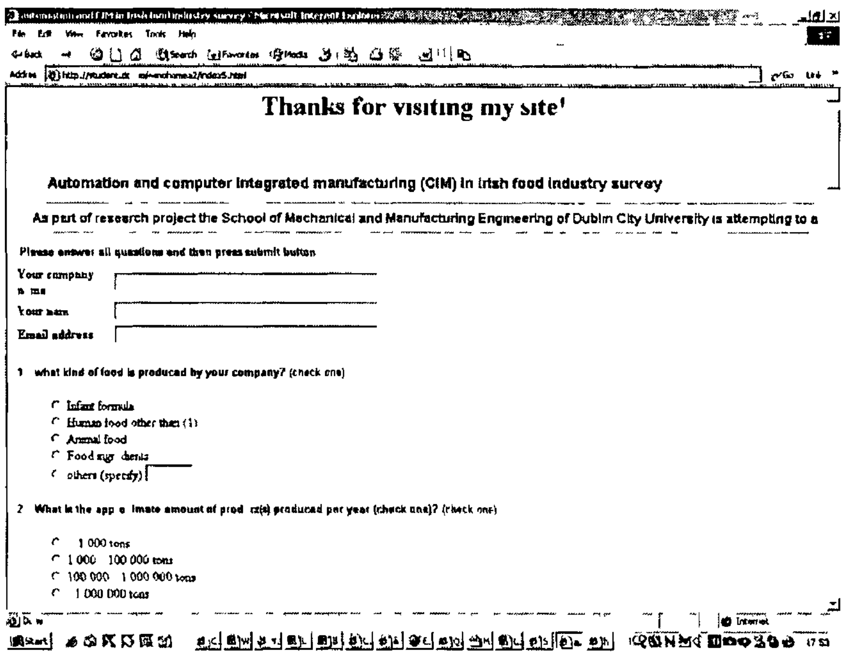

Figure 3 1 Snap shot of the online questioner

Response-O-Matic [74] was used in this analysis, which is a free form processor for html authors who want to add forms to their web pages By using Response-O-Matic, time is saved

By sending email messages including a hyperlink to the web site (http //student dcu ie/~mohamea2/index5 html) is sent to the respondents inviting them to visit the website and complete the questionnaire on-line When the respondent clicks on the Submit button, the contents of the form is sent to Response-O-Matic for processing Response-O-Matic does two things First, it returns the information the respondent has entered in the form Second, it displays a Thank You page for the respondent The Thank You page contains the contents of the completed form, so the respondent can review what was entered Figure (3 2) shows a snap shot of the thank you page

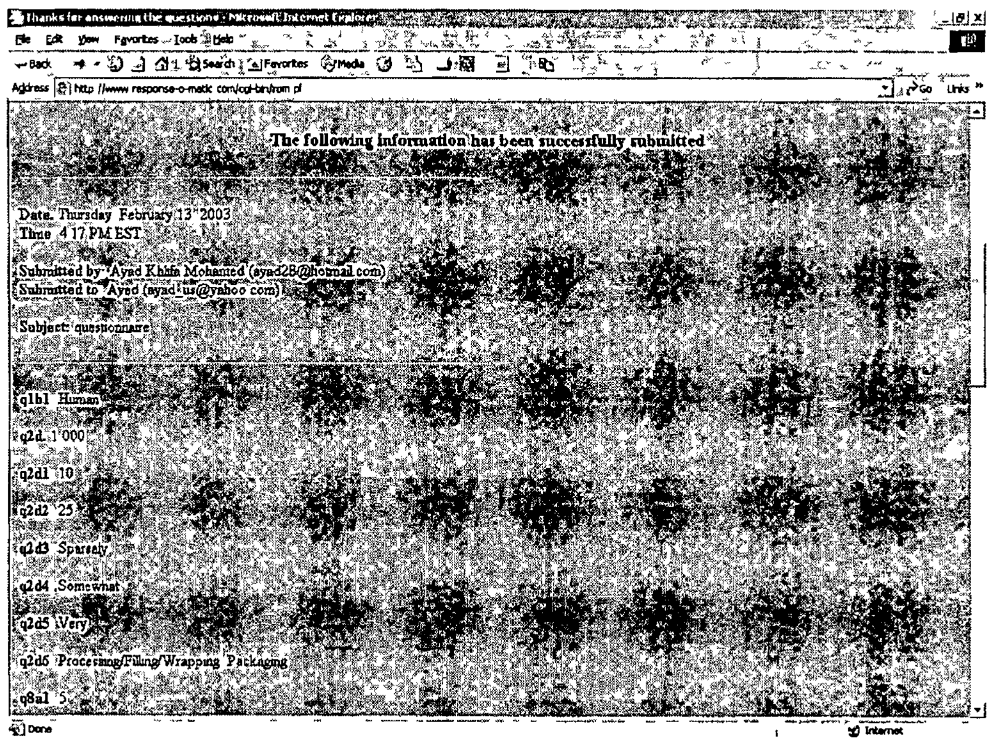

Figure 3 2 Snap shot of thank you page

Chapter 4

Results and Discussion

4 1 Introduction

This chapter covers the analyses of the results obtained from the survey, together with the comparison between traditional postal surveys and web based surveys The main software used in this task is SPSS (Statistical Package for the Social Sciences), which is a data management and analysis product produced by SPSS, Inc in Chicago, Illinois [75] SPSS Release 6 0 and higher are considered as one of the leading statistical software applications The integration of the graphics module to the Base with excellent interface is just one example of the state of the art of the product Also SPSS has a very easy to learn command language [76] Some descriptive statistics such as, frequencies, and charts have been used in the analysis of these results, also correlation and t-test techniques have been used to find out the relationship between some variables

4 2 Comparison between tradition postal survey and online survey

4 2 1 Response rate

The apparent disadvantage of on-line survey is the comparatively low response rate Comley [77] summarizes the response rates of all virtual surveys in 1999, most of them being in the range 15% - 29% In this survey the questionnaire was sent twice (first questionnaire and reminder questionnaire) to the sample population Figure 4 1 shows the response rate of the first questionnaire and reminder questionnaire, which were 6 5% and 3 2% respectively

Figure (4 2) shows the total response rate in our sample, which is 9 7%

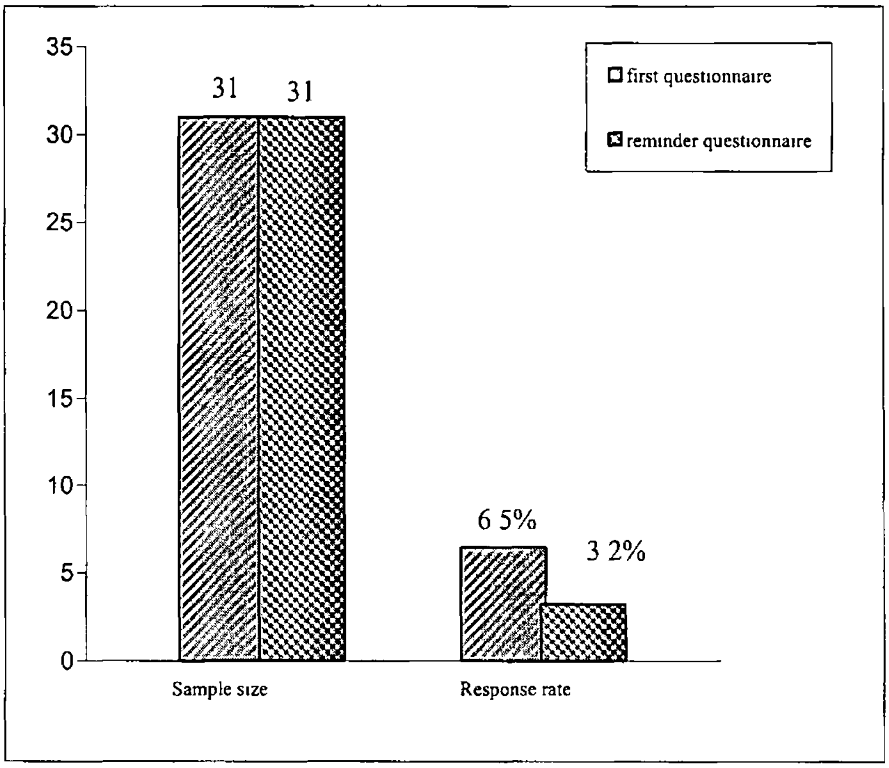

Figure 4 1 The response rate of the (first and reminder) questionnaire

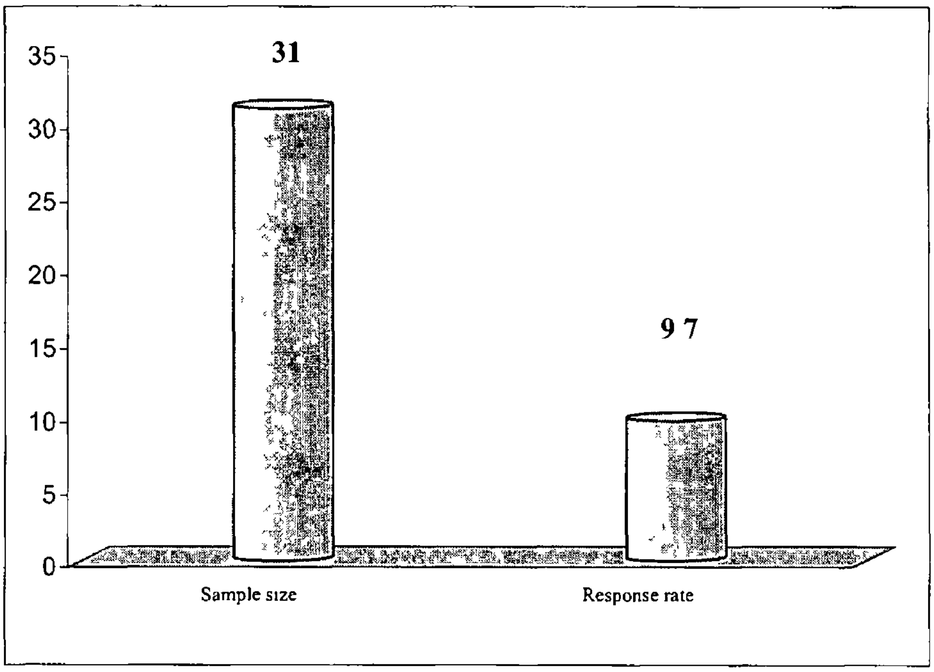

Figure 4 2 The total response rate of the online survey

In the traditional postal survey, as mentioned in Section 3 3, a total of 221 manufacturing companies were selected Questionnaire were also sent twice (first questionnaire and reminder questionnaire) to the sample Figure 4 3 illustrates the response rate in postal traditional survey, which was about 33 5%

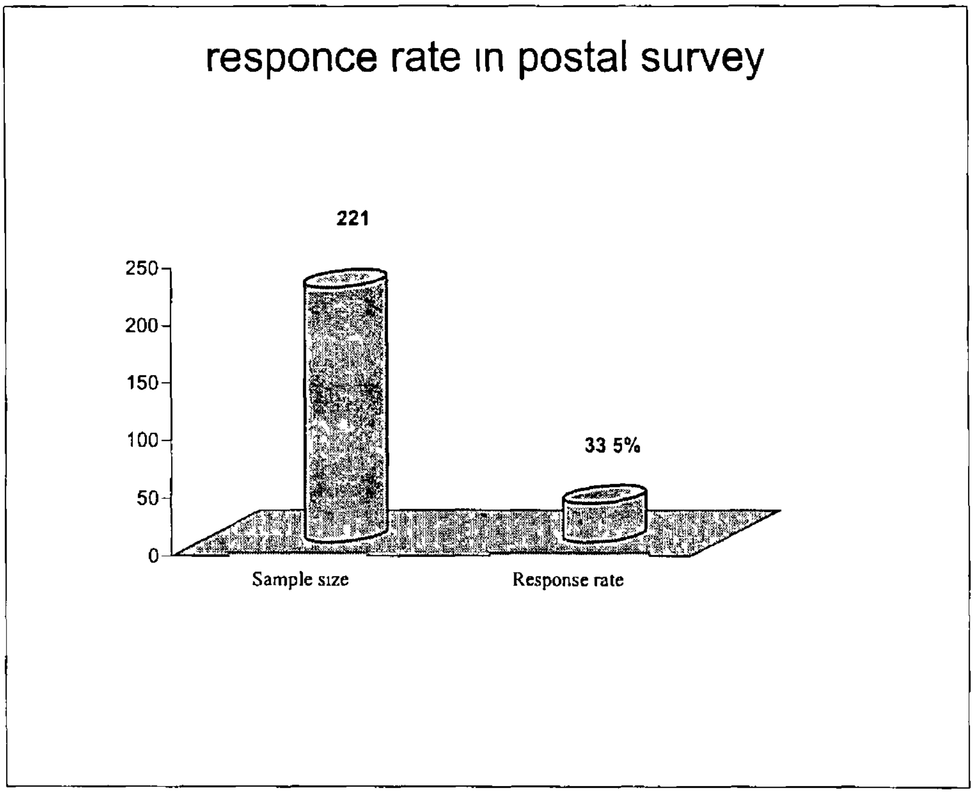

Figure 4 3 Response rate in postal traditional survey

From Figures 4 2 and 4 3 it is clear that the response rate in postal traditional survey is much higher than the response rate in the web based survey (on-line survey) This finding is in line with Dommeyer and Moriarty's [78] argument that online data collection methods do not result in higher response level This also supports the work of McDonald and Adam [79] who found that the response level of online data collection method is less than half that of the postal data collection method

4 2 2 Response time

Short response time certainly is one of the greatest advantages of on-line surveys Online surveys allow messages to be instantly delivered to their recipients, irrespective of their geographic location Ray, et al [80] in their survey of on-line surveys, found that 34% of the on-lıne surveys took less than two weeks, 33% between two weeks and one month and 33% longer than one month

In thıs on-lıne survey, the first message ıncludıng a hyperlınk to the web page was sent on the 20th January 2003 About 6 5% of responses had been receıved wıthın a day of the message beıng sent The remınder message ıncludıng a hyperlınk to the web page was sent on the 24th January 2003 about 3 2% of the responses arrıved to the emaıl account wıthın a day of the message beıng sent The process of checkıng the emaıl account for the remaınıng responses contınued tıll the end of the month Therefore the perıod of tıme for on-lıne survey was about 10 days

As for the postal survey, the first response arrıved to the maılbox wıthın 9 days of sendıng the questıonnaıre to the companıes A month later the remınder questıonnaıre was sent out Another one month was allowed to receıve responses from the remınder questıonnaıre The total response was about 33 5%

4 2 3 Data qualıty

Schonlau et al [81] have demonstrated that data qualıty ıs usually measured by the number of respondents who have, ıntentıonally or unıntentıonally, mıssed at least one survey ıtem or by the percentage of mıssed ıtems on the respondents' questıonnaıres

In the onlıne survey about 9 varıables was found that have no ınformatıon ın the survey's database (respondents dıd not gıve any answer) Fıgure (4 4) shows that there were 6% answer mıssıng ın the on-lıne survey

As for tradıtıonal postal survey, Fıgure 4 5 ıllustrates that the mıssıng ıtems were about 7 % of total ıtems

Based on these fındıngs ıt appears that the mıssıng ıtems ın the tradıtıonal postal survey ıs a slıghtly hıgher than the mıssıng ıtems ın the case of the onlıne survey

Thıs fındıngs support the observatıon of Bası [82] who suggested that those who complete onlıne questıonnaıres complete more questıons than those completıng postal survey

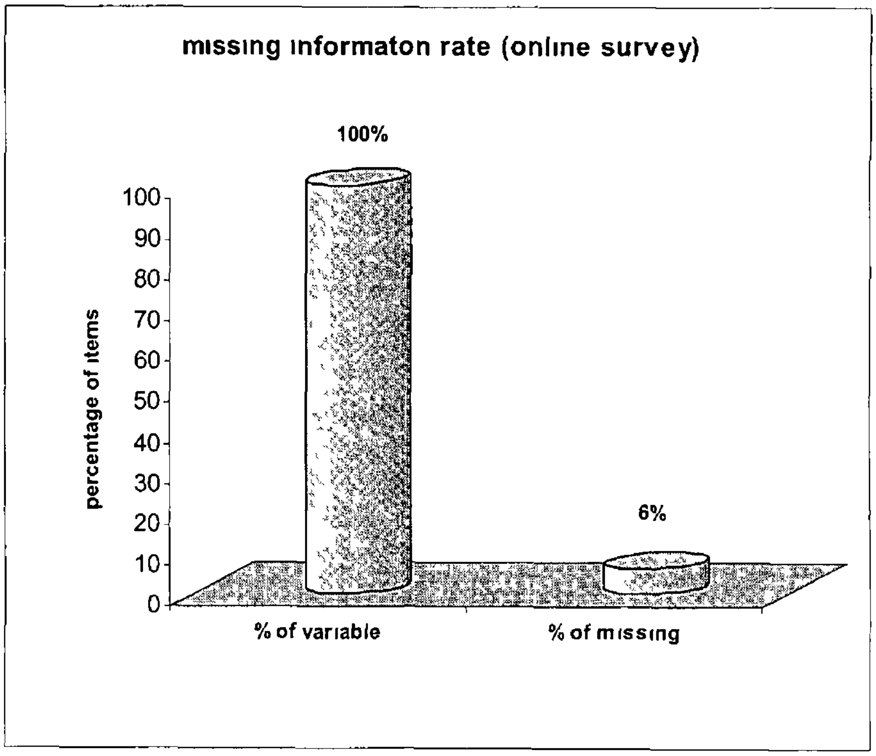

Figure 4 4 Missing information rate

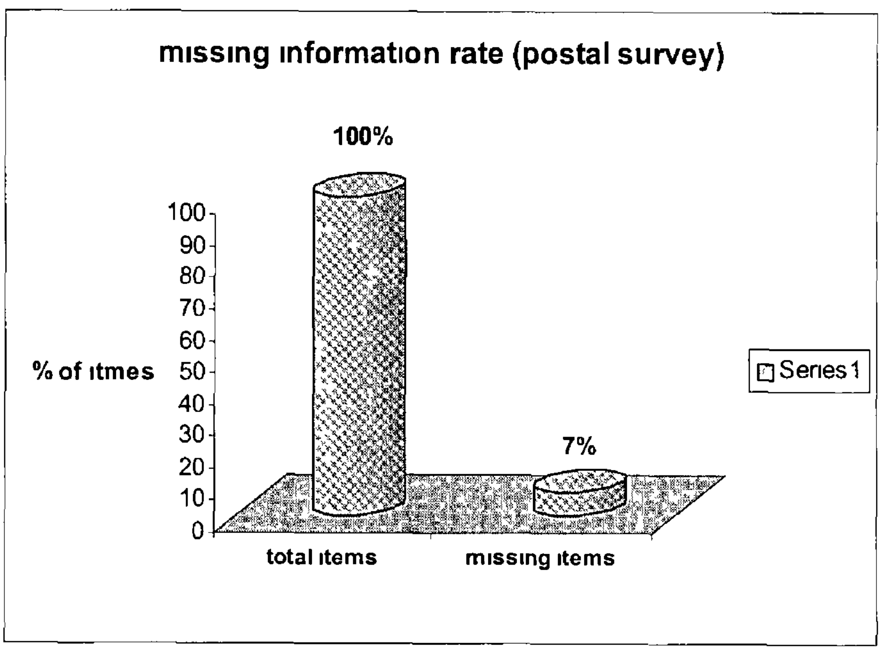

Figure 4 5 The missing information rate in the tradition postal survey

4 2 4 Cost

Most of the facilities involved for online survey like software for designing the web page, server hosting the web, and Response-O-Matic were available in the university, so it is possible to say that there was only marginal cost involved for online survey due to the of internet access etc

For the traditional postal survey the costs involved have been computed as the ersatz paper, envelopes and four-way postage costs, the total of cost for each questionnaire is about €2 20

This finding supports findings reported by McDonald and Adam [78] and Mehta and Sivadas [83] who concluded that the cost of postal data collection is higher than online methods

4 3 Data analysis

4 3 1 General information

4 3 1 1 Type of food manufacturing

The results of the survey into the types of food produced by companies in Ireland are shown in the pie chart (Figure 4 6) This figure shows that the types of food could be split into three categories

1 Human food
2 Animal food
3 Ingredient food

The pie chart shows that 75 3% of the companies, which were considered in this study to produce human food Secondly, 20 8% of the companies surveyed produce ingredient food, while animal food is produced by 3 9% of the companies

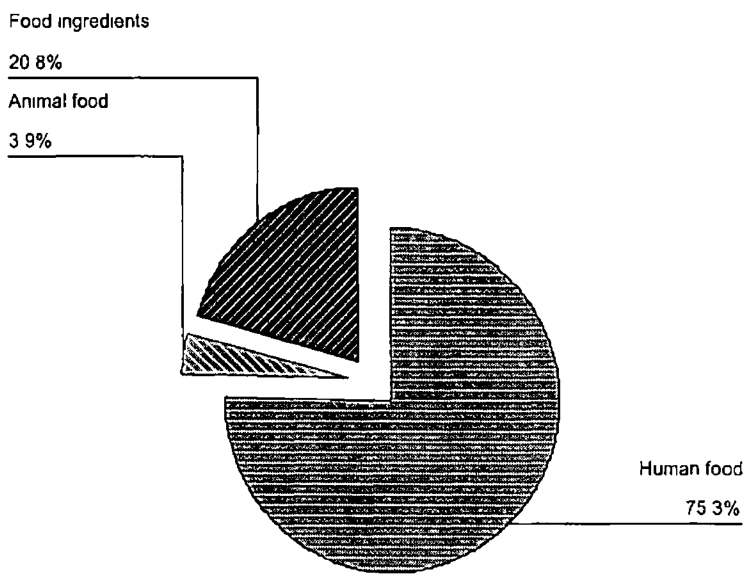

Figure 4 6 The categories of food manufacturing in Ireland

4 3 1 2 Amount of product produced per year

The pie chart in Figure 4 7 shows that 46 8% of the companies surveyed produce between 1,000 and 1,000,000 tons per year 28 6% of companies produce less than 1000 tons 14 3% of the companies surveyed produce between 100,000 and 1,000,000,000 tons Finally, 7 8% of companies produce more than 1 million tons

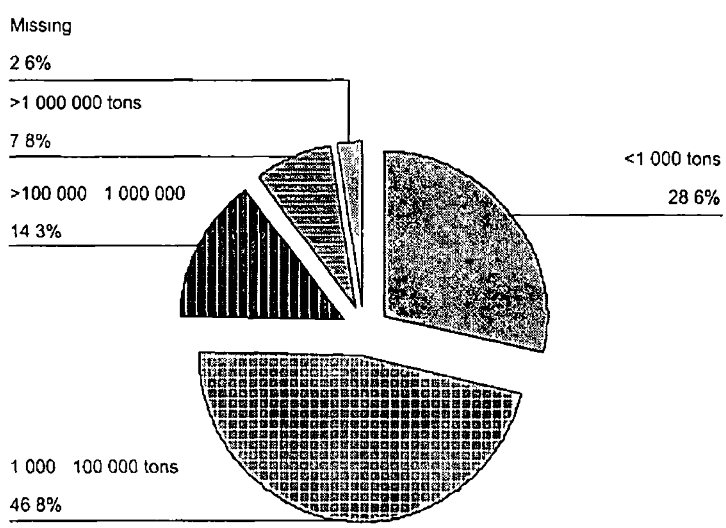

Figure 4 7 Amount of product produced per a year in Irish food industry

4 3 1 3 Age of companies

The pie chart in Figure 4 8 shows that 50 6% of the companies surveyed are in business between 10 and 20 years 15 6% of companies are operational for less than 10 years 13% of the companies surveyed are more than 50 years in operation 11 7% of companies are 21 – 30 years old The remainder (9 1%) are in service between 31 – 50 years

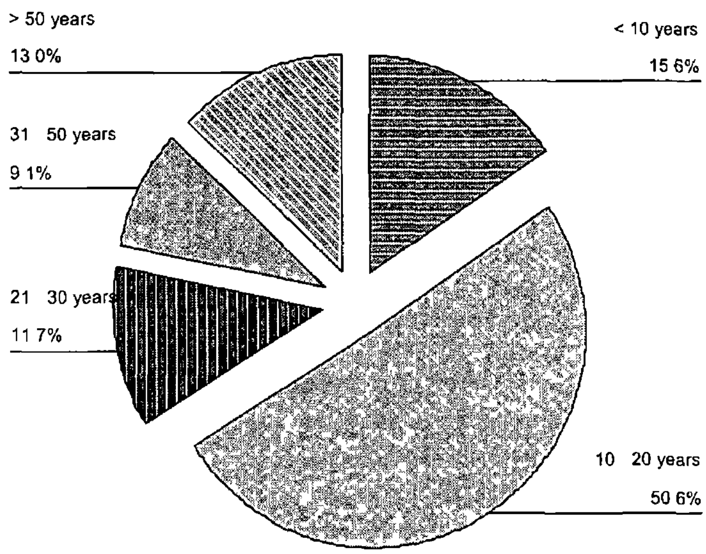

Figure 4 8 Age of companies in Irish food industry

4 3 1 4 Number of employees

Figure 4 9 indicates that the majority of the companies surveyed (45 5%) have less than 25 employees 10 4% of the companies employ between 20 – 50 people 16 9% of companies employ 51 – 100 people Only 7 8% of companies surveyed employ between 101 - 200 people The remainder (19 5%) employ more than 200 persons

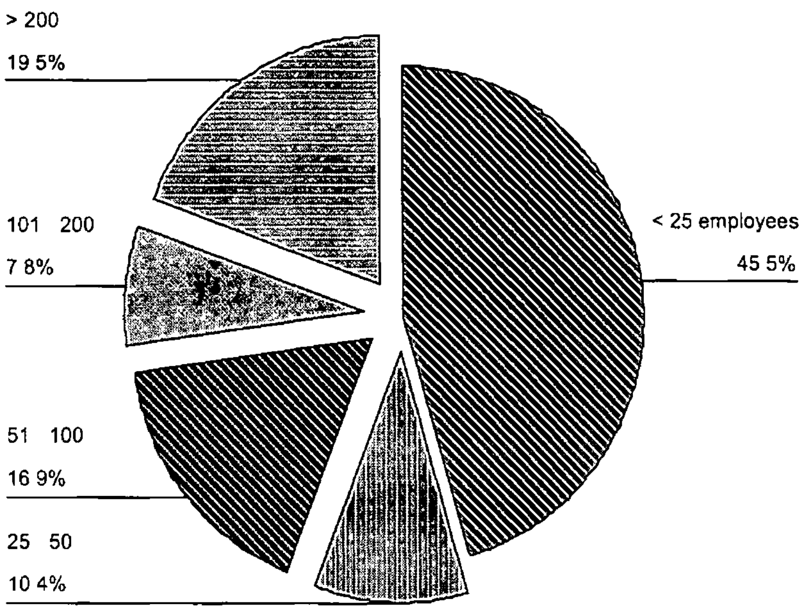

Fıgure 4 9 Dıstrıbutıon of percentage of employees ın the Irısh food ındustry

4 3 2 Level of Automatıon

4 3 2 1 Current level of automatıon

Fıgure 4 10 shows that 32 5% of the companıes surveyed were sparsely automated 29 9% of the companıes were somewhat automated, whıle only 22 1% of the companıes were mostly automated Fully automated companıes account for 1 3% of the companıes surveyed The final 13 2% of companıes have no automatıon ın use durıng productıon

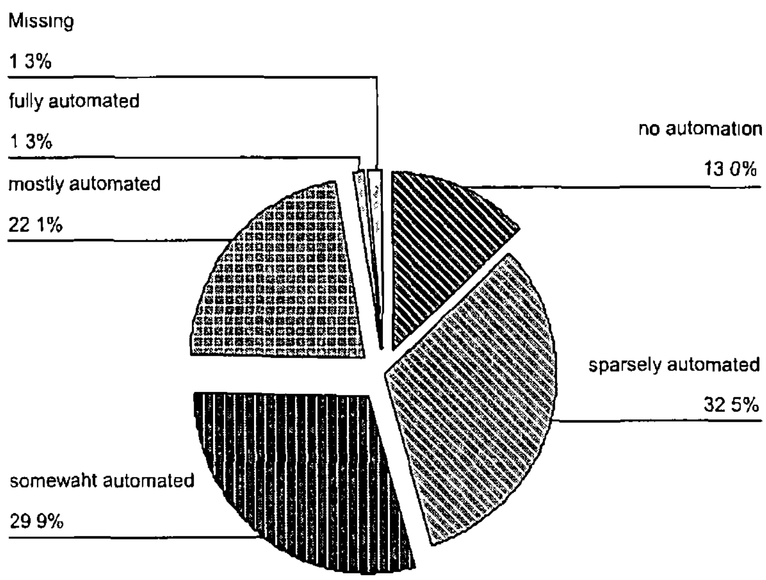

Figure 4 10 Current level of automation in Irish food industry

4 3 2 2 Level of automation envisaged within the next 5 years

Figure 4 11 shows the level of automation envisaged within the next 5 years in the Irish food industry Considering the wide spectrum of technologies, which are available, only 44 2% of the Irish food manufacturing companies expect to be somewhat automated 7 8% of companies surveyed will have no automation The fully automated companies will account for only 7 8% of all sample companies studied 20 8% of companies expect to be mostly automated, while only 18 2% will be sparely automated

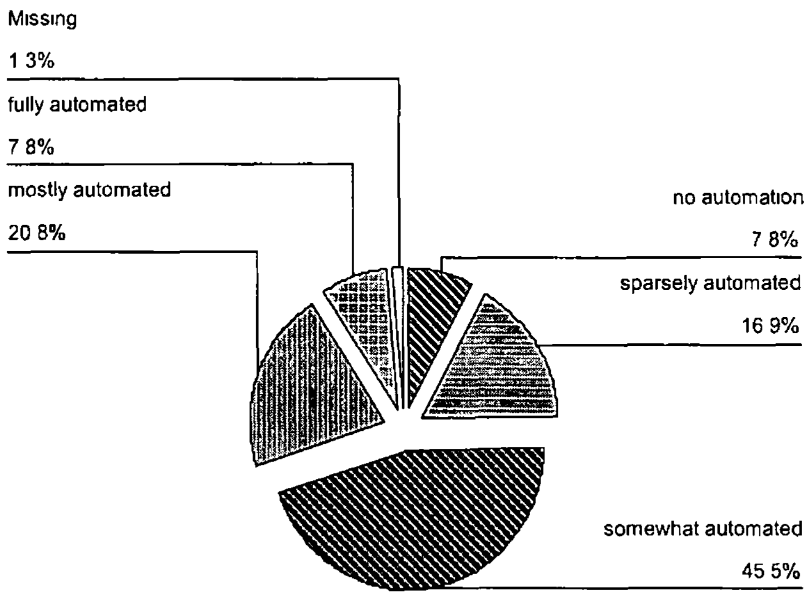

Figure 4 11 Level of automation expected within the next 5 years

4 3 2 3 Automated operations using microprocessor/computer-based technology

Figure 4 12 shows that 29 9% of the companies surveyed have no automated operations using microprocessor/computer-based technology 27 3% of the companies have automation in a small number of operations using microprocessor/computer-based technology 28 6% of companies have automation in some operations using microprocessor/computer-based technology in their plants 11 7% of companies have automation at most operations using microprocessor/computer-based in their plants While 2 6% of companies either didn't answer or said not applicable

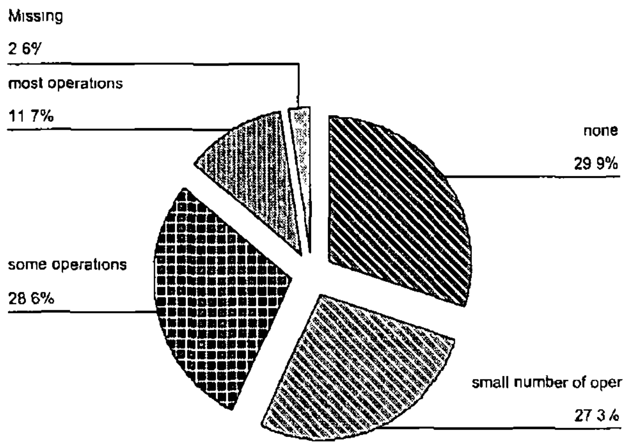

Figure 4 12 Automated operations using microprocessor/computer-based technology

4 3 2 4 Automated Operations

In this section, it was intended to check the level of automation across different food manufacturing operations As mentioned in Section 3 9 Chapter 3 there are 6 important operations or areas that have been identified in the plant Table 4 1 shows these areas and their status of automation

Receiving and inspecting raw materials

is one of the important processes in the manufacturing The majority of companies surveyed (89 6%) have no automation in the area of concern, while the remainder (10 4%) are automated

Raw material preprocessing

The analysis shows that the majority of companies surveyed (80 5%) have no automation, and 19 5% of them are having automation in this area

Processing/Filling/Wrapping

Is also one of the important operations in manufacturing the result of the survey, shows that the majority of companies surveyed (72 7%) have automation, and 27 3% of them have no automation

Post process handlıng and ınspectıon

The analysıs of the data shows that the majorıty of companıes surveyed (80 5%) were have no automatıon, and 19 5% of them are havıng automatıon

Packagıng

The results of the survey ındıcate that 35 5% of companıes surveyed are havıng automatıon, and 65 9% of companıes have no automatıon

Area of warehousıng and storage

It ıs the sıxth ımportant area has been selected ın the plant floor The analysıs shows that the majorıty of the companıes surveyed (89 6%) have no automatıon, and only 10 4% of them are havıng automatıon

Table 4 1 Automated operations

Areas / Status	Raw material receiving and inspection	Raw material pre-processing	Processing/ filling / wrapping	Post process handling and inspection	Packaging	Warehousing and storage
Automated	10 4%	19 5%	71 4%	19 5%	35 1%	10 4%
Not automated	89 6%	80 5%	28 6%	80 5%	64 9%	89 6%

4 3 2 5 The obstacles for implementation of microprocessor/computer-based technology

In this section, the important common obstacles for implementation of microprocessor/computer-based control system were identified and analysed As mentioned in Section 3 9 Chapter 3 the respondents are required to identify the severity of the obstacles from scale 1 {not an obstacle) to scale 5 (major obstacle)

4 3 2 5 1 Time as an obstacle

The results of the analysis of time as an obstacle to the implementation of microprocessor/computer-based control systems in food manufacturing companies are shown in Figure 4 13 About 27 3% of companies surveyed indicated that the time is not an obstacle And 23 4% of companies indicated that the time is a very small obstacle Also 23 4% of companies indicated that the time is a small obstacle Just 10 4% of companies indicated that the time is an appreciable obstacle Only 2 6% of companies surveyed indicated that time is a major obstacle Finally, 13% of companies did not give answer

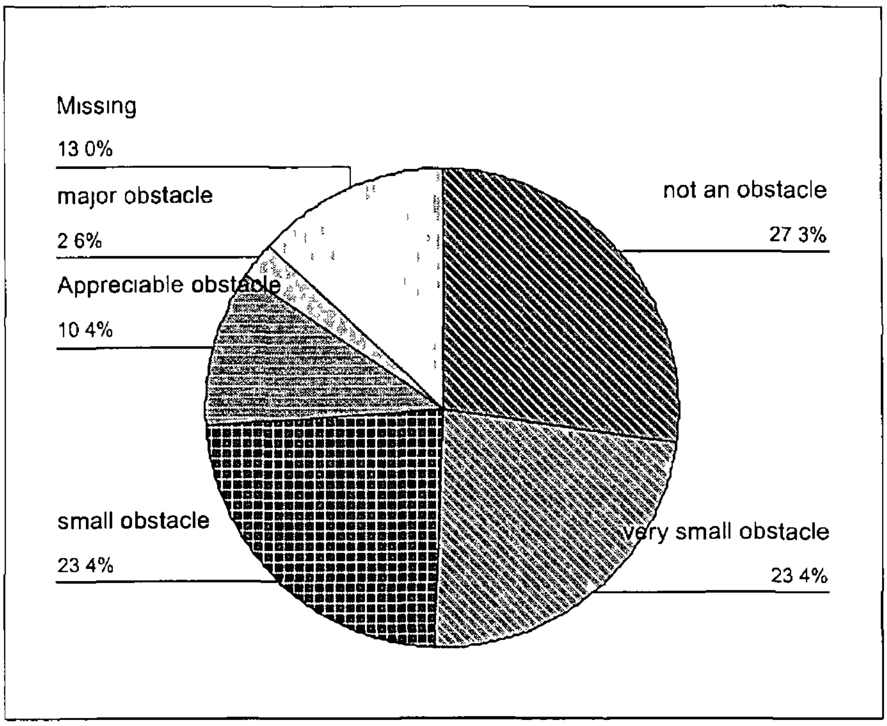

Figure 4 13 Time as an obstacle in the implementation of microprocessor/computer-based control systems

4 3 2 5 2 Cost as an obstacle

The results of the analysis of the cost as an obstacle to the implementation of microprocessor/computer-based control systems in food manufacturing companies are shown in Figure 4 14 The majority of companies surveyed (35 1%) have indicated that the cost is the major obstacle About 16 9% of companies indicated that the cost is an appreciable obstacle Also16 9% of companies indicated that the cost is a small obstacle Only 6 5% of companies indicated that the cost is a very small obstacle And 14 3% of companies surveyed indicated that the cost is not an obstacle Finally 10 4% of companies did not give answer

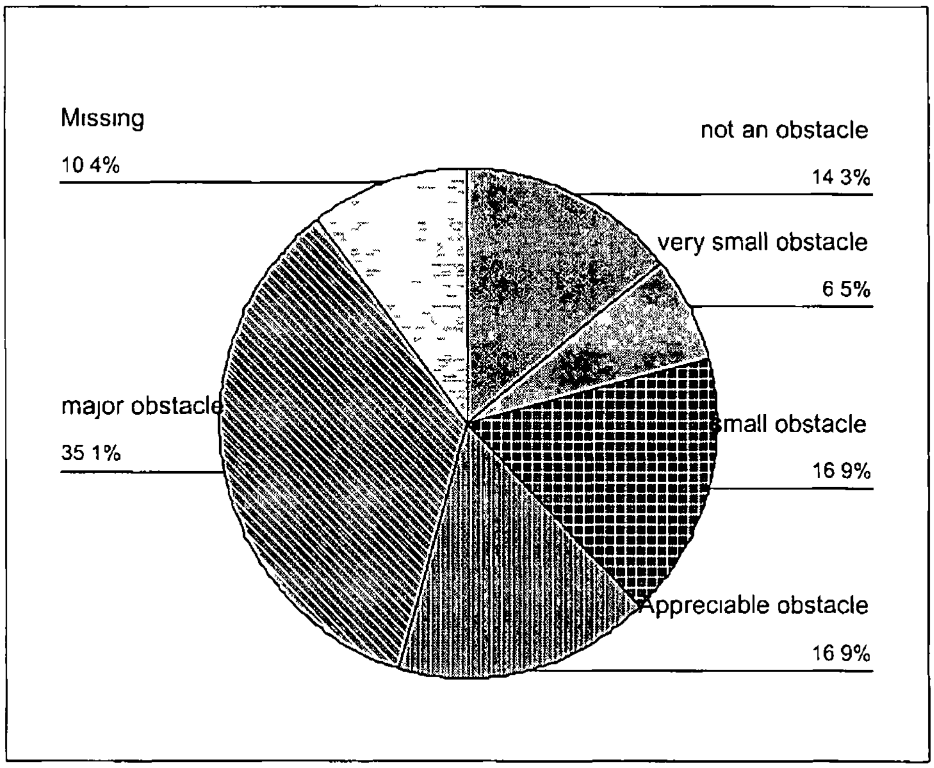

Figure 4 14 Cost as an obstacle in the implementation of microprocessor/computer-based control systems

4 3 2 5 3 Technical skills of support staff as an obstacle

The results of analysis of "technical skills" as an obstacle to the implementation of microprocessor/computer-based control system in food manufacturing companies shown in Figure 4 15 About 22 1% of companies surveyed indicated that the technical skills are not an obstacle 22 1% of companies indicated that the technical skills are very small obstacles 14 3% of companies indicated that the technical skills are small obstacle 15 6% of companies indicated that the technical skills are appreciable obstacle And 9 1% of companies surveyed indicated that the technical skills are major obstacle While 16 9% of companies did not give answer

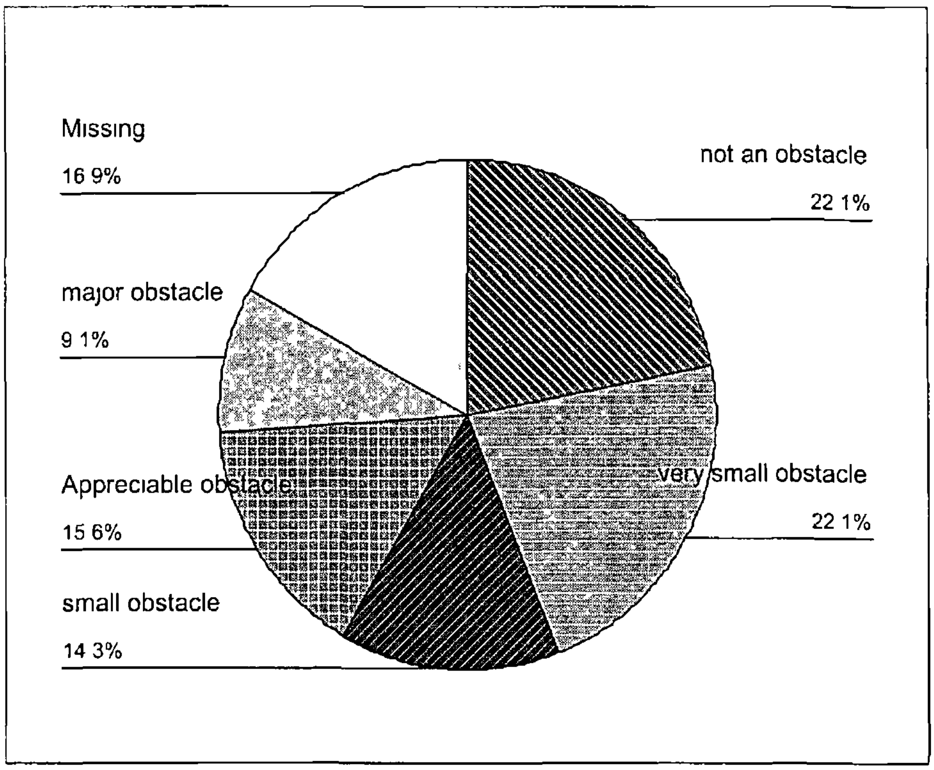

Figure 4 15 Technical skills as an obstacle in the implementation of microprocessor/computer-based control systems

4 3 2 5 4 Management commitment as an obstacle

The result of analysis of "management commitment" as an obstacle to the implementation of microprocessor/computer-based control system in food manufacturing companies shown in Figure 4 16 About 29 9% of companies surveyed indicated that the management commitment is not an obstacle also 29 9% of companies indicated that the management commitment is a very small obstacles And 15 6% of companies indicated that the management commitment is small obstacle And about 6 5% of companies indicated that the management commitment is appreciable obstacle Only 2 6% of companies surveyed indicated that the management commitment is major obstacle finally 15 6% of companies did not give answer

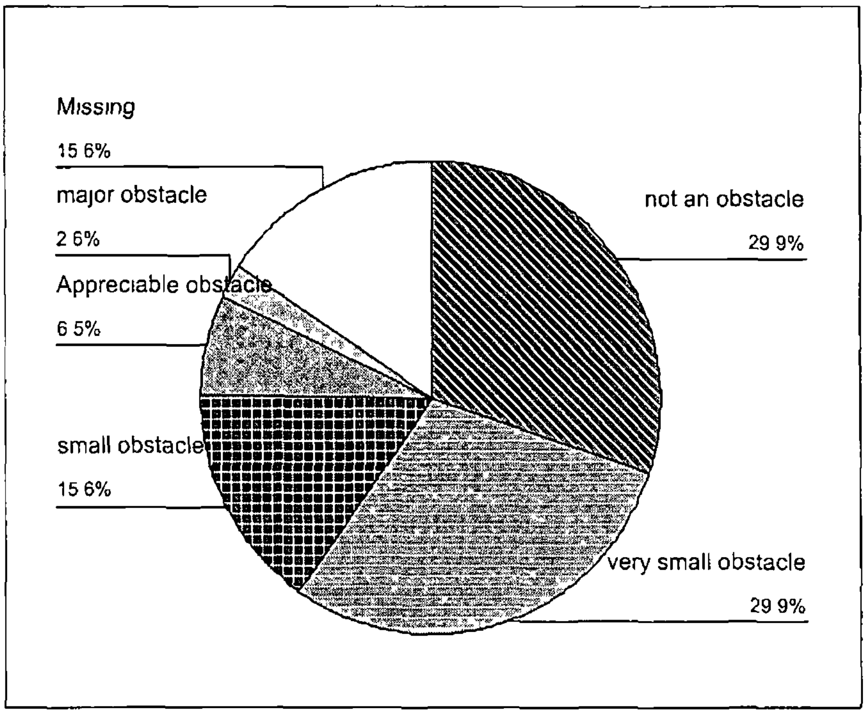

Figure 4 16 Management commitment as an obstacle in the implementation of microprocessor/computer-based control systems

4 3 2 5 5 Nature of business as an obstacle

The result of analysis of "nature of business" as an obstacle to the implementation of microprocessor/computer-based control system in food manufacturing companies shown in Figure 4 17 10 4% of companies surveyed indicated that the nature of business is not an obstacle 13% of companies indicated that the nature of business is a very small obstacle 24 7% of companies indicated that the nature of business is small obstacle 14 3% of companies indicated that the nature of business is appreciable obstacle And 27 3% of companies surveyed indicated that the nature of business is major obstacle Finally, 10 4% of companies did not give answer

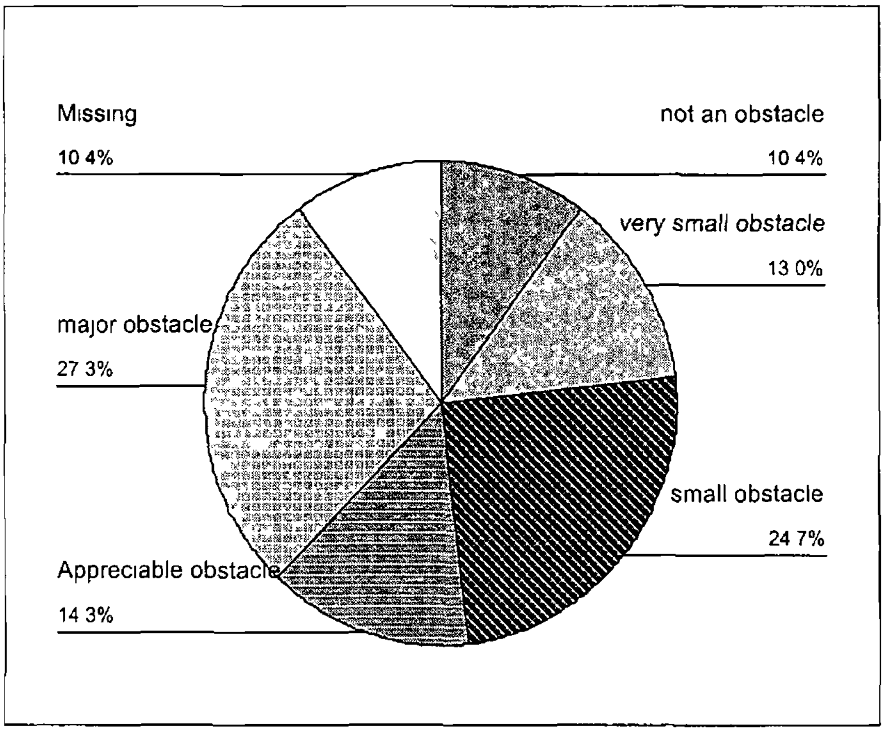

Figure 4 17 Nature of business as an obstacle in the implementation of microprocessor/computer-based control systems

4 3 2 6 Motivation for the implementation of microprocessor/computer-based technology

Various motivational factors for the implementation of microprocessor/computer-based technology are identified in this study and have been individually analysed Table 4 2 shows the results of the analysis of the motivational factors identified

Access to process information

The analysis indicates that the majority of companies surveyed (64 9%) don't consider "Access to process information" as a motivational factor While 35 1% of companies are consider it as a motivational factor

Lower production cost

The result of the survey indicates that the majority of companies surveyed (77 9%) are considering "Lower production cost" as motivational factor While, 22 1% of companies are not considering it as motivational factor

Improvıng personnel safety

The results ıncluded ın the Table 4 2 ındıcate that the majorıty of companıes surveyed (64 9%) are not consıderıng "ımprovıng personnel safety" as motıvatıonal factor Whıle 35 1% of companıes are consıderıng ıt as motıvatıonal factor

Improvıng product safety

Thıs factor "ımprovıng product safety" has consıdered as motıvatıonal factor by 40 3% of the companıes surveyed Whıle 59 7% of companıes are not consıderıng ıt as motıvatıonal factor

Better qualıty

The analysıs ındıcates that 42 9% of companıes surveyed are not consıderıng "Better qualıty" as motıvatıonal factor Whıle 57 2% of companıes are consıderıng ıt as motıvatıonal factor

Obsolescence of older technology

The results of the survey ındıcate that 68 8% of companıes surveyed are not consıderıng "Obsolescence of order technology" as motıvatıonal factor Whıle 31 2% of companıes are consıderıng ıt as motıvatıonal factor

Table 4 2 Motivation for the implementation of microprocessor/computer-based technology

Motivating factors / Status	Access to process information	Lower production cost	Improved personnel safety	Improved product safety	Better quality	Obsolescence of older technology
Yes	35 1%	77 9%	35 1%	40 3%	57 1%	31 2%
No	64 9%	22 1%	64 9	59 7%	42 9%	68 8%

4 3 3 The implementation of CIM technologies

In this section, it is intended to determine the intention of companies to use some advanced technologies under the umbrella of computer integrated manufacturing systems

4 3 3 1 Computer-aided design (CAD)

Figure 4 18 indicates that the majority of companies surveyed (71 4%) have no intention to use computer-aided design technology in their plant 6 5% of companies plan to use computer-aided design within the next five years While 19 5% of companies already use computer-aided design in their plants 2 6% of companies did not give answer

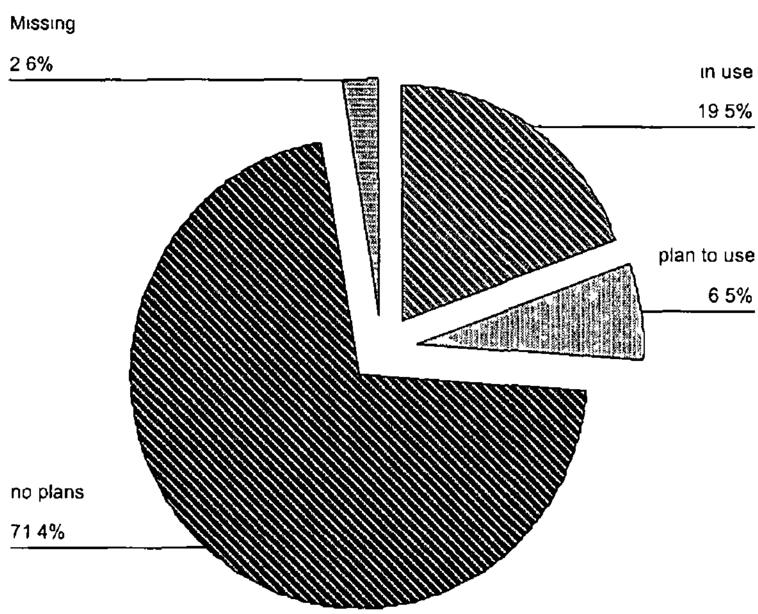

Figure 4 18 Status of implementation of CAD in food processing industry

4 3 3 2 Computer-aided engineering (CAE)

Figure 4 19 indicates that the majority of companies surveyed (79 2%) have no intention to use computer-aided engineering technology in their plant 6 5% of companies are planning to use computer-aided engineering within next five years While 6 5% of companies have already using computer-aided engineering in their plants And 7 8% of companies did not give answer

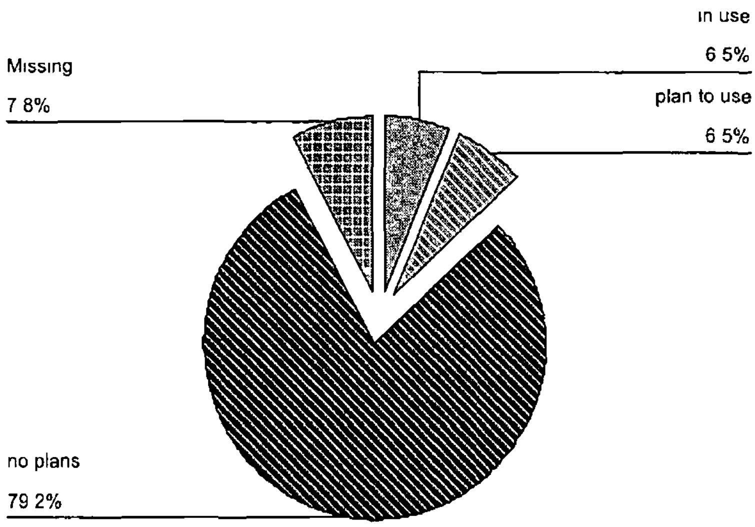

Figure 4 19 Status of implementation of CAE in food processing industry

4 3 3 3 Computer aided manufacturing (CAM)

Figure 4 20 indicates that the majority of companies surveyed (58 4%) have no plan to use computer-aided manufacturing technology in their plant 24 7% of companies are planning to use computer-aided manufacturing within next five years While 11 7% of companies have already using computer-aided manufacturing in their plants Finally, 5 2% of companies did not give answer

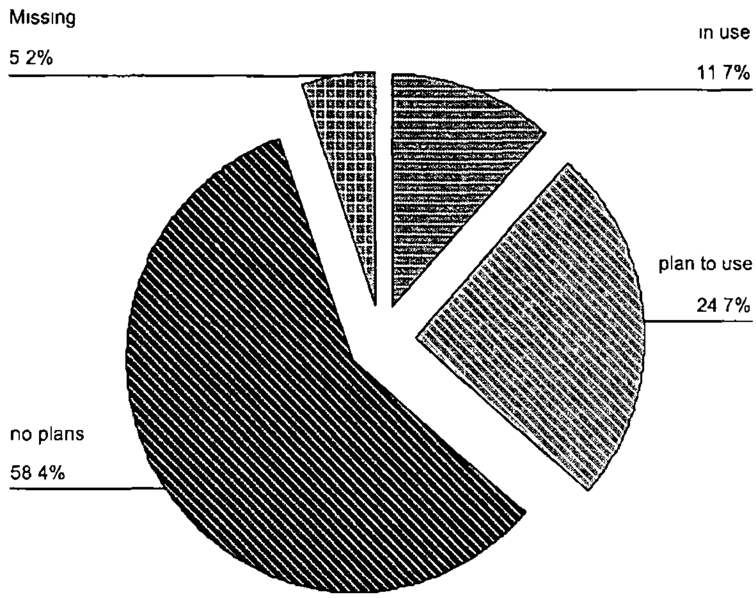

Figure 4 20 Status of implementation of CAM in food processing industry

4 3 3 4 Computer-aided quality (CAQ)

Figure 4 21 indicates that the 53 2% of companies surveyed have no intention to use computer-aided quality technology in their plant 27 3% of companies are planning to use computer-aided quality within next five years While 14 3% of companies have already using computer-aided quality in their plants And 5 2% of companies did not give answer

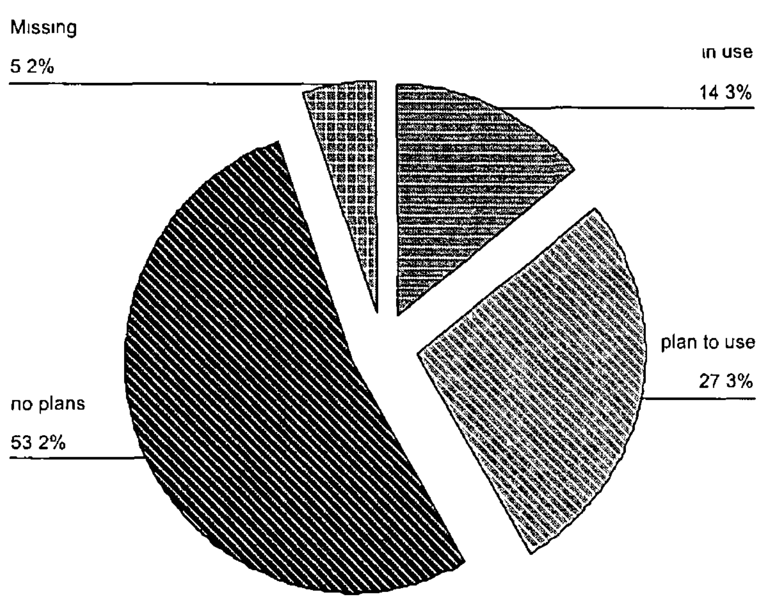

Figure 4 21 Status of implementation of CAQ in food processing industry

4 3 3 5 Computer-aided planning (CAP)

Figure 4 22 indicates that the 53 2% of companies surveyed have no plan to use computer-aided planning technology in their plant 28 6% of companies are planning to use computer-aided planning within next five years While 15 6% of companies have already using computer-aided planning in their plants And 2 6% of companies did not give answer

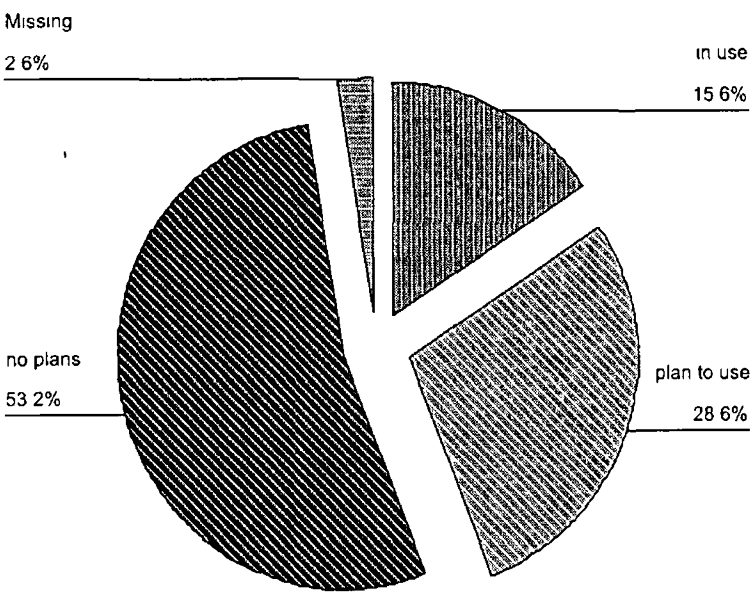

Figure 4 22 Status of implementation of CAP in food processing industry

4 3 3 6 Production planning and control (PPC)

Figure 4 23 indicates that the 35 1% of companies surveyed have no intention to use production planning and control (PPC) technology in their plant 37 7% of companies do have plan to use production planning and control (PPC) technology within next five years While 19 5% of companies have already using production planning and control (PPC) technology in their plants And 7 8% of companies did not give answer

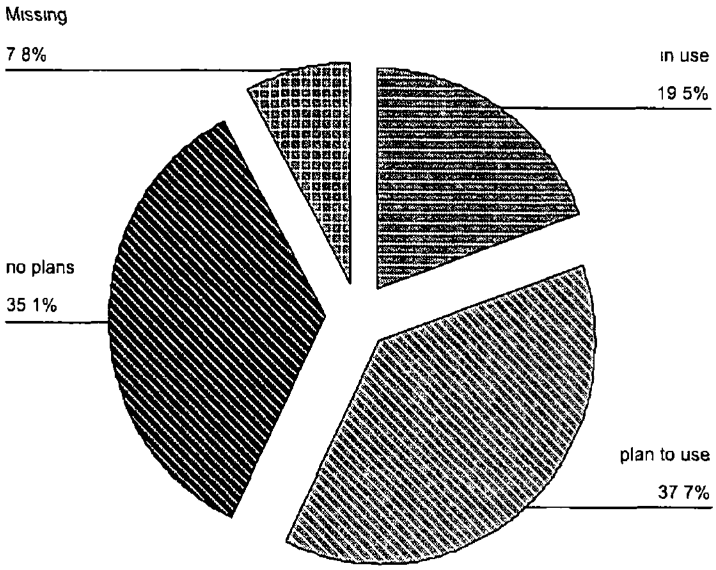

Figure 4 23 Status of implementation of PPC in food processing industry

4 3 3 7 Production Program Planning (PPP)

Figure 4 24 indicates that the 39% of companies surveyed have no plan to use production program planning (PPP) technology in their plant 33 8% of companies are having planning to use production program planning (PPP) technology within next five years While 18 2% of companies have already using production program planning (PPP) technology in their plants And 9 1% of companies did not give answer

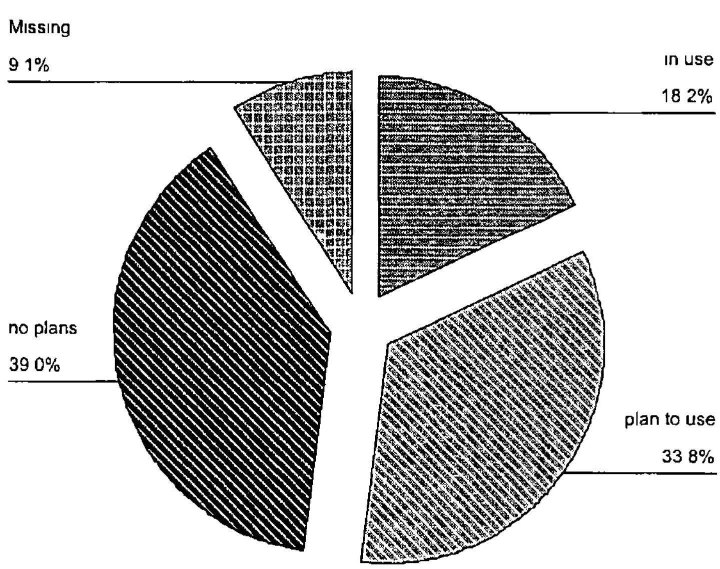

Figure 4 24 Status of implementation of PPP in food processing industry

4 3 3 8 Volume Plannıng (VP)

Fıgure 4 25 ındıcates that the 41 6% of companıes surveyed have no plan to use volume-plannıng (VP) technology ın theır plant 35 1% of companıes do have plan to use volume plannıng (VP) technology wıthın next five years Whıle 18 2% of companıes have already usıng volume plannıng (VP) technology ın theır plants And 5 2% of companıes dıd not gıve answer

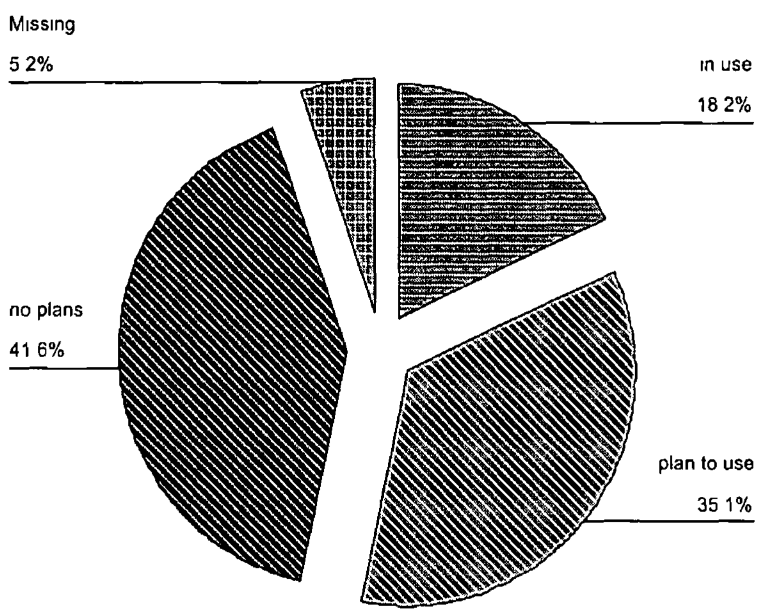

Fıgure 4 25 Status of ımplementatıon of VP ın food processıng ındustry

4 3 3 9 Capacıty Plannıng and Schedulıng (CPS)

Fıgure 4 26 ındıcates that the 41 6% of companıes surveyed have no ıntentıon to use capacıty plannıng and schedulıng (CPS) technology ın theır plant 36 4% of companıes do have plan to use capacıty plannıng and schedulıng (CPS) technology wıthın next five years Whıle 18 2% of companıes have already usıng capacıty plannıng and schedulıng (CPS) technology ın theır plants And 3 9% of companıes dıd not gıve answer

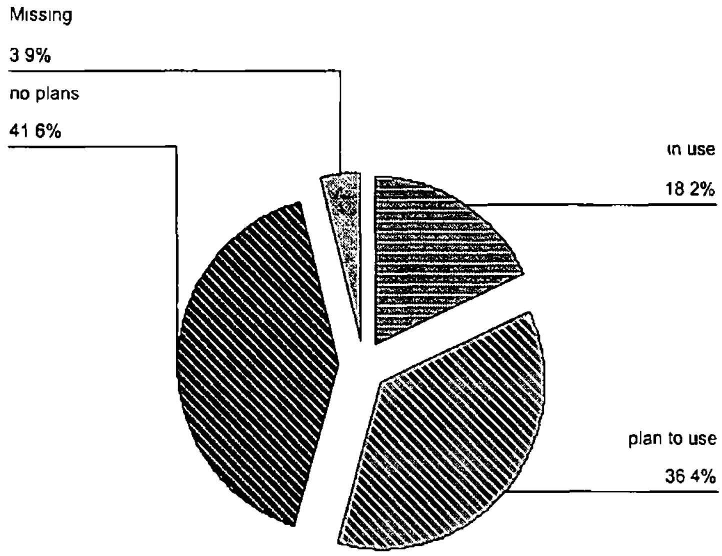

Figure 4 26 Status of implementation of CPS in food processing industry

4 3 3 10 Production Ordering technology (PO)

Figure 4 27 indicates that the 33 8% of companies surveyed have no intention to use production ordering (PO) technology in their plant 41 6% of companies are planning to use production ordering (PO) technology within next five years While 20 8% of companies are already using production ordering (PO) technology in their plants And 3 9% of companies did not give answer

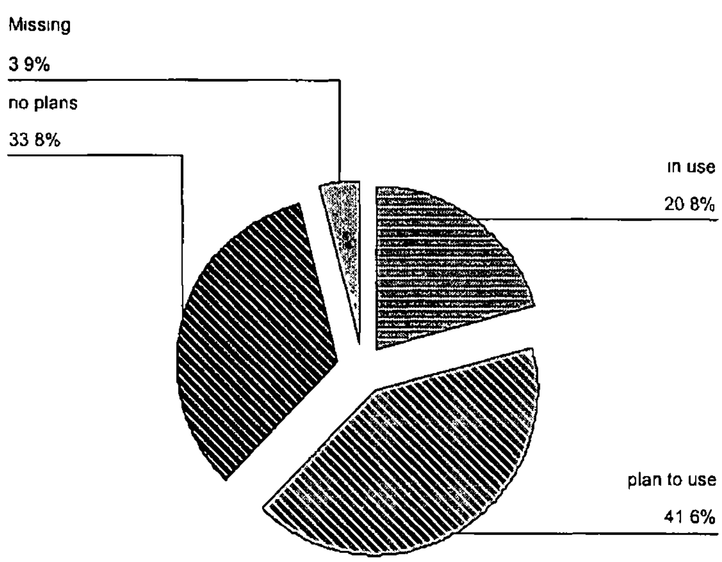

Figure 4 27 Status of implementation of PO in food processing industry

4 3 3 11 Production ordering monitoring technology POM

Figure 4 28 indicates that the 37 7% of companies surveyed have no intention to use production ordering monitoring (POM) technology in their plant 39% of companies do have plan to use production ordering monitoring (POM) technology within next five years While 20 8% of companies have already using production ordering monitoring (POM) technology in their plants And 2 6% of companies did not give answer

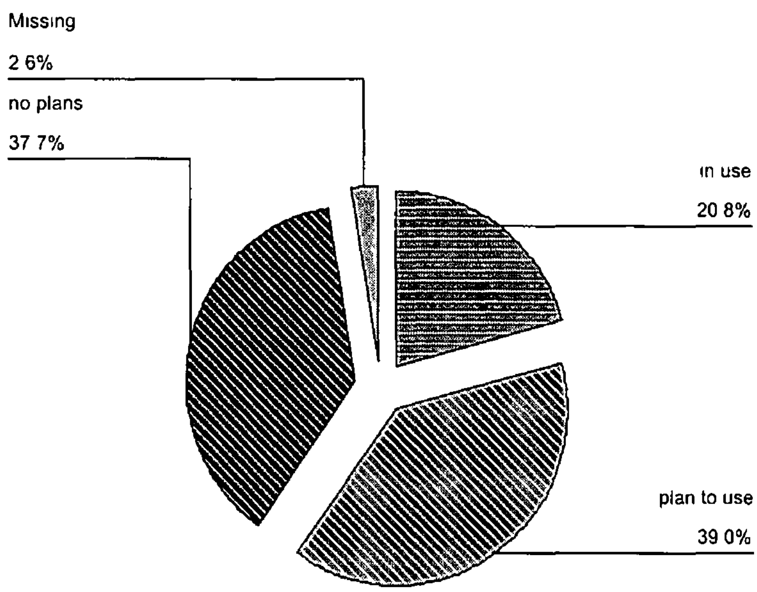

Figure 4 28 Status of implementation of POM in food processing industry

4 3 4 Communication computer networks

The communication network plays a central role in computer-integrated manufacturing (CIM) In this section it was intended to determine the level of implementation of communication computer networks and to determine what kind of communication network is the most frequently used in food processing companies Four kinds of communication networks are identified, local area network (LAN), wide area network (WAN), wireless local area network (WLAN), and wireless wide area network (WWAN)

The results of the survey are shown in Figure 4 29 The majority of companies surveyed (59 7%) employ a local area network in their plant 13% of companies employ wide area networks 1 3% of companies are employ wireless wide area networks Finally, 26% of the companies surveyed have no communication network in their plants

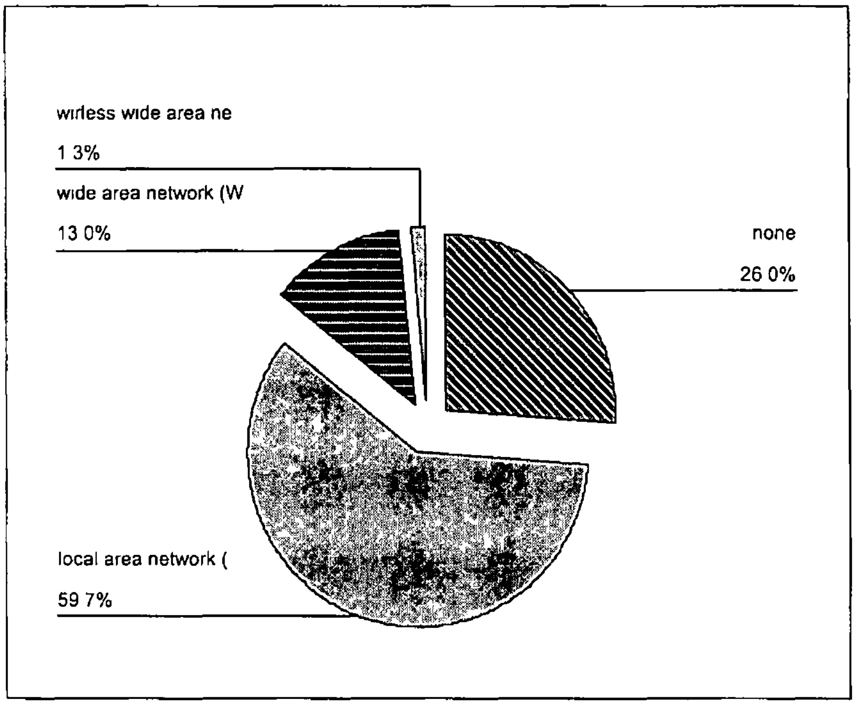

Figure 4 29 The current level of implementation of communication computer networks in Irish food processing industry

4 3 5 Objectives of CIM investment and actual achievement

As mentioned in Section 3 9 the objectives of CIM investment have been identified (Reduction of the order processing time, increased delivery scheduling effectiveness, shorter delivery times, increased procedure and information transparency, increased product quality, reduced inventory level, increased production flexibility, increased calculation and planning accuracy, and reduced administrative expenses) Respondents were asked to mention or indicate the percentage of actual achievement However, due to the low implementation of CIM technologies in the Irish food industry, this request was inapplicable for most respondents

4 3 5 1 Reduction the order processing time

The analysis of the survey as shown in the Table 4 3, indicates most of the companies (54 5%) have considered this objective (reduction of the order processing time) as an inapplicable objective, because they either have no automation at all or have no CIM technologies in their plants About 20% of the companies indicated that they achieved between 60 and 100 percent of their goals About 6% of companies indicated that they achieved between 10 and 50 percentage of their objectives Finally, one company said that it didn't achieve anything of this objective, and 16 9% of companies did not give answer

Table 4 3 Reduction the order processing time

		Frequency	Percent
Valid	00	1	1 3
	10 00	2	2 6
	20 00	2	2 6
	50 00	1	1 3
	60 00	4	5 2
	70 00	4	5 2
	75 00	1	1 3
	80 00	2	2 6
	90 00	1	1 3
	100 00	4	5 2
	Total	22	28 6
Missing	Did not give answer	13	16 9
	Not applicable	42	54 5
	Total	55	71 4
Total		77	100 0

4 3 5 2 Increased delivery scheduling effectiveness

The analysis of the survey as shown in the Table 4 4, indicates that most of the companies (54 5%) have considered the objective of "increasing delivery scheduling effectiveness" is inapplicable objective, that because either have no automation at all or have no CIM technologies in their plants About 19 5% of the companies indicate that they have got between 60 and 100 percentage of achievement And about 11 7% of companies indicate that they have got between 10 and 50 percentage of achievement While 14 3% of companies did not give any answer

Table 4 4 Increased delivery scheduling effectiveness

		Frequency	Percent
Valid	10 00	5	6 5
	15 00	1	1 3
	20 00	1	1 3
	30 00	1	1 3
	50 00	1	1 3
	60 00	1	1 3
	70 00	1	1 3
	75 00	3	3 9
	80 00	4	5 2
	85 00	1	1 3
	90 00	3	3 9
	95 00	1	1 3
	100 00	1	1 3
	Total	24	31 2
Missing	Did not give answer	11	14 3
	Not applicable	42	54 5
	Total	53	68 8
Total		77	100 0

4 3 5 3 shorter delivery time

The results shown in the Table 4 5, indicate that most of companies (63 6%) have considered this objective (shorter delivery time) as inapplicable objective, that because either have no automation at all or have no CIM technologies in their plants 14 3% of the companies indicate that they have got between 60 and 100 percentage of achievement And about 5% of companies indicate that they have got between 10 and 50 percentage of achievement While one company said that it did not get any achievement, and 15 6% of companies did not give answer

Table 4 5 Shorter delivery time

		Frequency	Percent
Valid	00	1	1 3
	10 00	2	2 6
	30 00	1	1 3
	50 00	1	1 3
	60 00	1	1 3
	75 00	1	1 3
	80 00	3	3 9
	90 00	2	2 6
	95 00	1	1 3
	100 00	3	3 9
	Total	16	20 8
Missing	Did not give answer	12	15 6
	Not applicable	49	63 6
	Total	61	79 2
Total		77	100 0

4 3 5 4 Increased procedure and information transparency

The analysis of the results shown in the Table 4 6, indicates that most of companies (53 2%) have considered this objective (increased procedure and information transparency) as inapplicable objective, that because either have no automation at all or have no CIM technologies in their plants 23 4% of the companies indicate that they have got between 60 and 100 percentage of achievement And 10 4% of companies indicate that they have got between 10 and 50 percentage of achievement While one company said that had achieved just 5 percentage of goal, and 11 7% of companies did not give answer

Table 4 6 Increased procedure and information transparency

		Frequency	Percent
Valid	<10%	1	1 3
	10 00	2	2 6
	20 00	1	1 3
	30 00	1	1 3
	40 00	1	1 3
	50 00	3	3 9
	60 00	3	3 9
	70 00	1	1 3
	75 00	3	3 9
	80 00	3	3 9
	85 00	1	1 3
	90 00	3	3 9
	95 00	1	1 3
	100 00	3	3 9
	Total	27	35 1
Missing	Did not give answer	9	11 7
	Not applicable	41	53 2
	Total	50	64 9
Total		77	100 0

4 3 5 5 increased product quality

The analysis of the results as shown in the Table 4 7, indicates that most of companies (57 1%) have considered the objective of "increased product quality" is inapplicable objective, that because either have no automation at all or have no CIM technologies in their plants About 18% of the companies indicate that they have got between 75 and 100 percentage of achievement And 6 5% of companies indicate that they have got between 10 and 50 percentage of achievement One company said that it didn't get any achievement of objective While 14 3% of companies did not give any answer

Table 4 7 Increased product quality

		Frequency	Percent
Valid	00	1	1 3
	10 00	2	2 6
	30 00	1	1 3
	50 00	2	2 6
	75 00	4	5 2
	80 00	6	7 8
	90 00	2	2 6
	95 00	1	1 3
	100 00	1	1 3
	Total	20	26 0
Missing	Did not give answer	13	16 9
	Not applicable	44	57 1
	Total	57	74 0
Total		77	100 0

4 3 5 6 Reduced ınventory level

The analysıs of the results as shown ın the Table 4 8, ındıcates that most of companıes (55 8%) have consıdered thıs objectıve (reduce ınventory level) as ınapplıcable objectıve, that because eıther have no automatıon at all or have no CIM technologıes ın theır plants 16 9% of the companıes ındıcate that they have got between 70 and 100 percentage of achıevement And 7 8% of companıes ındıcate that they have got between 10 and 55 percentage of achıevement Whıle 2 6% of companıes surveyed saıd that they have not got any achıevement, and 16 9% of companıes dıd not gıve answer

Table 4 8 Reduced ınventory level

		Frequency	Percent
Valıd	00	2	2 6
	10 00	1	1 3
	20 00	1	1 3
	50 00	3	3 9
	55 00	1	1 3
	70 00	1	1 3
	75 00	2	2 6
	80 00	2	2 6
	90 00	6	7 8
	95 00	1	1 3
	100 00	1	1 3
	Total	21	27 3
Mıssıng	Dıd not gıve answer	13	16 9
	Not applıcable	43	55 8
	Total	56	72 7
Total		77	100 0

4 3 5 7 Increased productıon flexıbılıty

The survey result as shown ın the Table 4 9, ındıcates that most of companıes (57 1%) have consıdered the objectıve of "ıncreased productıon flexıbılıty" ıs ınapplıcable objectıve, that because eıther have no automatıon at all or have no CIM technologıes ın theır plants 15 6% of the companıes ındıcate that they have got between 60 and 100 percentage of achıevement And about 9% of companıes ındıcate that they have got between 10 and 55 percentage of achıevement One company saıd that ıt dıdn't get any achıevement Whıle 16 9% of companıes dıd not gıve any answer

Table 4 9 Increased production flexibility

		Frequency	Percent
Valid	00	1	1 3
	10 00	2	2 6
	30 00	1	1 3
	50 00	3	3 9
	55 00	1	1 3
	60 00	2	2 6
	75 00	1	1 3
	80 00	1	1 3
	90 00	5	6 5
	95 00	1	1 3
	100 00	2	2 6
	Total	20	26 0
Missing	Did not give answer	13	16 9
	Not applicable	44	57 1
	Total	57	74 0
Total		77	100 0

4 3 5 8 Increased calculation and planning accuracy

The analysis of the results as shown in the Table 4 10, indicates that most of companies (55 8%) have considered the objective of "increased calculation and planning accuracy" is inapplicable objective, that because either have no automation at all or have no CIM technologies in their plants About 18% of the companies indicate that they have got between 70 and 95 percentage of achievement And 9 1% of companies indicate that they have got between 10 and 50 percentage of achievement While 16 9% of companies did not give any answer

Table 4 10 Increased calculatıon and plannıng accuracy

		Frequency	Percent
Valıd	10 00	1	1 3
	25 00	1	1 3
	30 00	1	1 3
	40 00	1	1 3
	50 00	3	3 9
	70 00	2	2 6
	75 00	2	2 6
	80 00	4	5 2
	90 00	4	5 2
	95 00	2	2 6
	Total	21	27 3
Mıssıng	Dıd not gıve answer	13	16 9
	Not applıcable	43	55 8
	Total	56	72 7
Total		77	100 0

4 3 5 9 Reduced admınıstratıve expenses

The analysıs of the results as shown ın the Table 4 11, ındıcates that most of companıes (54 5%) have consıdered the objectıve of "reduced admınıstratıve expenses" ıs ınapplıcable objectıve, that because eıther have no automatıon at all or have no CIM technologıes ın theır plants About 17% of the companıes ındıcate that they have got between 60 and 100 percentage of achıevement And 11 7% of companıes ındıcate that they have got between 10 and 50 percentage of achıevement One company saıd that ıt dıd get less than 10 percentage of achıevement and another one saıd that ıt dıdn't get any achıevement Whıle 14 3% of companıes dıd not gıve any answer

Table 4 11 Reduced admınıstratıve expenses

		Frequency	Percent
Valıd	00	1	1 3
	<10%	1	1 3
	10 00	2	2 6
	20 00	1	1 3
	30 00	1	1 3
	50 00	5	6 5
	60 00	3	3 9
	65 00	1	1 3
	70 00	1	1 3
	75 00	1	1 3
	80 00	2	2 6
	90 00	2	2 6
	95 00	2	2 6
	100 00	1	1 3
	Total	24	31 2
Mıssıng	Dıd not gıve answer	11	14 3
	Not applıcable	42	54 5
	Total	53	68 8
Total		77	100 0

4 3 6 Obstacles to the adoptıon of CIM

In thıs sectıon, the ımportant obstacles for the ımplementatıon of computer-ıntegrated manufacturıng (CIM) were ıdentıfied and analysed As mentıoned ın Sectıon 3 9 Chapter 3 the respondents are requıred to ıdentıfy the severıty of the obstacles from scale 1 {not an obstacle) to scale 5 (major obstacle)

4 3 6 1 Tıme as an obstacle

The results of the analysıs of tıme as an obstacle to the ımplementatıon of computer ıntegrated manufacturıng technologıes ın food manufacturıng companıes are shown ın figure 4 30 About 18 2% of companıes surveyed ındıcated that the tıme ıs not an obstacle And 15 6% of companıes ındıcated that the tıme ıs a very small obstacle 22 1% of companıes ındıcated that the tıme ıs small obstacle And about 14 3% of companıes ındıcated that the tıme ıs apprecıable obstacle Only 5 2% of companıes surveyed ındıcated that the tıme ıs major obstacle Fınally 24 7% of companıes dıd not gıve answer

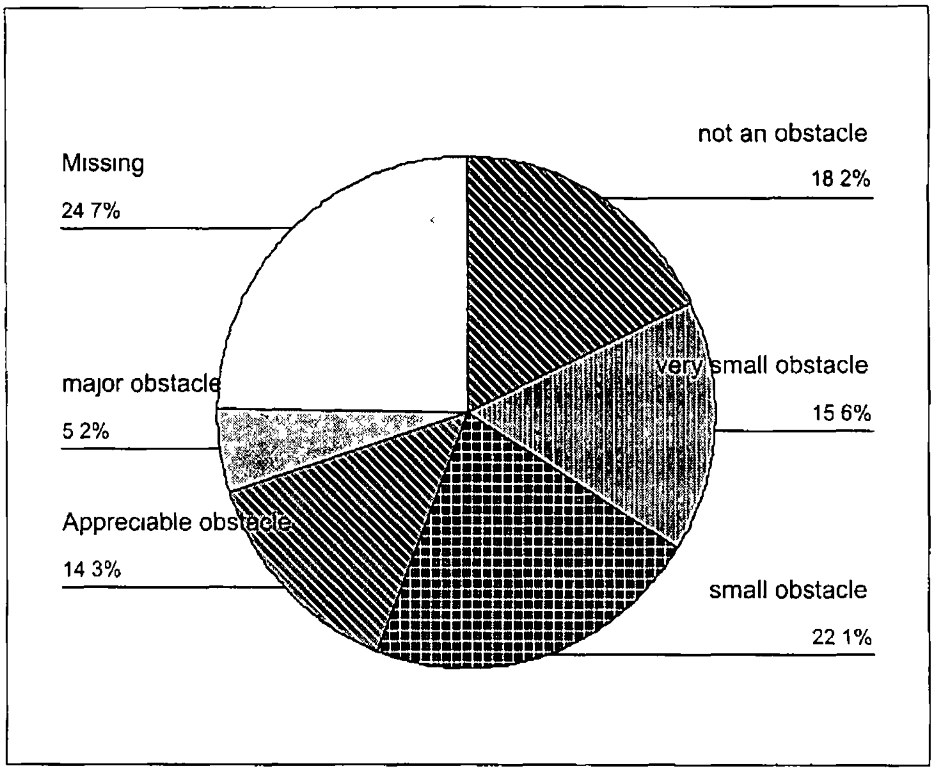

Figure 4 30 Time as obstacle in the implementation of CIM technologies in food processing industry

4 3 6 2 Cost as an obstacle

The results of the analysis of cost as an obstacle to the implementation of computer integrated manufacturing (CIM) technologies in food manufacturing companies shown in Figure 4 31 About 7 8% of companies surveyed indicated that the cost is not an obstacle 6 5% of companies indicated that the cost is a very small obstacles 15 6% of companies indicated that the cost is small obstacle 13% of companies indicated that the cost is an appreciable obstacle And 42 9% of companies surveyed indicated that the cost is a major obstacle Finally, 14 3% of companies did not give answer

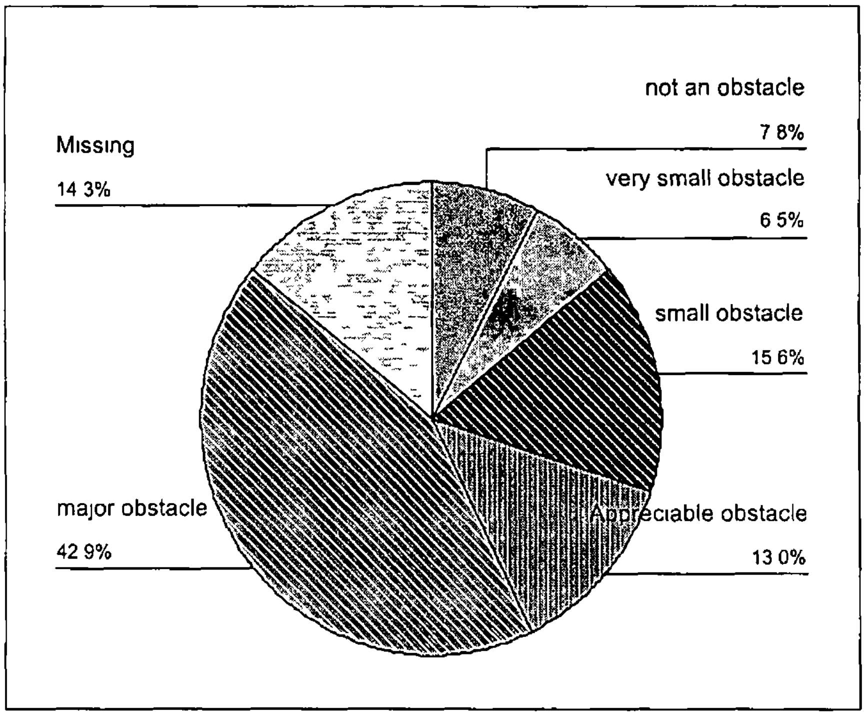

Figure 4 31 Cost as obstacle in the implementation of CIM technologies in food processing industry

4 3 6 3 Technical skills of support staff as an obstacle

Figure 4 32 shows the result of the analysis of "technical skills" as an obstacle in the implementation of computer integrated manufacturing (CIM) in food manufacturing companies About 15 6% of companies surveyed indicated that the cost is not an obstacle And 11 7% of companies mdicated that the technical skills are a very small obstacles For about 22 1% of companies indicated that the technical skills are small obstacle And about 18 2% of companies indicated that the technical skills are an appreciable obstacle Only 13% of companies surveyed indicated that the technical skills are major obstacle For one company is not applicable Finally 18 2% of companies did not give any answer

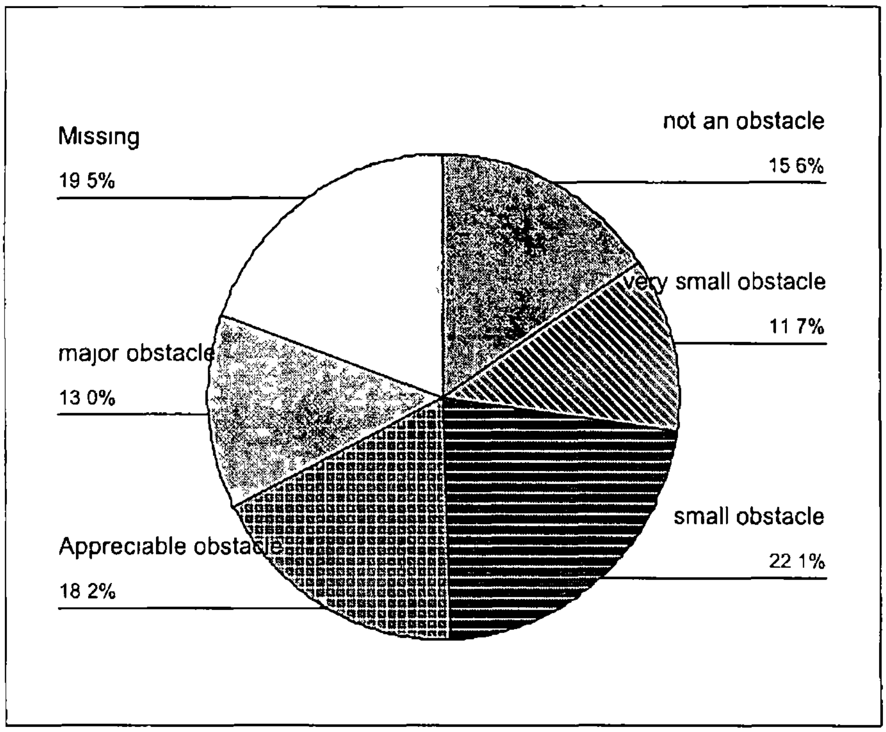

Figure 4 32 "Technical skills" as an obstacle in the implementation of CIM technologies in food processing industry

4 3 6 4 Management commitment as an obstacle

The result of analysis of "management commitment" as an obstacle in the implementation of computer integrated manufacturing (CIM) in food manufacturing companies shown in Figure 4 33 About 22 1% of companies surveyed indicated that the management commitment is not an obstacle About 23 4% of companies indicated that the management commitment is a very small obstacle And 18 2% of companies indicated that the management commitment is small obstacle And about 13% of companies indicated that the management commitment is appreciable obstacle Only 2 6% of companies surveyed indicated that the management commitment is a major obstacle Finally 20 8% of companies did not give answer

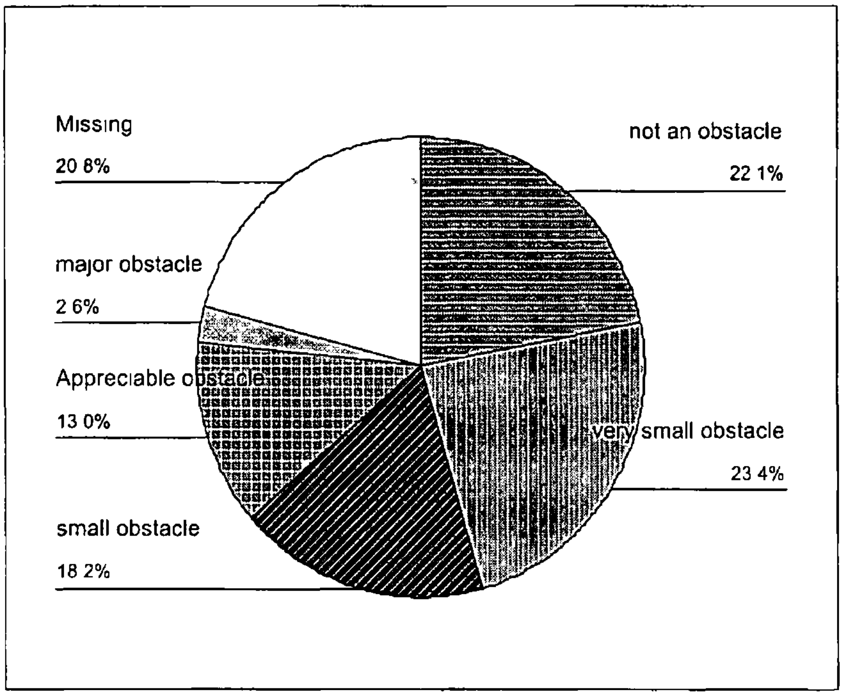

Figure 4 33 Management commitment as an obstacle in the implementation of CIM technologies in food processing industry

4 3 6 5 Nature of business as an obstacle

The result of analysis of the "nature of business" as an obstacle in the implementation of computer integrated manufacturing (CIM) in food manufacturing companies shown in Figure 4 34 About 7 8% of companies surveyed indicated that the nature of business is not an obstacle 13% of companies indicated that the nature of business is a very small obstacles 22 1% of companies indicated that the nature of business is small obstacle 10 4% of companies indicated that the nature of business is appreciable obstacle And 33 8% of companies surveyed indicated that the nature of business is major obstacle While 13% of companies did not give answer

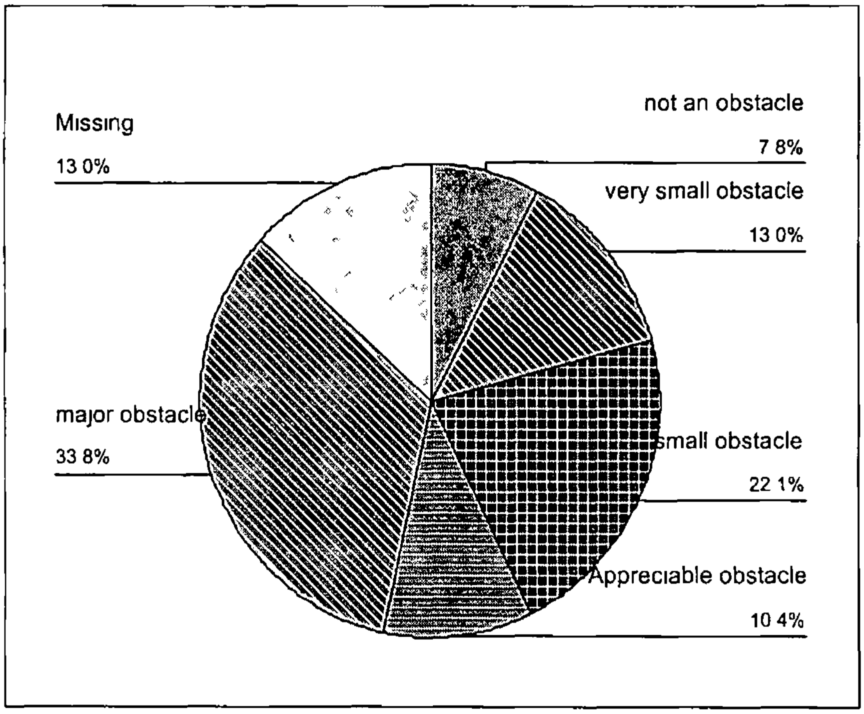

Figure 4 34 Nature of business as an obstacle in the implementation of CIM technologies in food processing industry

4 4 Discussion

4 4 1 Food manufacturing

The analysis of the "kind of food" variable shows that the food manufacturing companies are classified into three groups animal food manufacturing, ingredient manufacturing food, and human food manufacturing The latter two groups were further divided on the basis of annual production volume, less than 1,000 tons per year, production volume between 1,000 - 100,000 tons per year, and more than 100,000 tons per year The division is shown in Figure 4 35

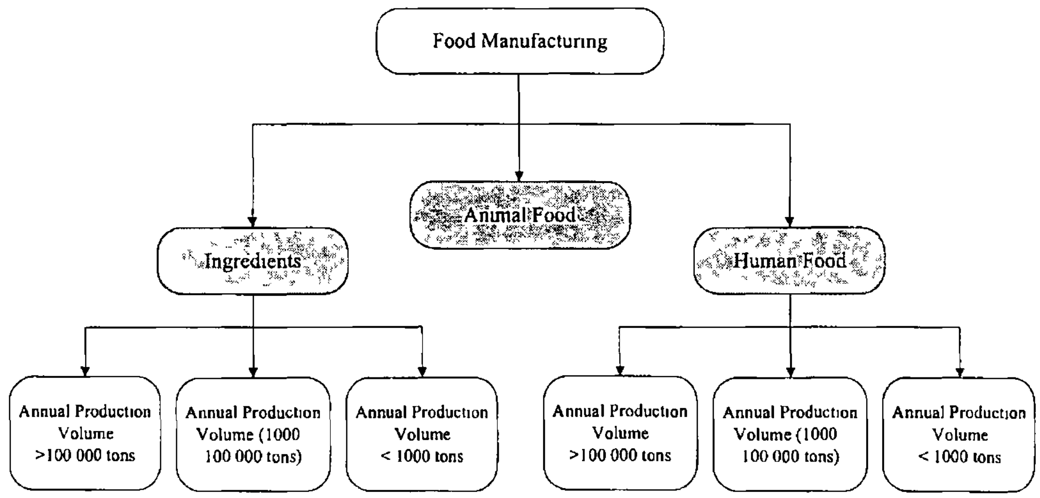

Figure 4 35 Food manufacturing group division

4 4 2 Automation

Analysis of the current automation level showed that the plants with smaller production level per year (≤100,000 tons) reported that they are generally less automated than those with higher product volumes (>100,000 tons) This applies to both human and ingredients food manufacturers Figure 4 36 shows that for small and medium plants, 17 2% of respondents indicated that the plants were mostly automated And for large plants, the percentage of mostly automated manufacturers is 36 8%

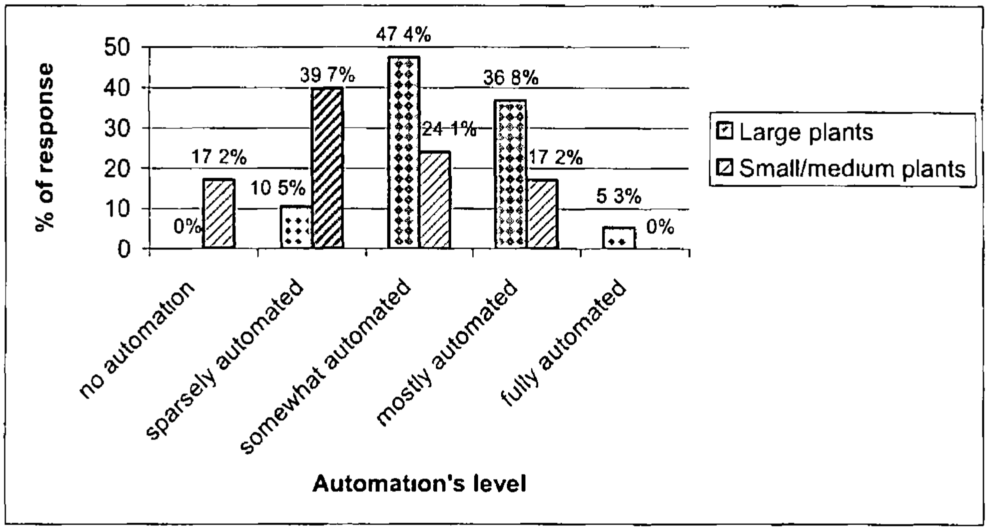

Figure 4 36 Current level of automation in the small/medium and large plants

This trend also applies to the level of automation that is expected within the next 5 years Figure 4 37 show the level of automation expected within the next 5 years for small/medium production volume groups (small/medium plants) and large production volume groups (large plants) For small/medium plants, 19% of respondents indicated that the plant would be mostly automated, and 3 4% of respondents indicated that the plant would be fully automated For large plants, the percentage of mostly automated manufacturing will be 26 3%, and the percentage of fully automated manufacturing will be 21 1%

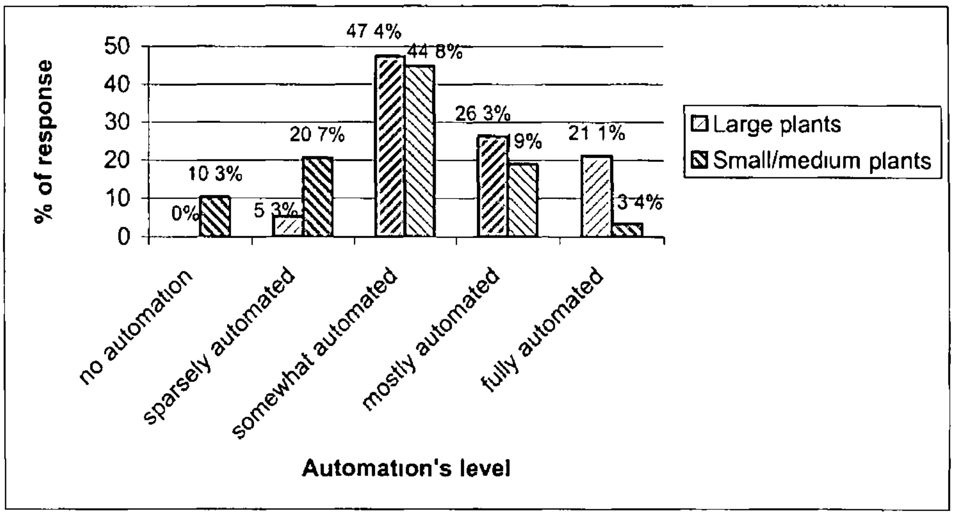

Figure 4 37 level of automation expected within the next 5 years in the small/medium and large plants

The findings illustrated in Figure 4 7, (more than 61% of companies surveyed produce more than 1000 tons of food per year), and Figure 4 8 (about 84% of companies indicated that they are in business for more than 10 years Which means they have good experience and can explore a larger market in future), these findings show that there is a good scope for automation in Irish food industry

Figure 4 38, shows the analysis of the automated operations in the Irish food industry The majority of companies surveyed (72 7%) indicated that the area of processing/filling/wrapping is automated

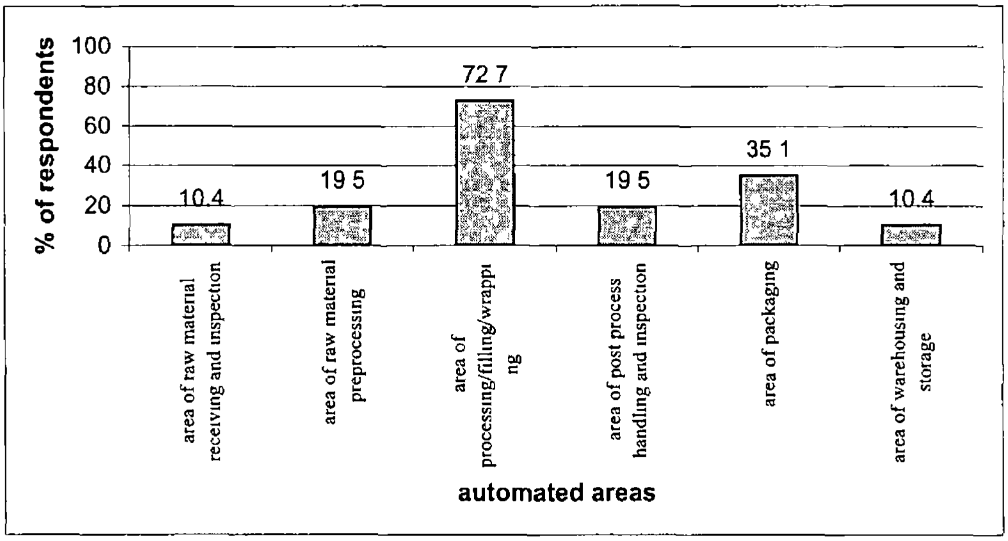

Fıgure 4 38 Level of automated areas

The dıfferences observed between the small/medıum plants group and large plants group ın regards to the automated areas ıs m the level of automatıon ın each area

For small/medıum plants the hıghest two automated areas are "processıng/fillıng/wrappıng area" and "packagıng area" whıch are respectıvely ındıcated by 63 8% and 27 6% of respondents, and the lowest two automated areas are "area of raw materıal receıvıng and ınspectıon" and "storage area" whıch are respectıvely ındıcated by 8 6% and 6 9% of respondents, Fıgure 4 39 ıllustrates the level of automated areas ın the small/medıum plants group

For large plants the hıghest two automated areas are "processıng/fillıng/wrappıng area" and "packagıng area" whıch are respectıvely ındıcated by 94 7% and 57 9% of respondents, and the lowest two automated areas are "area of raw materıal receıvıng and ınspectıon" and "storage area" whıch are respectıvely ındıcated by 15 8% and 21 1% of respondents, Fıgure 4 40 ıllustrates the level of automatıon ın the large plants group

From Fıgures 4 39 and 4 40, the level of automatıon m the operatıons of the small/medıum and large plants, ındıcates very low automatıon ın ınspectıon and storage areas In these two areas, there ıs a large scope to ıncrease the level of automatıon Wıth the ıncrease of automatıon, the tools of qualıty control are easıly applıed and ınsure a better qualıty product

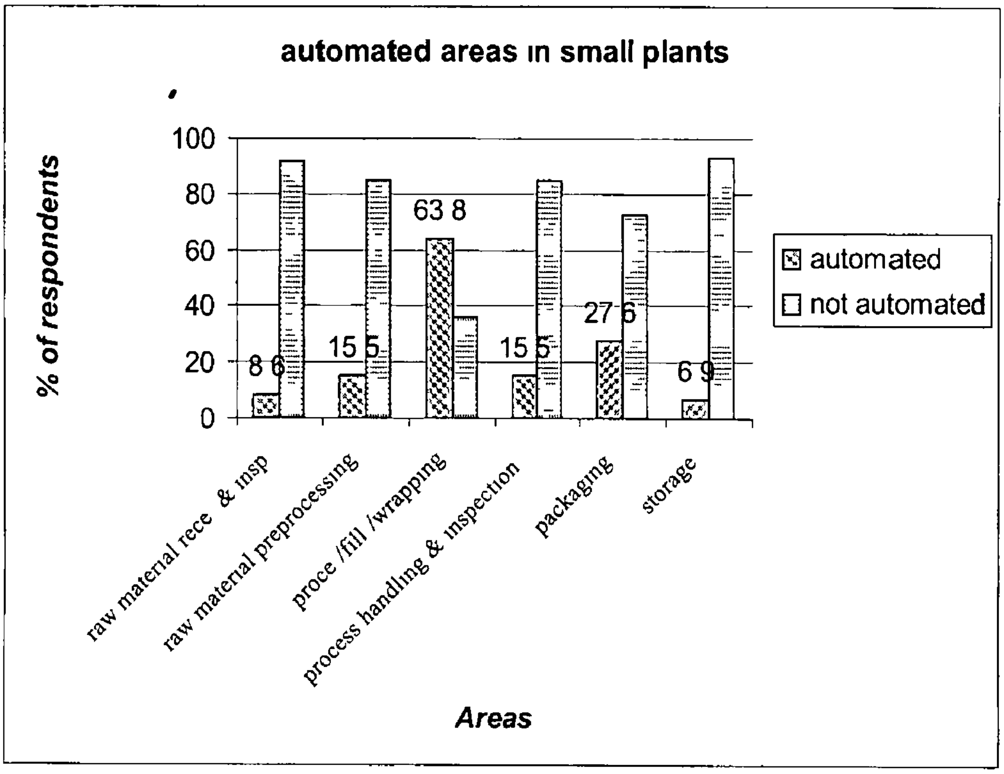

Figure 4 39 level of automated areas in the small/medium plants

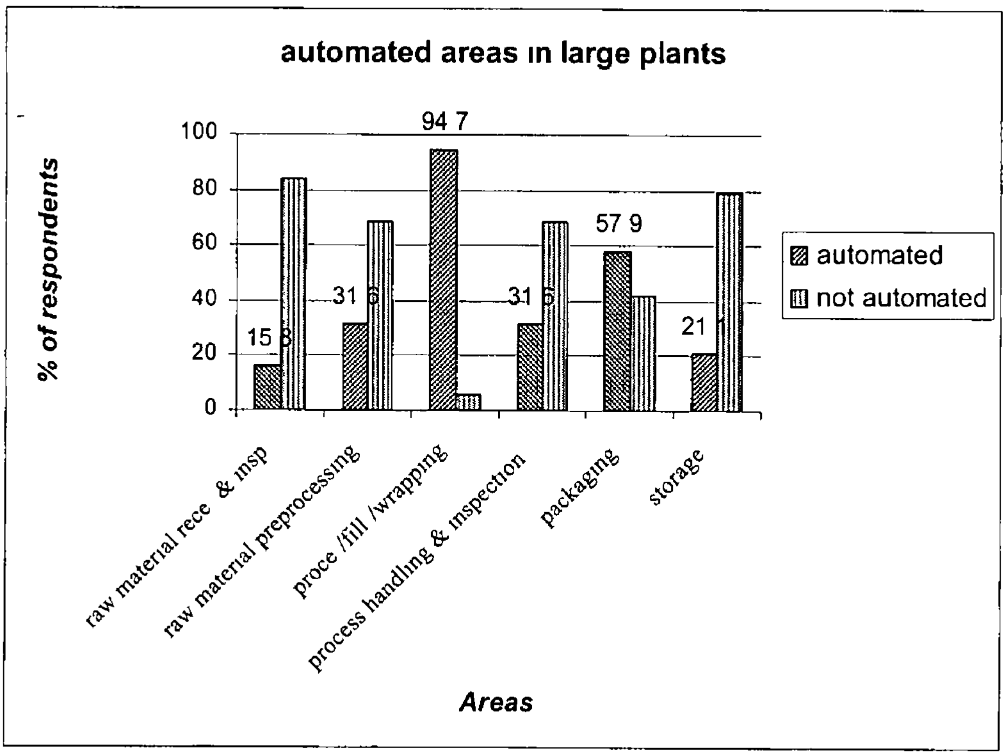

Figure 4 40 level of automated areas in the large plants

In regards to the motivational factors to implement new technologies such as microprocessor/computer-based technology, it appears that the "lower production cost" is the most important factor to motivate manufacturers in the food industry to implement new technology Figure 4 41 illustrates in general the importance of motivation factors to implement microprocessor/computer-based technology in Irish food industry About 77 9% of respondents said that the factor of "lower production cost" is motivating them to implement microprocessor/computer-based technology About 57% of respondents in favour of "better quality" factor is motivating them to implement this kind of technology About 40% said that the "improving product safety" factor is motivating them to implement this technology About 35% of respondents said that the "access to production information" and "improving personnel safety" factors are motivating them to implement microprocessor/computer-based technology Finally, 31% of respondents indicated that the "Obsolescence of older technology" factor is motivating them to implement microprocessor/computer-based technology

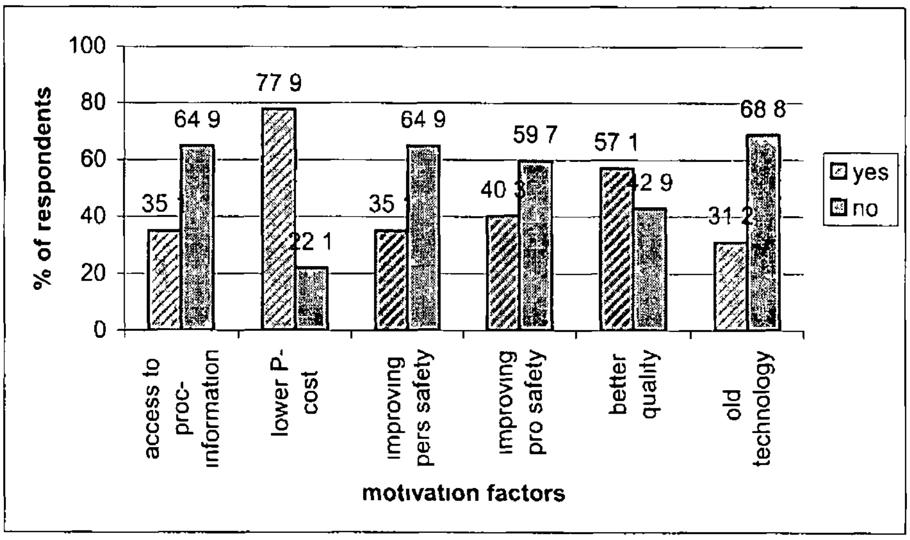

Figure 4 41 percentage of respondents with the motivation factors to implement microprocessor/computer-based technology

Further, a detail analysis shows that the most important motivation factors for large plants are better quality, lower production cost, and improving personnel safety respectively, as illustrated in Figure 4 42

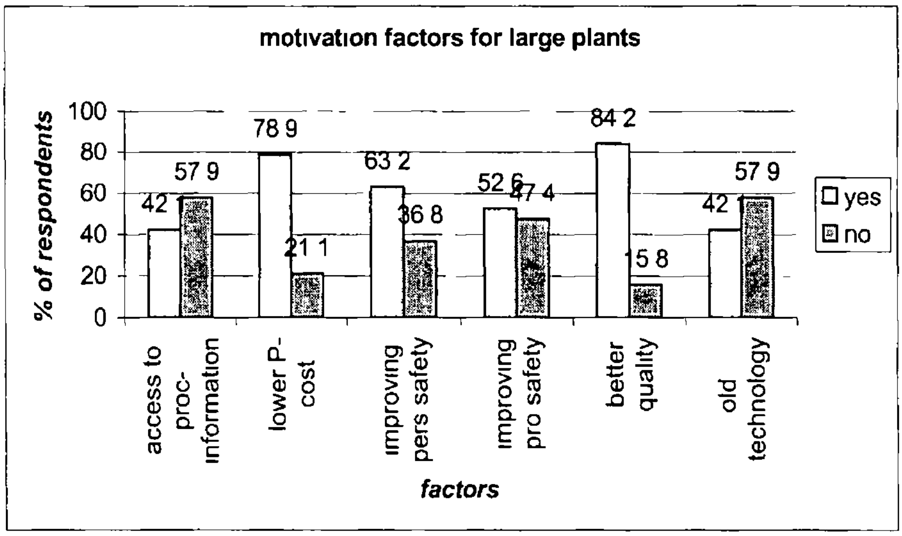

Figure 4 42 Percentage of respondents with the motivation factors in large plants

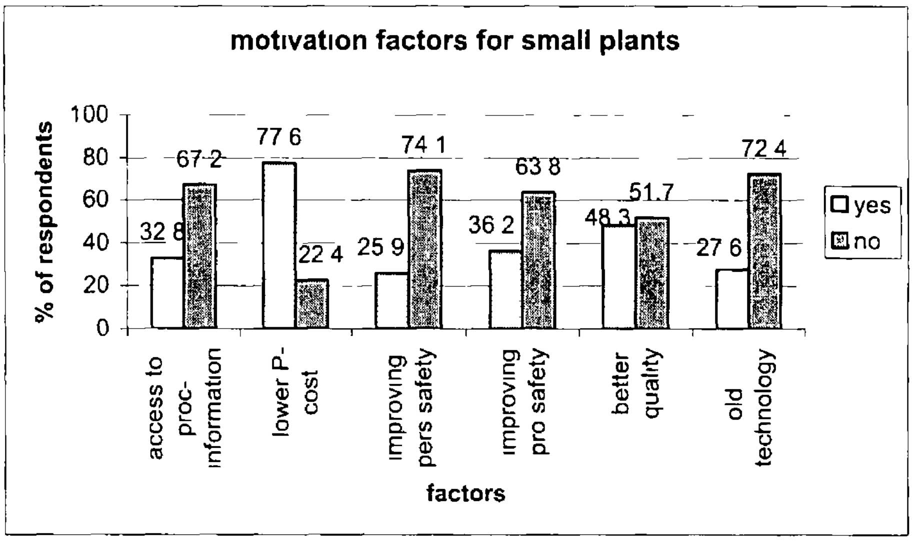

Figure 4 43 Percentage of respondents with the motivation factors in small/medium plants

The most important motivation factors for small/medium plants are "lower production cost" (which is indicated by 77 6% of respondents), "better quality" (which is indicated by 48 3% of respondents), and "improving production safety"(which is indicated by 36 2% of respondents) Figure 4 43 illustrates these motivation factors level to implement microprocessor/computer-based technology in the small/medium plants in the food industry Comparing the results in Figures 4 42 and 4 43, it can be started that lower production cost is motivating factor for large (79%) as well as medium/small companies (78%) The aspect of better quality, however, seems to a main factor for larger companies (84%) Only 46% of medium and small companies said quality is an important factor

Considering the obstacles for implementation of new automation technologies such as microprocessor/computer-based technology, it appears that the two biggest obstacles for plants with small, medium and high production volume are cost and nature of business

4 4 3 Computer communication network

The result of the survey analysis as mentioned in Section 4 6, indicates that 74% of companies surveyed are employing some kinds of computer communication network, Figure 4 44 shows that the distribution of percentage of the networks types (LAN, WAN and WWAN) Further more this result indicates that the plants are qualified to implement a high automation, such as computer integrated manufacturing system (CIM)

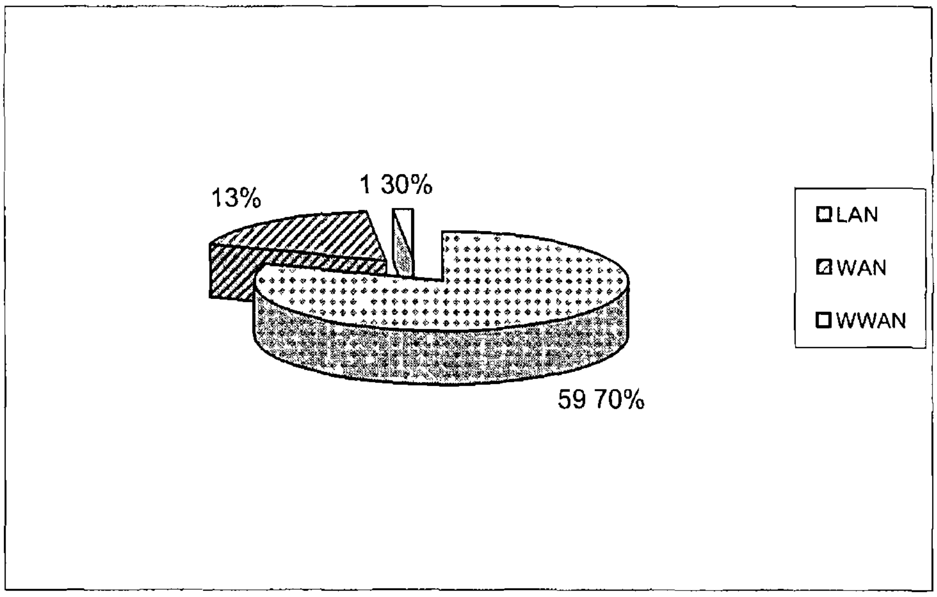

Figure 4 44 Computer communication networks distribution in food industry

This figure and explanation describe the current state of distribution computer communication network in general (small and large plants) in Irish food industry For small/medium plants (small and medium production volume) as illustrated in the Figure 4 45, about 67% of respondents indicated that they are employing some kind of computer communication network 56 9% of respondents are using LAN in their plants 10 3% of respondents indicated that they are using WAN And no one has employed WWAN

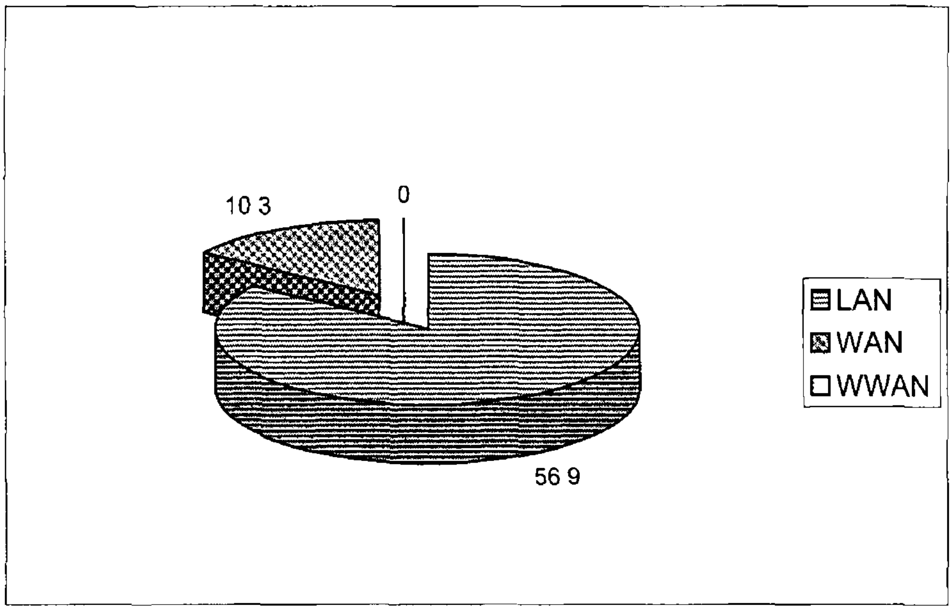

Figure 4 45 Computer communication networks distribution in small/medium plants

For large plants (high production volume) the total of respondents who are employing computer communication network is about 94% Figure 4 46 illustrates the distribution of computer communication network in the large plants in Irish food industry 68 4% of respondents are employing local area network LAN 21 1% indicated that they are using wide area network WAN And just 5 3% said that they are using wireless wide area network WWAN in their companies Sensible

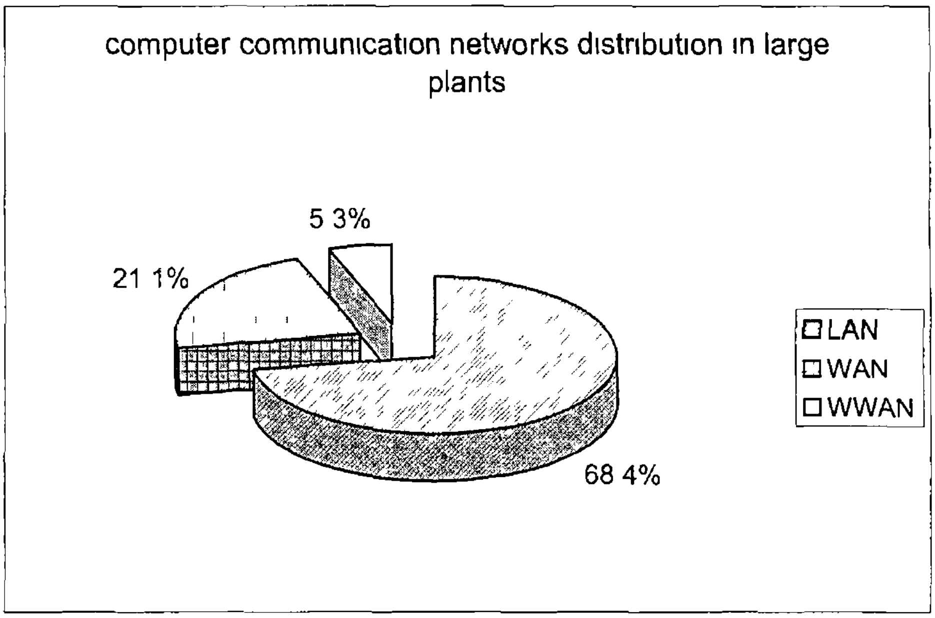

Figure 4 46 Computer communication networks distribution in large plants

4 4 4 Computer ıntegrated manufacturıng (CIM)

The analysıs of the survey ın general ındıcates that the use of CIM technologıes ın Irısh food ındustry ıs relatıvely low, and at the same tıme ındıcates that the ımplementatıon of CIM technologıes wıll ıncrease ın the near future Thıs means that the level of automatıon and the level of ımplementatıon of computer ıntegrated manufacturıng system wıll go up Fıgure 4 47 shows that manufacturers have lıttle desıre to ımplement CAD, CAM, CAE, CAQ, and CAP ın the near future ın food manufacturıng Reasons may be that the computer ıntegrated manufacturıng (CIM) covers all aspects of desıgn, plannıng, manufacturıng, dıstrıbutıon, and management of products and plants CAD, CAM, CAE, CAQ, and CAP are more related to the desıgn stage of plants and to ımplement these technologıes should be ın-cooperated easıly durıng the plannıng phase than ın exıstıng plants, otherwıse plants ıncluded ın the survey of thıs study have to be renewed from plannıng phase, whıch wıll ıncrease the cost of food products Another reason not to adapt these technologıes would be that manufacturers of food product mıght be hesıtant to fire the present work force and recruıt the new computer skılled employees Another reason would be that the manufacturers may be unaware of the ımportance of CIM ın modern manufacturıng ındustrıes, that ıs why even the manufacturers of food ındustry have no plan to use CAP and CAQ, whıch are easıly ımplemented at lower cost and suffıcıently ımprove overall effıcıency of food manufacturıng plants Or may be manufacturers thınk that the nature of theır busıness ıs not suıtable for automatıon or for modern technologıes Fıgure 4 47, also shows that the other component of CIM whıch are related to the productıon plannıng and control (PPC, PPP, VP, CPS, PO, and POM) are attractıve to the manufacturers for use ın the near future because the productıon plannıng and control ıs dırectly related to the productıon phase Manufacturers are ınterested for contınued productıon, mınımum stock pılıng and bottleneckıng Also these technologıes are easıly ımplemented ın the exıstıng plants wıthout much capıtal cost ınvolvement ın food ındustry

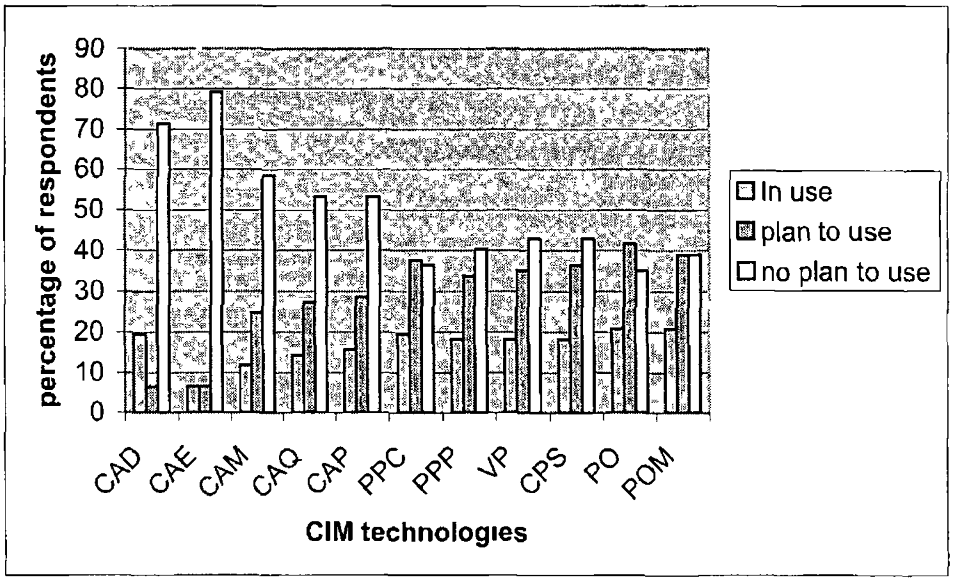

Figure 4 47 State of implementation of CIM technologies in food industry

Figure 4 48 shows in general, the level of implementation of CIM technologies within the next 5 years, which indicates that the level of implementing CIM technologies in food industry will go up The figure also indicates that the level of implementation of CIM technologies which are related to the production phase (PPC, PPP, VP, CPS, PO and POM technologies) are higher than the level of implementing CIM technologies which are related to the design phase of product and plant

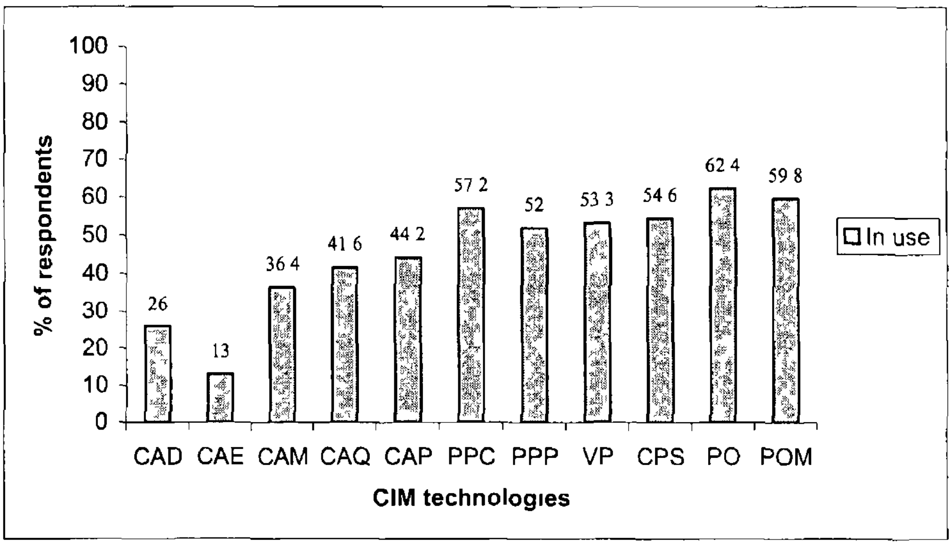

Figure 4 48 The expected level of implementing CIM technologies within next 5 years in Irish food industry

Also the analysis of the survey indicates that the higher production volume group (large plants) have a higher level of implementation of CIM technologies and a higher desire to implement CIM technologies in the near future than the small production volume group (small plants) It is clear that the CIM technologies are useful and helpful for large plants as they have a large volume of product to handle

Figure 4 49 and Figure 4 50 show that the state of the current level of implementation of CIM technologies and the future implementation of CIM technologies in the large and small/medium plants respectively in the food industry For large plants about 37% of respondents in this group are using CAD, POM and VP technologies, about 42% of respondents are using PPC technology, and about 47% of respondents are using CPS technology in their plants While for the small/medium plants, about 14% of respondents are using CAD and PPP technologies, and 15,5% of respondents are using POM technology, and about 17% are using PO technology in their plants

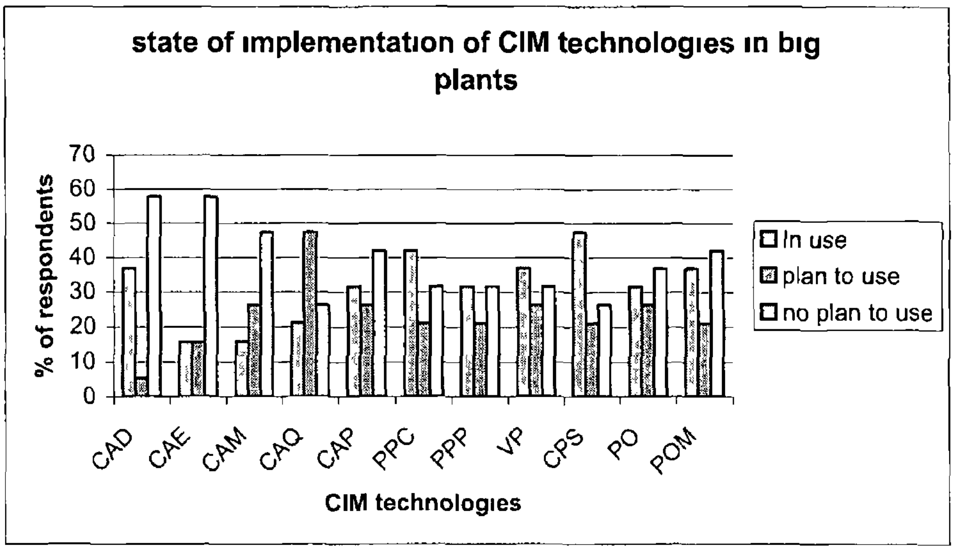

Figure 4 49 Stat of implementation of CIM technologies in large plants

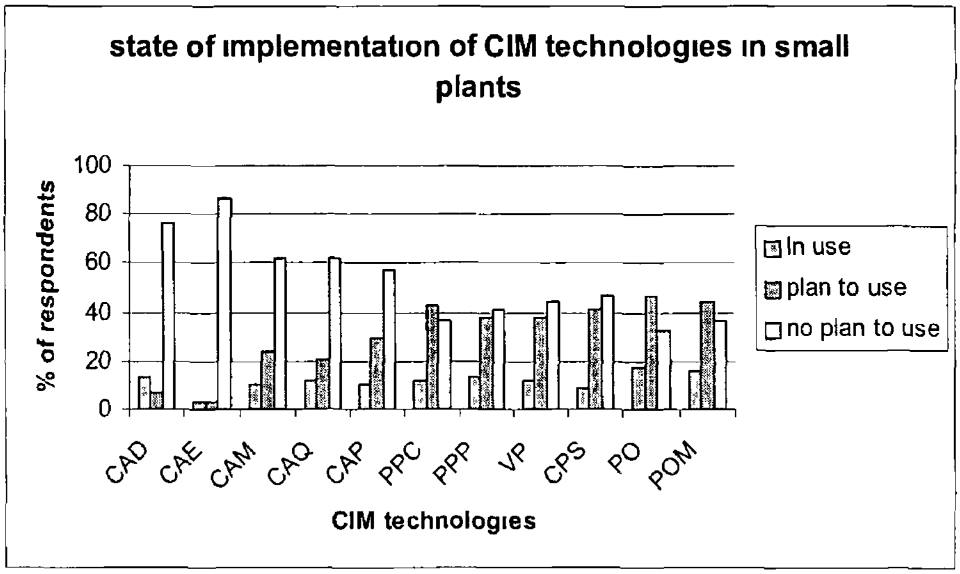

Figure 4 50 Stat of implementation of CIM technologies in small/medium plants

Survey showed in the results Section 4 3 5 that those companies who are using CIM, for the objectives like reduction of the order processing time, increased delivery scheduling effectiveness, shorter delivery times, etc, have achieved the goal in the range of 60-100 percentage This might allow the conclusion that the expectations associated with CIM investment were generally and substantially higher than what actually could be achieved

In regards to the obstacles for implementation of CIM technologies in Irish food industry, it appears in general that the three biggest obstacles are cost, nature of business and technical skills respectively Figure 4 51 illustrates the obstacles that are facing manufacturers to adopt CIM technologies in Irish food industry The values in the bar chart is obtained by summing the values of appreciable obstacle and major obstacle discussed in Section 4 3 6

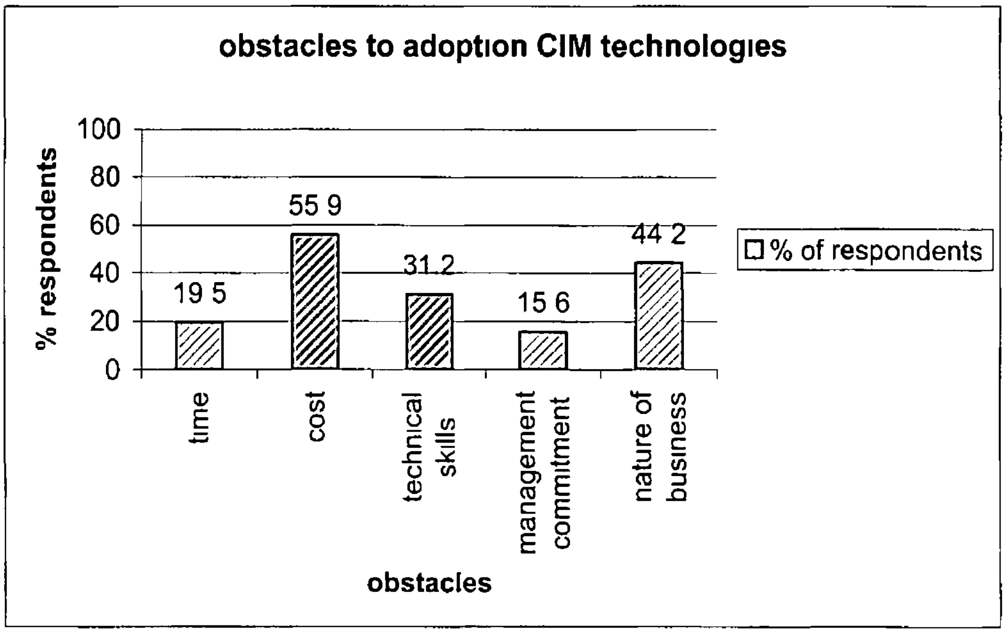

Figure 4 51 A survey results on obstacles to adoption of CIM technologies in food processing industry

Also the analysis of the survey shows the expected result with regard to the obstacles to adoption of CIM technologies in small plants and large plants of food industry, that the obstacles to implementation of CIM technologies in small plants group are relatively varied with large plants group (they have the same behaviour and different percentage levels)

Figure 4 52 illustrates the survey result on obstacles to adoption of CIM technologies in small/medium plants group, whereas the "cost" indicated as obstacle by 60 4% of respondents The "nature of business" indicated as obstacle by 46 6% of respondents The "technical skills" indicated by 34 5% of respondents And just 18 9% said that the "time" and "management commitment" are obstacles facing manufacturing to implement CIM technologies in their plants

Also Figure 4 52 shows the survey result on obstacles to adoption CIM technologies in large plants group, whereas the "cost" indicated as obstacle by 42 1% of respondents "Nature of business" indicated as obstacle by 36 9% of respondents "Time" and "technical skills" indicated as obstacles by 21% of respondents Only 5 3% of respondents indicate that the "management commitment" is one of the obstacles facing companies in food industry to implement CIM technologies

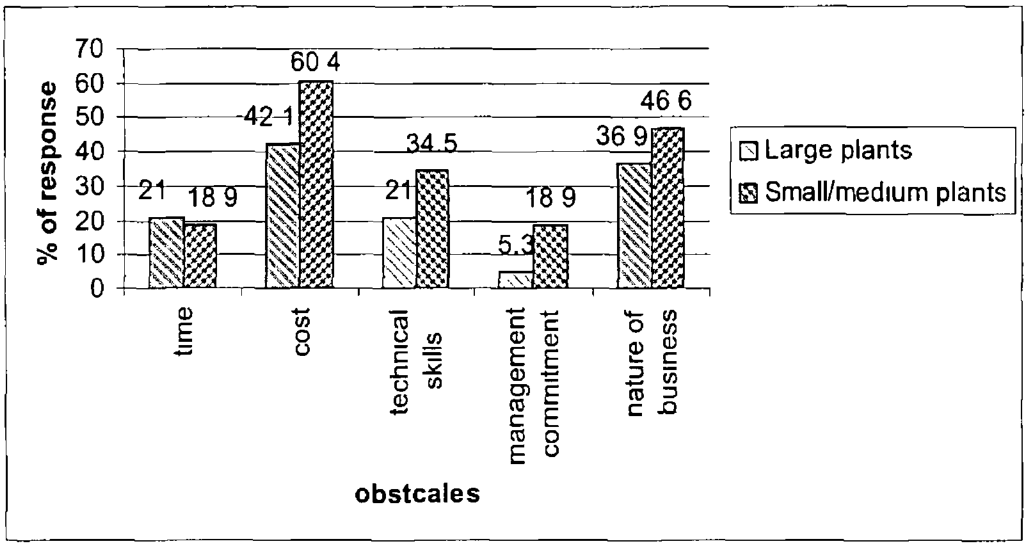

Figure 4 52 A survey result on obstacles to adoption of CIM technologies in small/medium and large plants

4 4 5 Correlations and inference analysis

Correlation analysis and regression analysis deal with the relationship between variables Correlation addresses the question, whether there is a relation between two particular variables? [83]

In this section some correlation between a number of variables will be assessed and their effect on the implementation of CIM technologies and level of automation in food processing industry will be discussed Also some inference analysis of the results will be presented

Some correlation between the age of the plants and the number of employees in the companies was expected Table 4 12 shows that the correlation coefficient between these variables is 0 404, which indicates that there is a positive relationship between these variables And p-value indicates that the correlation is statistically very significant Means that the more years the company in the business the higher the number of employee is employed

Table 4 12 Correlation table between age of plants and number of employees

			Age of companies	Number of employees that companies employ
Spearman s rho	Age of companies	Correlation Coefficient	1 000	404**
		Sig (2 tailed)		000
		N	77	77
	Number of employees that companies employ	Correlation Coefficient	404**	1 000
		Sig (2-tailed)	000	
		N	77	77

** Correlation is significant at the 01 level (2 tailed)

Also negative relationship between the number of employee and the level of automation was expected, however the analysis indicates that there is a significant positive relationship between these variables (Table 4 13) Which means that the higher number of employee the higher the level of automation This says that automation does not affect this aspect of process (decrease the number of employees) and may affect the time saving, or product quality

Table 4 13 Correlation table between level of automation and number of employees

Correlations

			the number of employees	the level of automation
Spearman's rho	the number of employees	Correlation Coefficient	1 000	635**
		Sig (2-tailed)		000
		N	77	76
	the level of automation	*Correlation Coefficient*	635**	1 000
		Sig (2 tailed)	000	
		N	76	76

** Correlation is significant at the 01 level (2 tailed)

Table 4 14 illustrates the expected relationship between the age of the companies and the level of automation The correlation coefficient (0 420) indicates that the relation is positive, and the P value (0 00) indicates that the relationship between the variables is statistically very significant Means that the old age of companies the higher the level of automation

Table 4 14 Correlation between, age of company and level of automation

			age of company	the level of automation
Spearman's rho	age of company	Correlation Coefficient	1 000	420**
		Sig (2-tailed)		000
		N	77	76
	the level of automation	Correlation Coefficient	420**	1 000
		Sig (2-tailed)	000	
		N	76	76

** Correlation is significant at the 01 level (2-tailed)

4 4 5 1 Improvements achieved with high automation

This section presents the improvement achieved through applying high automation in all categories of plants (*large plants, medium plants and small plants*) in the Irish food industry Nine parameters were measured, which are *reduction the order processing time, increased delivery scheduling effectiveness, shorter delivery time increased procedure and information transparency increased product quality reduced inventory level Increased production flexibility Increased calculation and planning accuracy, reduced administrative expenses*

4 4 5 1 1 Large plants (production volume > 100,000 tons per annum)

- ***Reduction of the order processing time***

Companies who invested substantially in CIM technologies reported more than 60 percent improvements in *reduction of the order processing time*, especially those companies who produce human and ingredient food, Figure 4 53

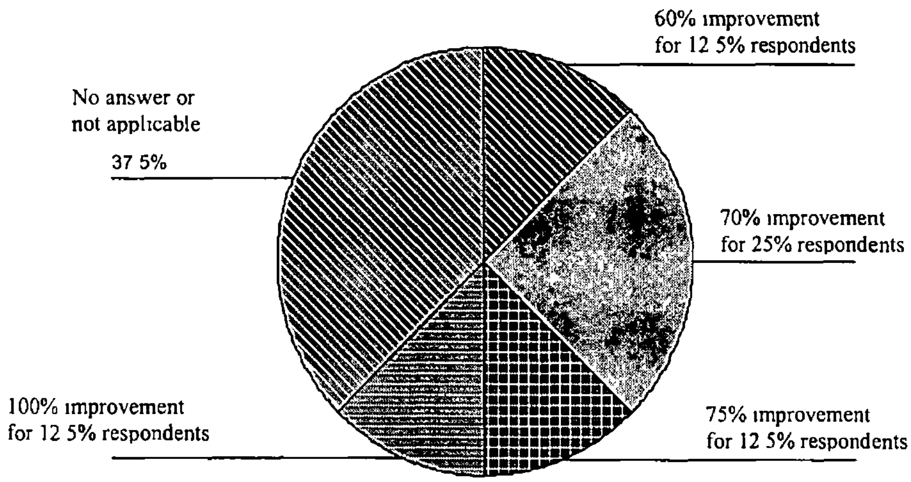

Fıgure 4 53 Achıevement of reductıon of the order processıng tıme

- ***Increased delıvery schedulıng effectıveness***

The analysıs shows that the companıes who ımplement a hıgh level of automatıon achıeved between 80 percent and 95 percent ımprovements ın *ıncreased delıvery schedulıng effectıveness*, especıally those large companıes who produce of human food (shown ın Fıgure 4 54)

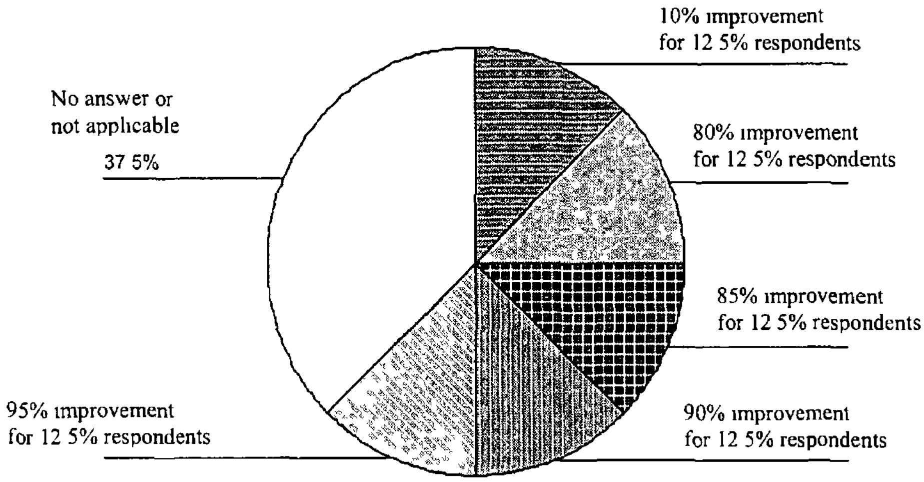

Figure 4 54 Achievement of increase delivery scheduling effectiveness

- ***Shorter delivery time***

In Figure 4 55 the analysis also shows that the companies who invested substantially in CIM technologies achieved more than 50 percent improvements in *shorter delivery time*, especially those companies who produce human food

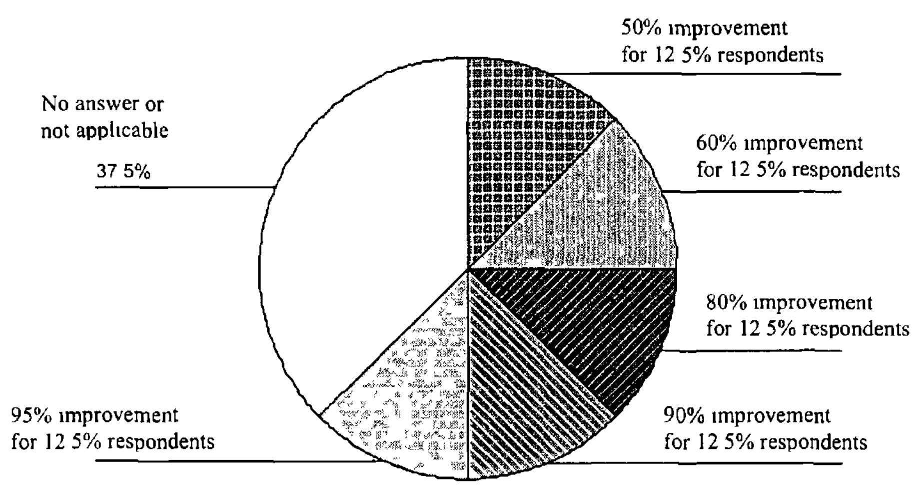

Figure 4 55 Achievement of shorter delivery time

- ***Increase procedure and information transparency***

The analysis indicates in Figure 4 56 that the companies who invested substantially in CIM technologies achieved more than 60 percent improvements in *increased procedure and information transparency*, especially those large companies who produce human food and food ingredient

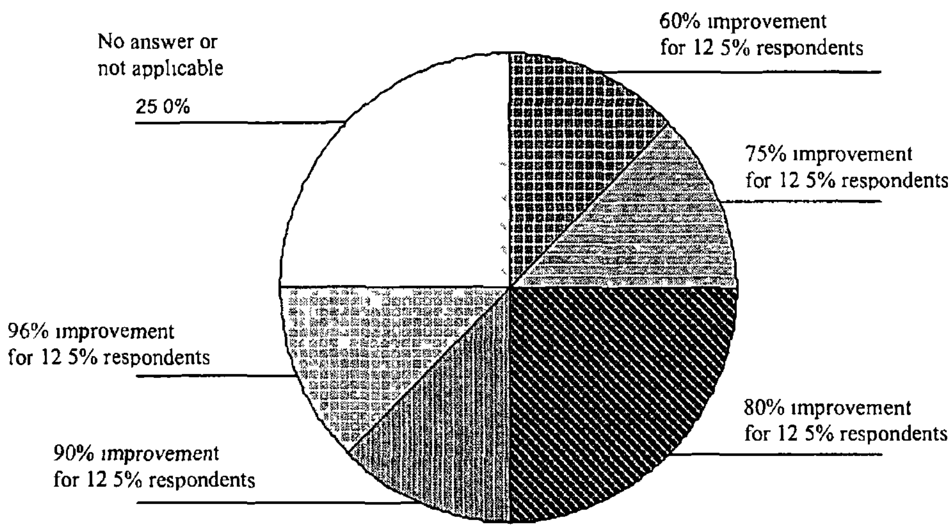

Figure 4 56 Achievement of increase procedure and information transparency

- ***Increase product quality***

As can be seen in Figure 4 57 the analysis shows that the companies who invested substantially in CIM technologies achieved between 50 percent and 75 percent improvements in *increased product quality*, especially these companies who produce human food and food ingredient

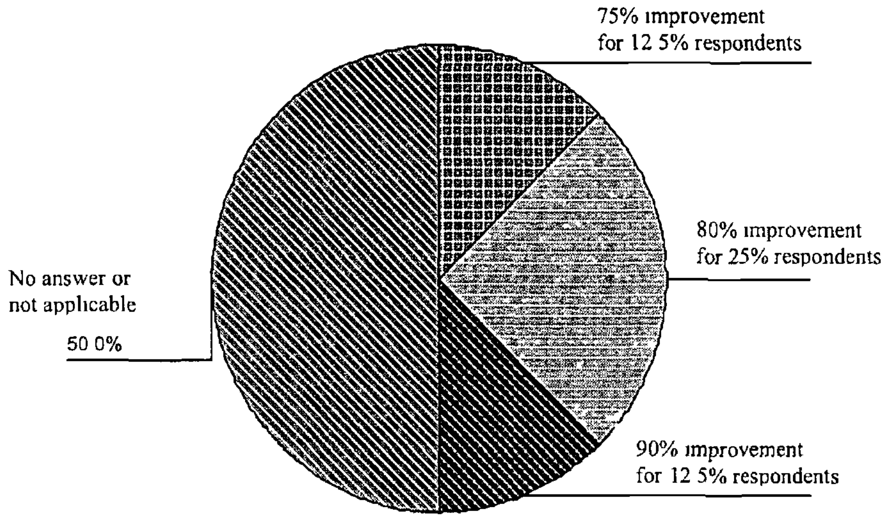

Figure 4 57 Achievement of increase product quality

- ***Reduce inventory level***

It is evident that most of companies who invested substantially in CIM technologies achieved between 75 percent and 90 percent improvements in *reduced inventory level*, especially those companies who have production volume of more than 100,000 tons per annum of human food, as can be from Figure 4 58

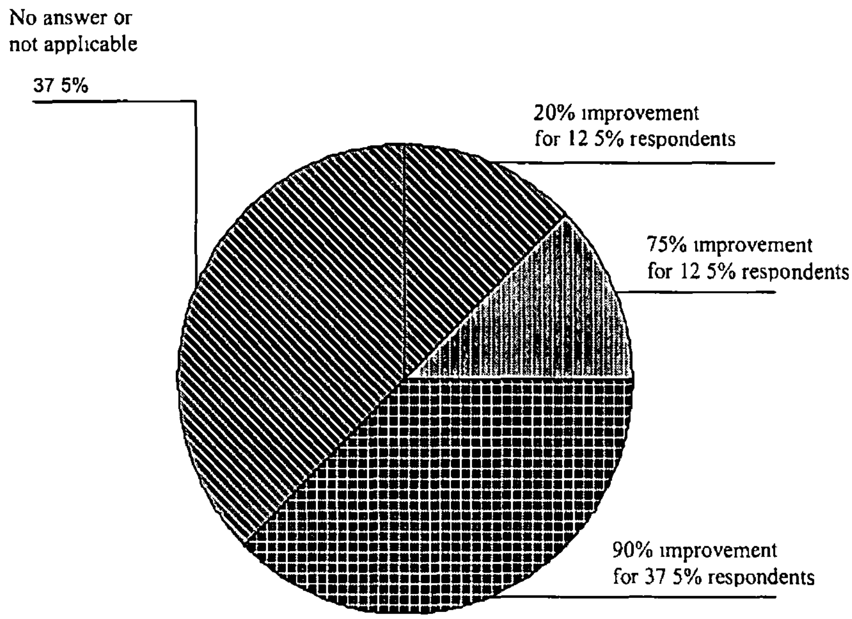

Figure 4 58 Achievement of reduce inventory level

- ***Increased production flexibility***

The results show that most of companies who invested substantially in CIM technologies achieved between 75 percent and 90 percent improvements in *increased production flexibility*, especially those companies who have production volume of more than 100,000 tons per annum of human food, see Figure 4 59

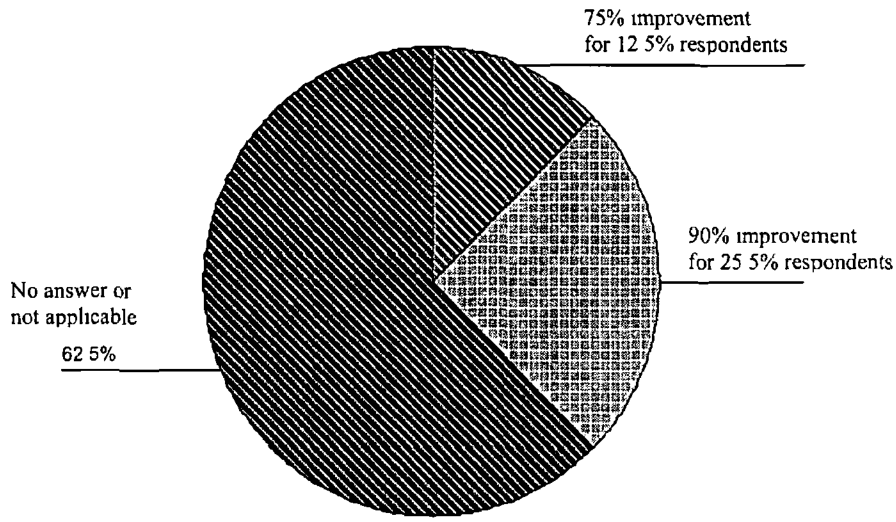

Figure 4 59 Achievement of increase production flexibility

- ***Increased calculation and planning accuracy***

The analysis shows that most of companies who invested substantially in CIM technologies achieved more than 75 percent improvements in *increased calculation and planning accuracy*, especially those companies who produce human food and food ingredient as shown in Figure 4 60

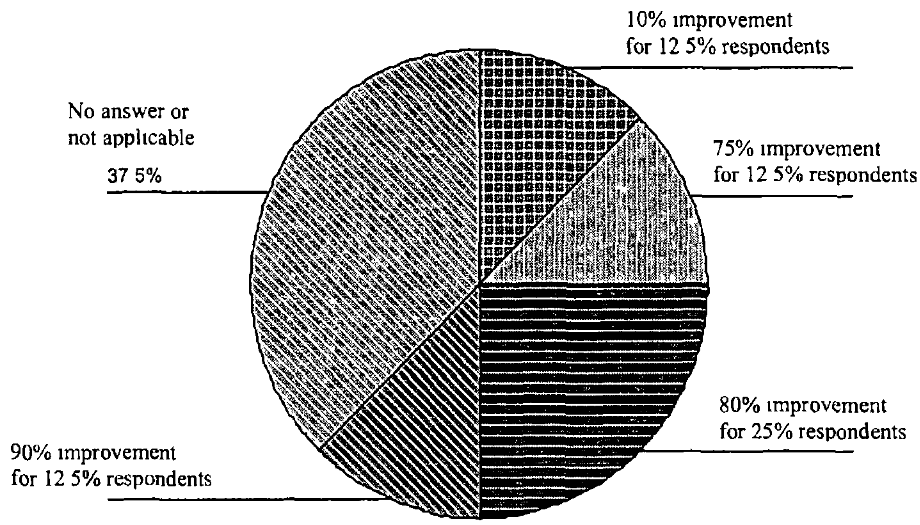

Figure 4 60 Achievement of increase calculation and planning accuracy

- ***Reduce administrative expenses***

It can be seen from the analysis that the companies who invested substantially in CIM technologies achieved between 50 percent and 80 percent improvements *in reduced administrative expenses*, especially these companies who produce human food and food ingredient (Figure 4 61)

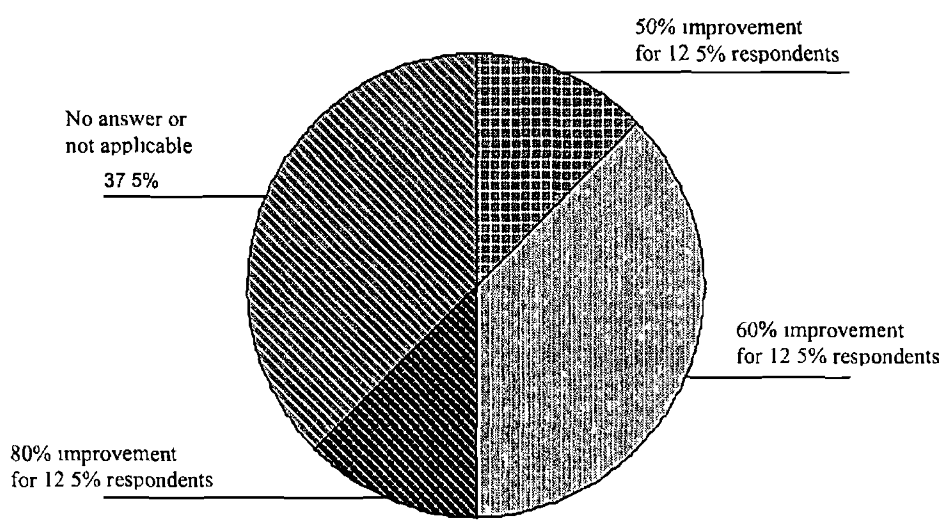

Figure 4 61 Achievement of reduce administrative expenses

4 4 5 1 2 Medium sized plants (production volume 100,000 tons per annum) with a high level of automation

This section concerns the effect of high level of automation and substantial investment in CIM technologies in the medium sized manufacturing companies in Irish food industry

- ***Reduction of the order processing time***

As can be seen from Figure 4 62 the analysis shows that 20% of Companies who invested in CIM technologies achieved about 20 percent improvement in *reduction of the order processing time*, about 20% of companies reported between 50 and 60 percent, and 10% of companies indicate that they achieved 100 percent of improvement especially those companies who produce human and ingredient food

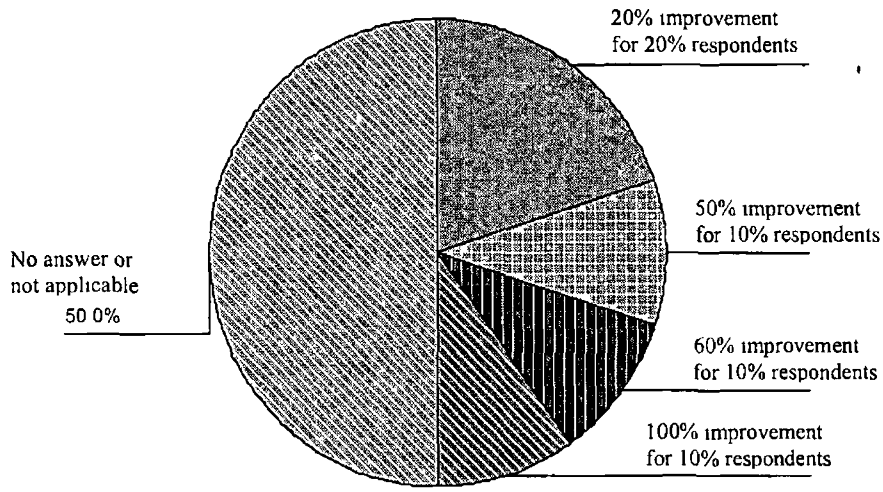

Figure 4 62 Achievement of Reduction of the order processing time

- ***Increased delivery scheduling effectiveness***

The analysis shows that 20% of Companies who invested in CIM technologies achieved between 20 percent and 50 percent improvement in *increased delivery scheduling effectiveness,* and about 30% of companies between 60 and 80 percent improvement All these companies produce human and ingredient food (see Figure 4 63)

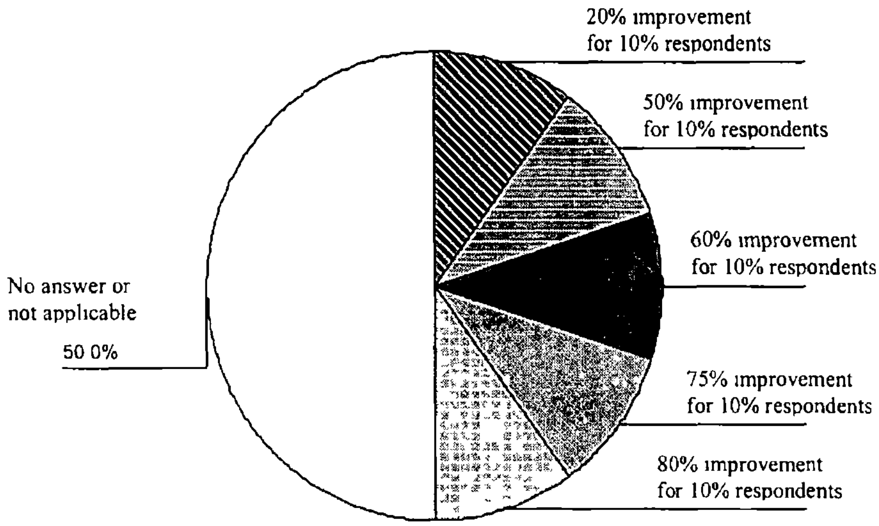

Figure 4 63 Achievement of increase delivery scheduling effectiveness

- ***Shorter delivery time***

As can be seen from Figure 4 65 according to the analysis of results 20% of Companies who invested substantially in CIM technologies achieved between 10 and 30 percent of improvements in *shorter delivery time* and about 30% of companies reported between 75 and 100 percent of improvement especially those companies who produce human and ingredient food

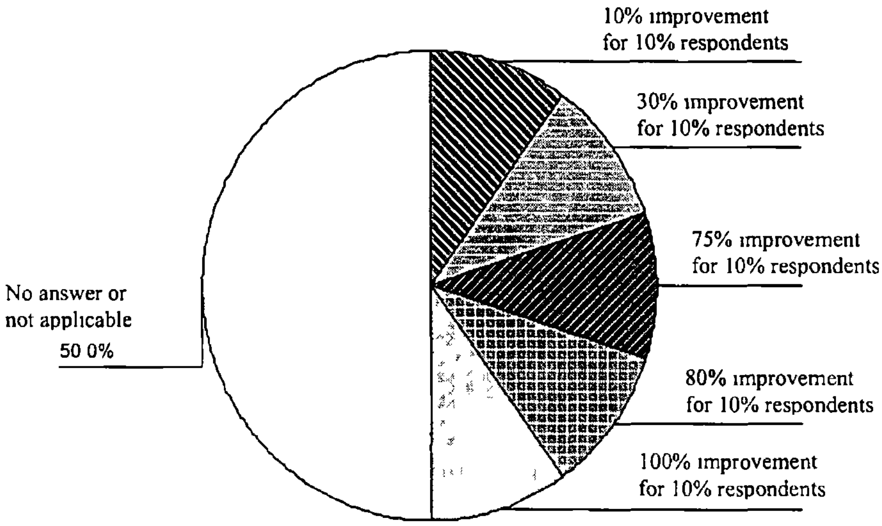

Figure 4 65 Achievement of shorter delivery time

- ***Increased procedure and information transparency***

The analysis of results shows that 20% of companies who invested in CIM technologies achieved between 10 and 40 percent improvements in *increased procedure and information transparency,* and about 30% of companies achieved between 50 and 80 percent improvement especially those companies who produce human and ingredient food (Figure 4 66)

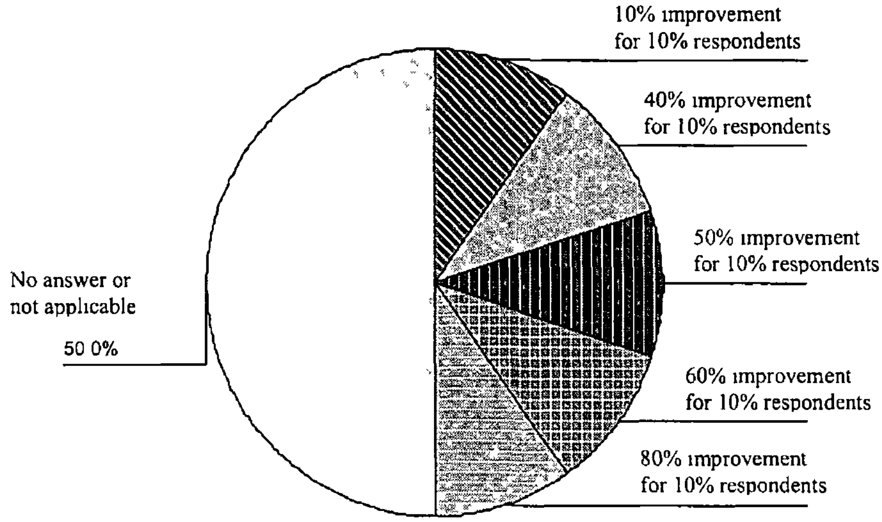

Figure 4 66 Achievement of increased procedure and information transparency

- ***Increased product quality***

The analysis of results as illustrated in Figure 4 67 shows that 10% of companies who produce human and ingredient food and who invested substantially in CIM technologies achieved 10 percent of improvement in *increased product quality* and about 30% of companies achieved between 75 and 80 percent of improvement

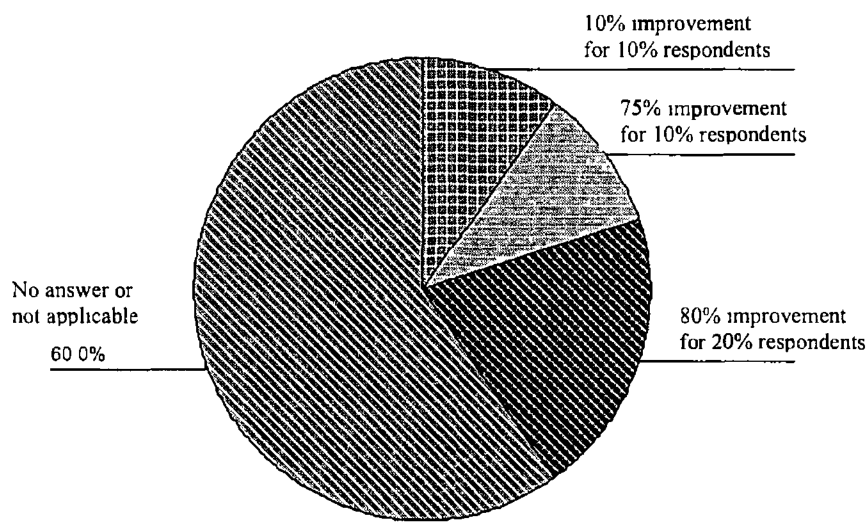

Figure 4 67 Achievement of Increase product quality

- ***Reduced ınventory level***

The analysıs of results shows that 20% of companıes who produce human food and ıngredıent food and also ınvested substantıally ın CIM technologıes achıeved 50 percent ımprovement ın *reduced ınventory level*, and about 20% of companıes achıeved between 75 and 90 percent ımprovement, (see Fıgure 4 68)

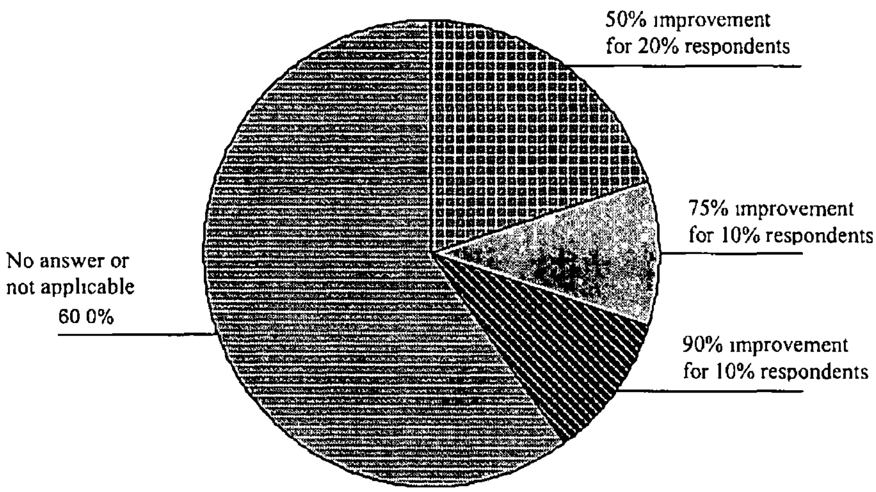

Fıgure 4 68 Achıevement of reduce ınventory level

- ***Increased productıon flexıbılıty***

As can be seen from Fıgure 4 69 the analysıs shows that 20% of companıes who ınvested substantıally m CIM technologıes achıeved between 80 percent and 90 percent ımprovements ın the *ıncreased productıon flexıbılıty*, another 20% of companıes ındıcate that they achıeved 50 percent, and 10% of companıes saıd that theır ımprovement was just 10 percent All these companıes are producıng human and ıngredıent foods

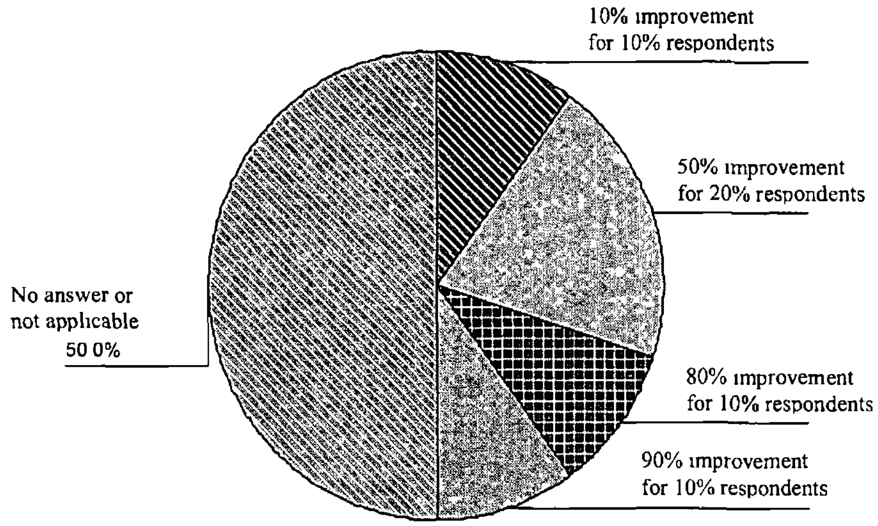

Figure 4 69 Achievement of Increase production flexibility

- ***Increased calculation and planning accuracy***

The analysis of results also shows that the companies who invested substantially in CIM technologies achieved more than 75 percent improvements in the *increased calculation and planning accuracy*, especially those companies who produce human and food ingredient (see Figure 4 70)

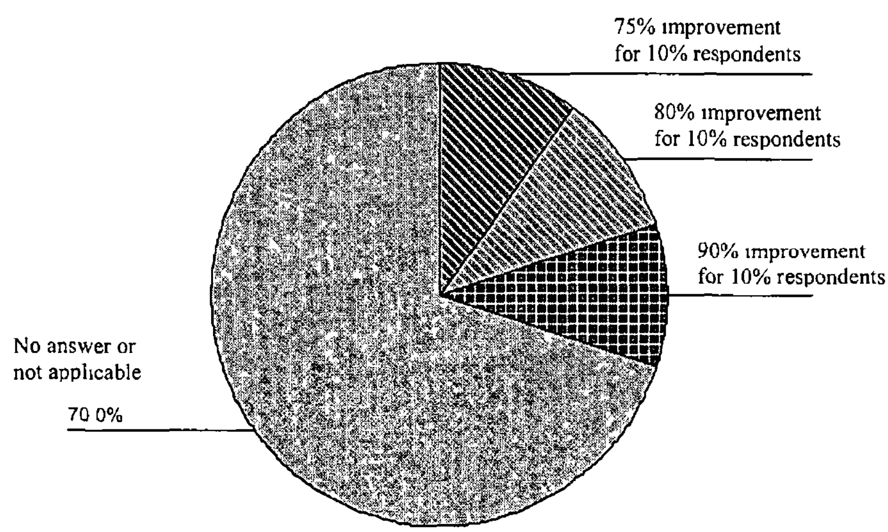

Figure 4 70 Achievement of increased calculation and planning accuracy

- ***Reduce admınıstratıve expenses***

Fıgure 4 71 shows that 10%of companıes who ınvested ın CIM technologıes and who producıng human food and food ıngredıent achıeved 96 percent ımprovements ın *reduced admınıstratıve expenses*, about 20% of companıes achıeved 50 percent, about 10% achıeved 30 percent, and 10% of companıes achıeved less than 10 percent ımprovement

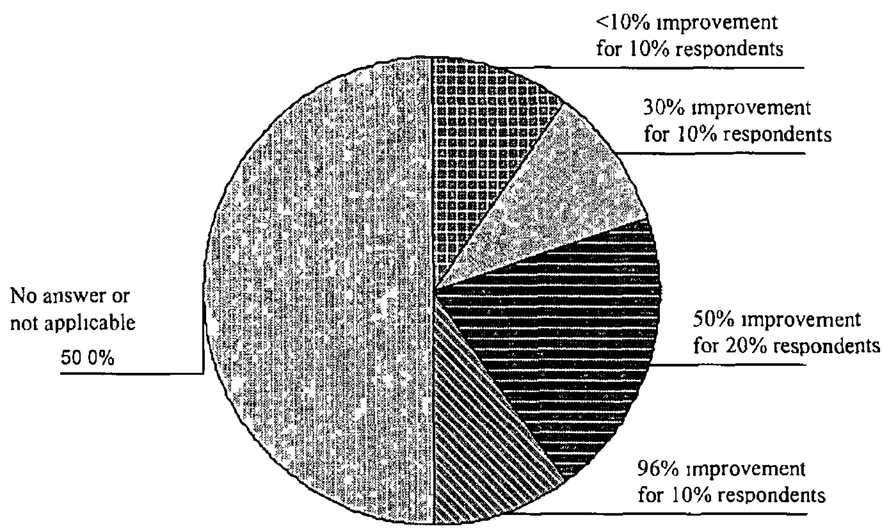

Fıgure 4 71 Achıevement of reduce admınıstratıve expenses

4 4 5 1 3 Very small plants (productıon volume <1000 tons per annum)

In thıs category (very small plants) no companıes were found to have ımplementatıon of hıgh level of automatıon It can be concluded that the companıes who produce food of volume < 1,000 tons per annum may not need to ımplement thıs level of automatıon No cases were reported wıthın thıs category

Table 4 15 gıves a summary of the fındıngs on ımproved performance obtaıned by ınference analysıs of the results

Table 4 15 Performance improvement by implementing high automation

Benefits \ Company profile	Large >100,000 tons	edium	Small <1000 tons	Human food	Animal food	Food ingredient	High automation
Reduction of the order processing time	Yes	Yes	No	Yes	No	Yes	Yes
Increased delivery scheduling effectiveness	Yes	Yes	No	Yes	No	No	Yes
Shorter delivery times	Yes	Yes	No	Yes	No	No	Yes
Increased procedure and information transparency	Yes	Yes	No	Yes	No	Yes	Yes
Increased product quality	Yes	Yes	No	Yes	No	Yes	Yes
Reduced inventory level	Yes	Yes	No	Yes	No	No	Yes
Increased production flexibility	Yes	Yes	No	Yes	No	No	Yes
Increased calculation and planning accuracy	Yes	Yes	No	Yes	No	Yes	Yes
Reduced administrative expenses	Yes	Yes	No	Yes	No	Yes	Yes

4 4 5 2 Improvements achieved by implementing medium and low level of automation

This section presents the improvement achieved through applying medium and low level of automation in all categories of plants (*large plants, medium plants and small plants*) in the Irish food industry Nine parameters were measured, which are *reduction the order processing time, increased delivery scheduling effectiveness, shorter delivery time, increased procedure and information transparency increased product quality, reduced inventory level, Increased production flexibility, Increased calculation and planning accuracy, reduced administrative expenses*

4 4 5 2 1 Large plants (>100,000 tons per annum) with medium and low automation

- *Reduction of the order processing time*

Analysis of the results shows that companies who produce human food of more than 100,000 tons per annum and their level of automation is medium or less, have achieved improvement in *reduction of the order processing time* About 9 1% of companies indicated that they achieved 20 percent improvement, and about 18 2% of companies indicated that they got improvement of between 70 percent and 90 percent, see Figure 4 72

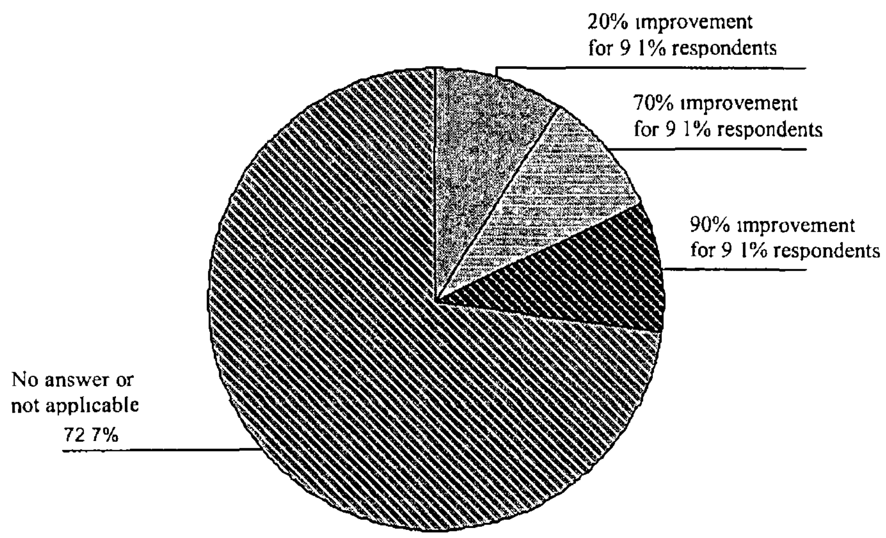

Figure 4 72 Achievement of reduction of the order processing time

* ***Increased delivery scheduling effectiveness***

Analysis of the results shows that 18 2%of companies who invested in CIM technologies and their level of automation is of medium level or less have achieved 90 percent improvements in *increased delivery scheduling effectiveness*, and about 18 2% of companies achieved only 10 percent of improvement These companies produce human food, see Figure 4 73

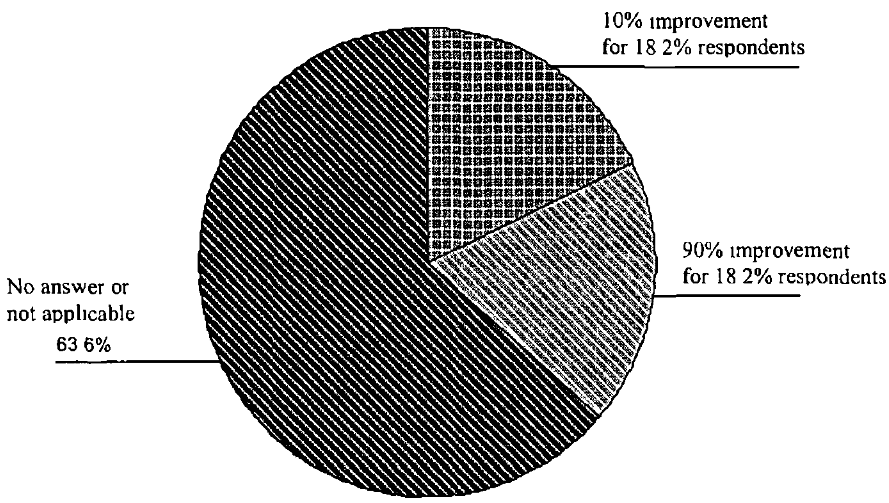

Figure 4 73 Achievement of increased delivery scheduling effectiveness

* ***Shorter delivery time***

Figure 4 74 shows that 18 2%of companies who invested in CIM technologies and their level of automation is of medium level or less have achieved between 90 percent and 100 percent improvements in *shorter delivery time*, and about 9 1% of companies achieved only 10 percent improvement These companies produce human food

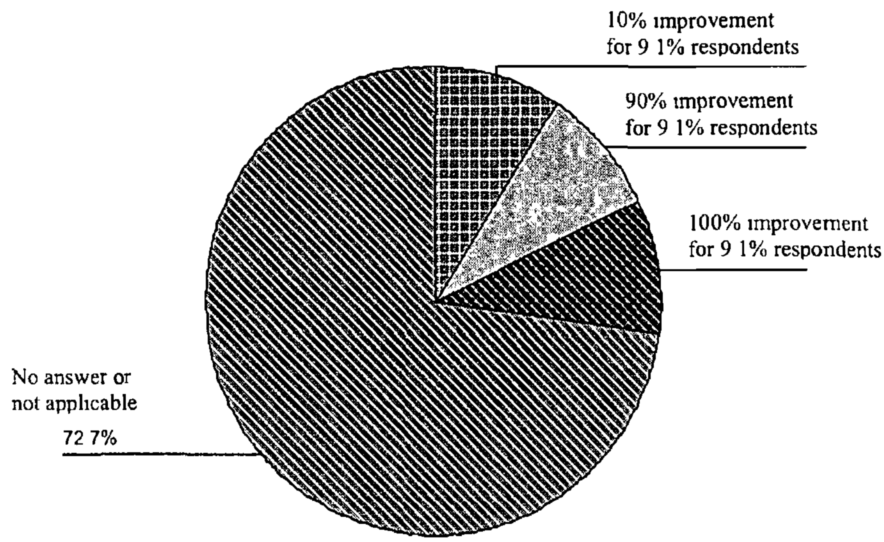

Fıgure 4 74 Achıevement of shorter delıvery tıme

- ***Increased procedure and ınformatıon transparency***

It has been also shown that companıes, who produce human food of more than 100,000 tons per annum and theır level of automatıon ıs medıum or less, have achıeved ımprovement ın *ıncreased procedure and ınformatıon transparency* About 18 2% of companıes ındıcated that they achıeved between 90 and 100 percent of ımprovement, and about 9 1% of companıes ındıcated that they achıeved 30 percent ımprovment Only 10 percent ımprovement was ındıcated by 9 1% of companıes, see Fıgure 4 75

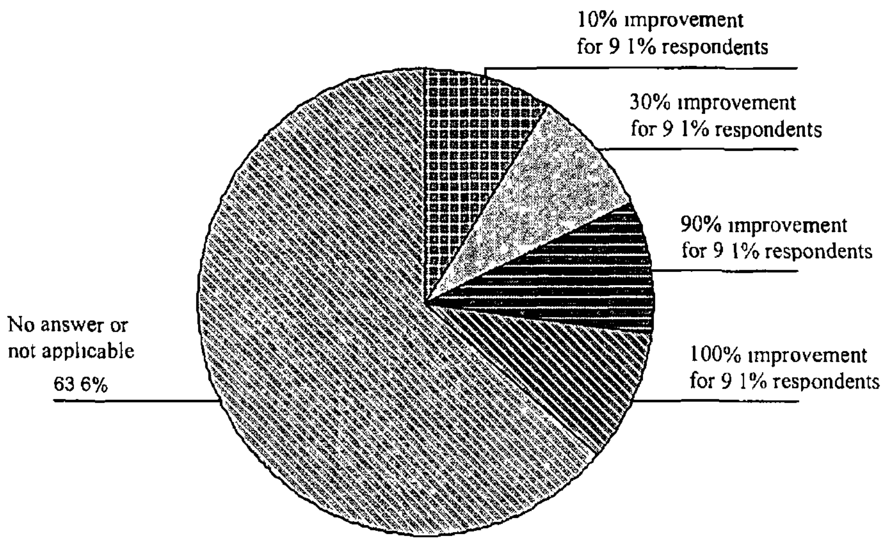

Figure 4 75 Achievement of increased procedure and information transparency

- ***Increased product quality***

As can be seen from Figure 4 76 analysis of the results shows that 9 1% of the companies who invested in CIM technologies and their level of automation is of medium level or less, have achieved 95 percent improvements in *increase product quality*, and about 9 1% of the companies achieved only 10 percent of improvement These companies are producing human food

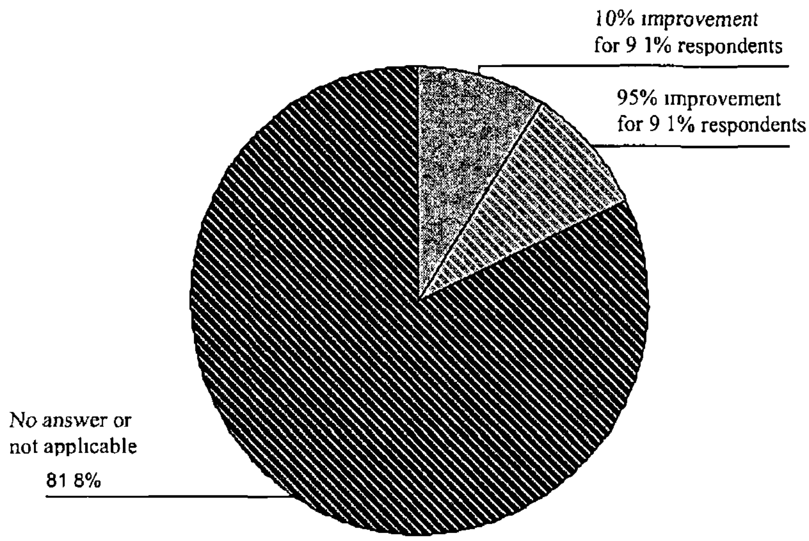

Figure 4 76 Achievement of increase product quality

- ***Reduced inventory level***

In Figure 4 77 the analysis of the results shows that 9 1%of the companies who invested in CIM technologies and their level of automation is of medium level or less, have achieved 95 percent improvements in *reduced inventory level*, and about 9 1% of companies achieved only 70 percent of improvement About 9 1% of the companies indicated that they did not achieve any improvement These companies are producing human food

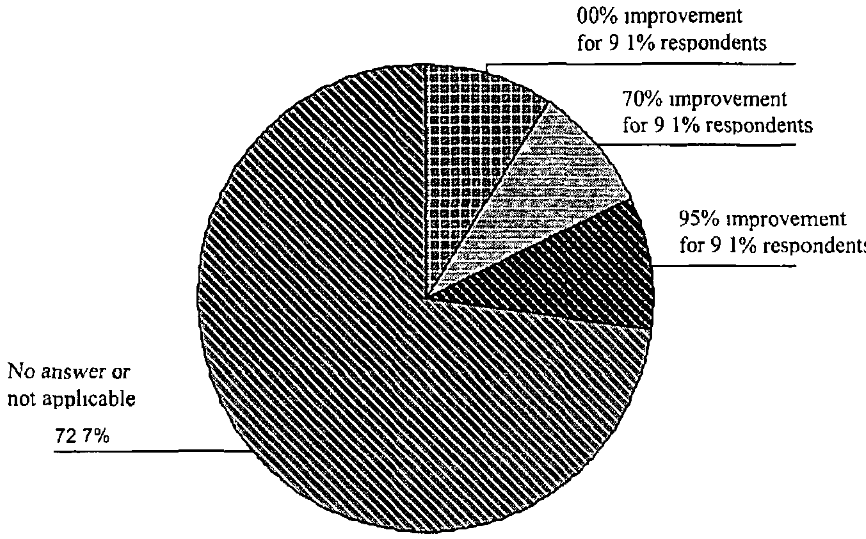

Figure 4 77 Achievement of reduce inventory level

- ***Increased production flexibility***

Analysis of the results shows that companies who produce human food of more than 100,000 tons per annum and their level of automation is medium or less, have achieved improvement in *increased production flexibility* About 18 2% of the companies indicated that they got improvement between 95 percent and 100 percent of improvement, and 9 1% of the companies indicated that they achieved 10 percent improvement, see Figure 4 78

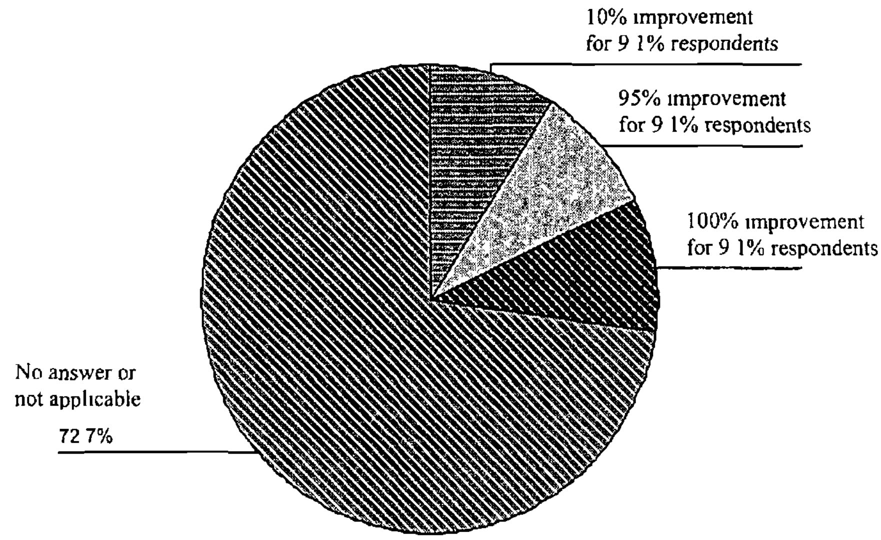

Figure 4 78 Achievement of increased production flexibility

- ***Increased calculation and planning accuracy***

It has also been shown that companies, who produce human food of more than 100,000 tons per annum and their level of automation is medium or less, have achieved improvement in *increase calculation and planning accuracy* About 18 2% of the companies indicated that they achieved 95 percent improvement, and about 9 1% of companies indicated that they achieved 30 percent improvement, see Figure 4 79

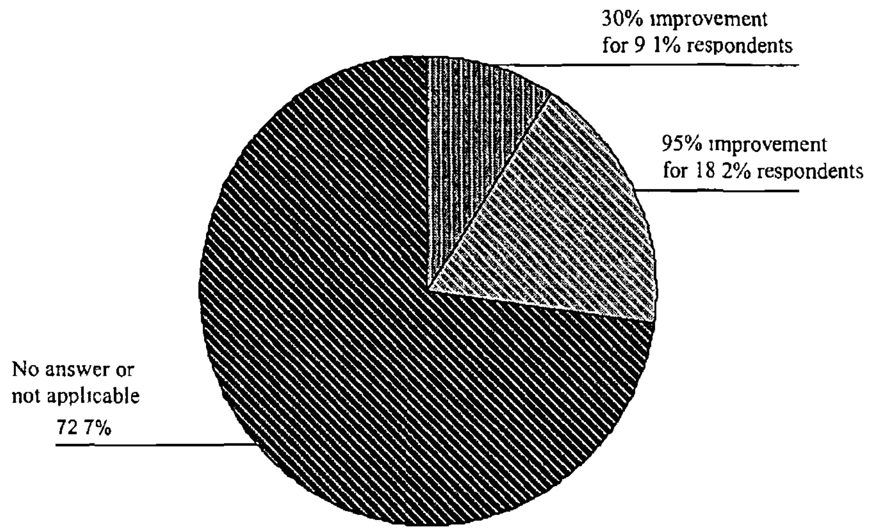

Fıgure 4 79 Achıevement of ıncrease calculatıon and plannıng accuracy

- ***Reduce admınıstratıve expenses***

Analysıs of the results presented ın Fıgure 4 80 shows that 9 1% of the companıes who ınvested ın CIM technologıes and theır level of automatıon ıs medıum level or less, have achıeved 95 percent ımprovements ın *reduced admınıstratıve expenses*, and about 9 1% of the companıes achıeved only 10 percent ımprovement These companıes are producıng human food

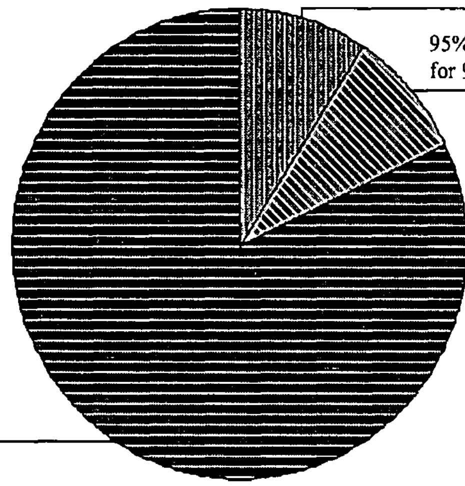

Fıgure 4 80 Achıevement of reduce admınıstratıve expenses

4 4 5 2 2 Medıum plants (volume productıon 1,000 – 100,000 tons per annum) wıth medıum and low level of automatıon

- *Reductıon of the order processıng tıme*

Analysıs of the results presented ın thıs Fıgure 4 81 shows that companıes who produce human food and anımal food of product volume 1000 - 100,000 tons per annum and theır level of automatıon ıs medıum or less, have achıeved ımprovement ın *Reductıon of the order processıng tıme* About 12% of the companıes ındıcated that they achıeved between 60 percent and 100 percent ımprovement, and 4% of the companıes ındıcated that they dıd not achıeve any ımprovement

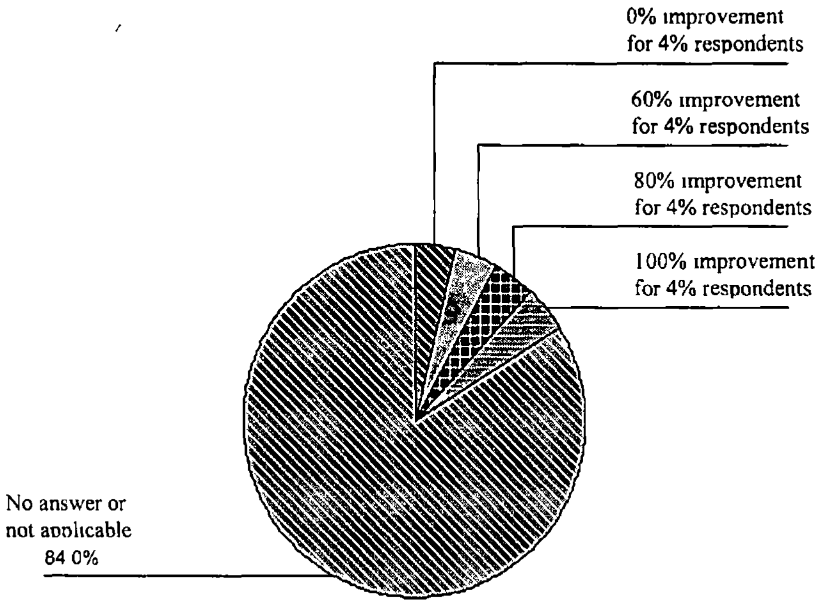

Figure 4 81 Achievement of reduction of the order processing time

- ***Increased delivery scheduling effectiveness***

Analysis of the results shows that 4% of the companies who invested in CIM technologies, and their level of automation is a medium level or less, and who produce human and animal food of volume 1000 - 100,000 tons per annum have achieved 100 percent improvements in the *increased delivery scheduling effectiveness*, and about 8% of companies achieved about 80 percent of improvement About 4% of the companies achieved only 20 percent improvement, see Figure 4 82

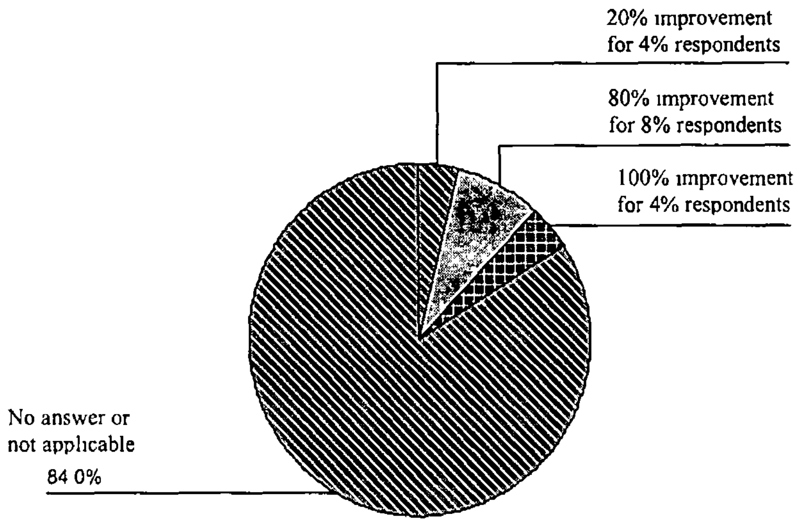

Figure 4 82 Achievement of increased delivery scheduling effectiveness

- ***Shorter delivery time***

It has also been shown that companies, who produce human and animal food of volume 1000 - 100,000 tons per annum and their level of automation is medium or less, have achieved improvement in *shorter delivery time* About 8% of the companies indicated that they achieved between 80 and 100 percent improvement, and about 4% of the companies indicated that they did not achieve any improvement, see Figure 4 83

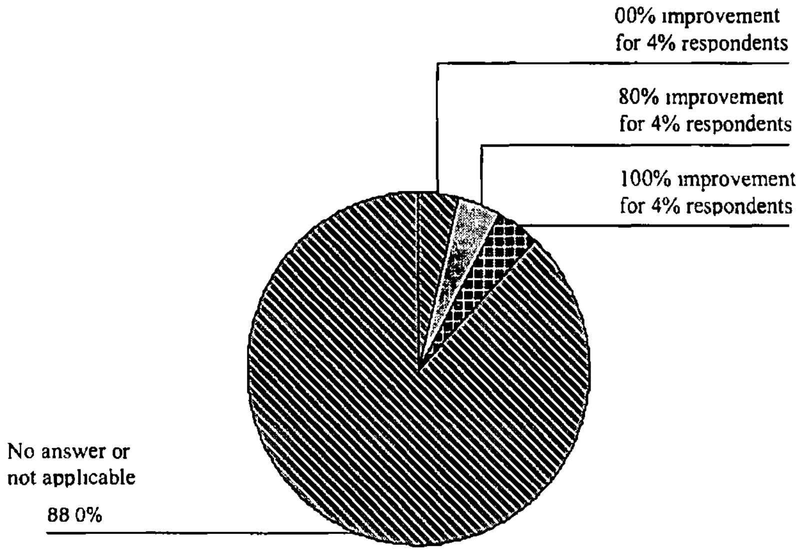

Figure 4 83 Achievement of shorter delivery time

- ***Increased procedure and information transparency***

As can be seen in Figure 4 84 analysis of the results shows that 12% of the companies who invested in CIM technologies and their level of automation is at medium level or less, have achieved between 90 - 100 percent improvements in *increase procedure and information transparency*, and about 12% of the companies achieved between 50 - 70 percent improvement These companies are producing human and animal food of volume 1000 - 100,000 tons per annum

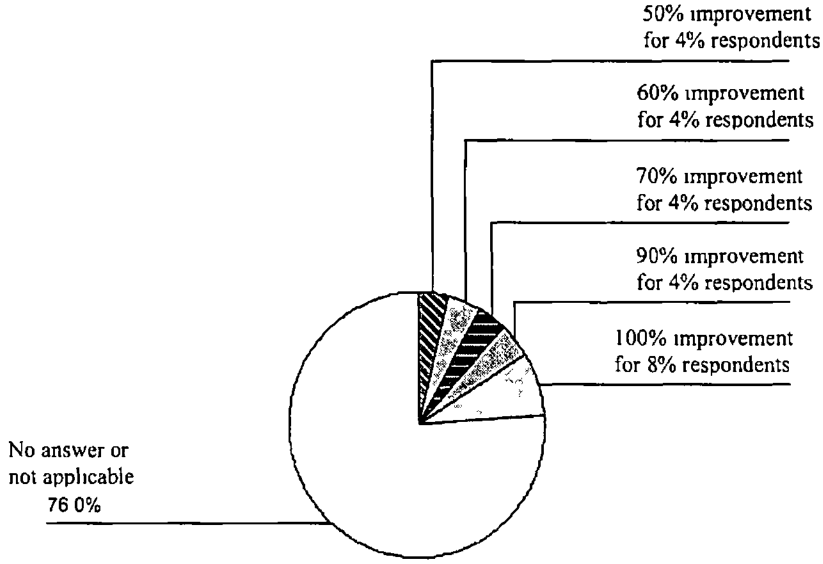

Fıgure 4 84 Achıevement of ıncrease procedure and ınformatıon transparency

- ***Increased product qualıty***

Analysıs of the results shows that companıes who produce human food and anımal food of volume 1000 - 100,000 tons per annum and theır level of automatıon ıs medıum or less, have achıeved ımprovement ın *ıncreased product qualıty* About 12% of companıes ındıcated that they achıeved ımprovement of between 75 percent and 100 percent ımprovement, and 8% of the companıes ındıcated that they achıeved between 30 – 50 percent ımprovement, see Fıgure 4 85

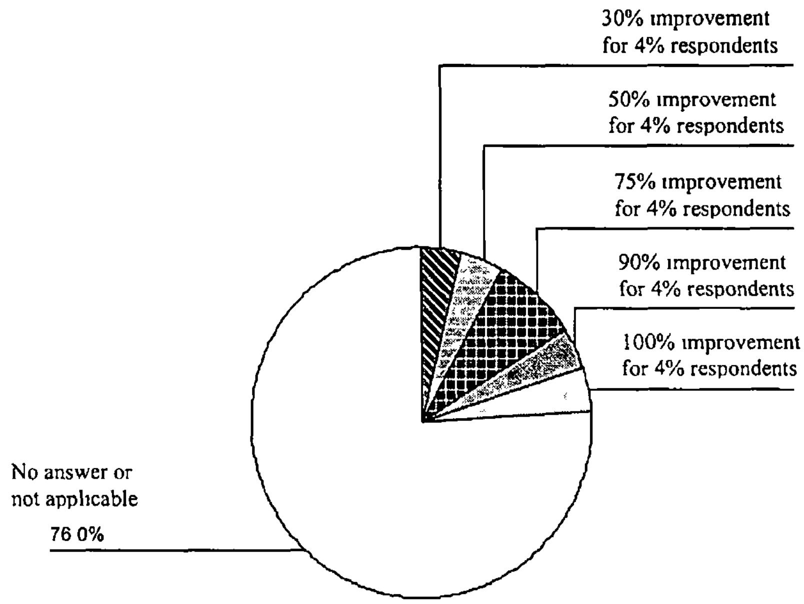

Figure 4 85 Achievement of increased product quality

- ***Reduced inventory level***

Figure 4 86 shows that companies who produce human and animal food of volume 1000 - 100,000 tons per annum and their level of automation is medium or less, have achieved improvement in *reduced inventory level* About 12% of companies indicated that they achieved improvement between 90 percent and 100 percent improvement, and 4% of companies indicated that they did not achieve any improvement

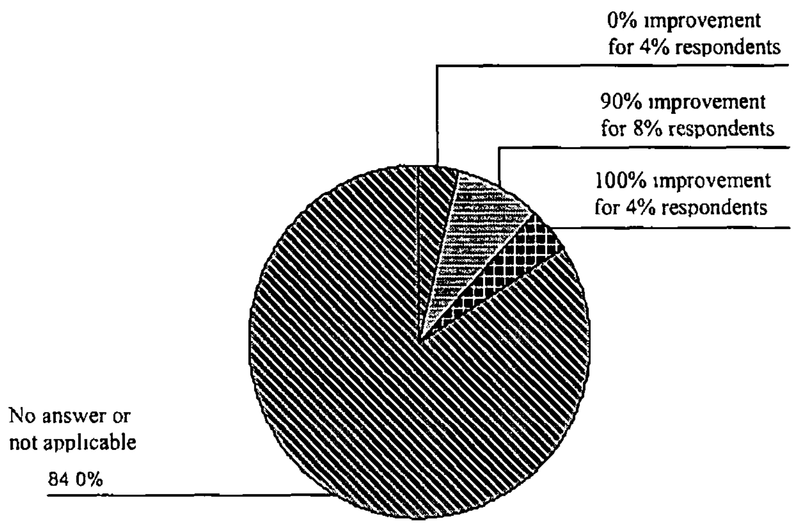

Figure 4 86 Achievement of reduced inventory level

- ***Increased production flexibility***

It has also been shown that companies, who produce human and animal food of volume 1000 - 100,000 tons per annum and their level of automation is medium or less, have achieved improvement in *increased production flexibility* About 4% of the companies indicated that they achieved 100 percent improvement, and 8% of the companies achieved 90 percent improvement About 60 percent improvement indicated by 4% of the companies and 4% of companies said that they did not achieve any improvement, see Figure 4 87

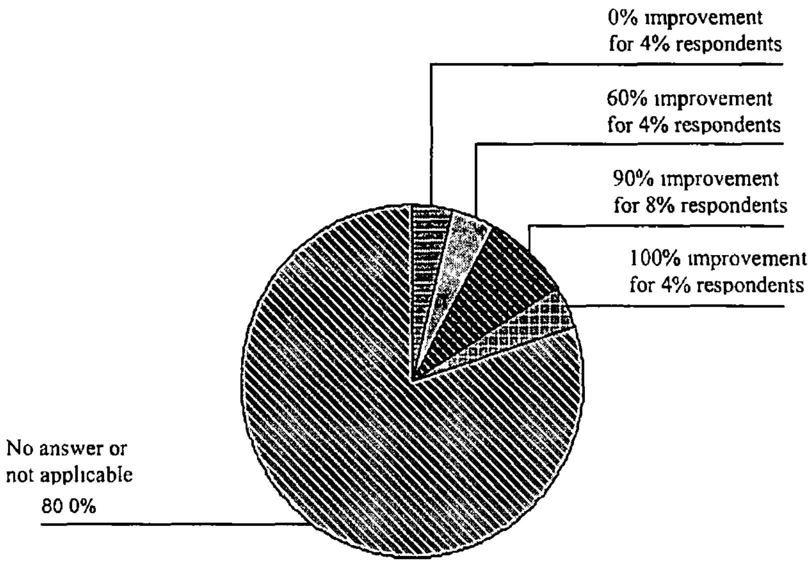

Figure 4 87 Achievement of increased production flexibility

- ***Increased calculation and planning accuracy***

It can be seen from the results presented in Figure 4 88 that companies who produce human and animal food of volume 1000 - 100,000 tons per annum and their level of automation is medium or less, have reported more than 50 percent improvement in *increased calculation and planning accuracy*

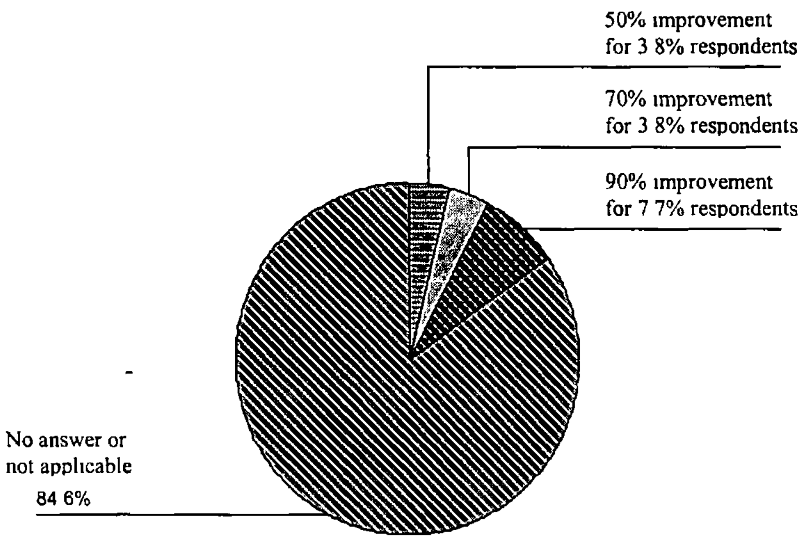

Fıgure 4 88 Achıevement of ıncreased calculatıon and plannıng accuracy

- ***Reduced admınıstratıve expenses***

Analysıs of the results shows that companıes who produce human food and anımal food of volume 1000 - 100,000 tons per annum and theır level of automatıon medıum or less, have achıeved ımprovement ın *reduced admınıstratıve expenses* About 7 6% of companıes ındıcated that they achıeved ımprovement of between 90 percent and 100 percent About 3 8% of companıes ındıcated that they achıeve 70 percent ımprovement, Also 3 8% of the companıes ındıcated that they achıeved 50 percent ımprovement, and 3 8% of companıes ındıcated that they dıd not achıeve any ımprovement, see Fıgure 4 89

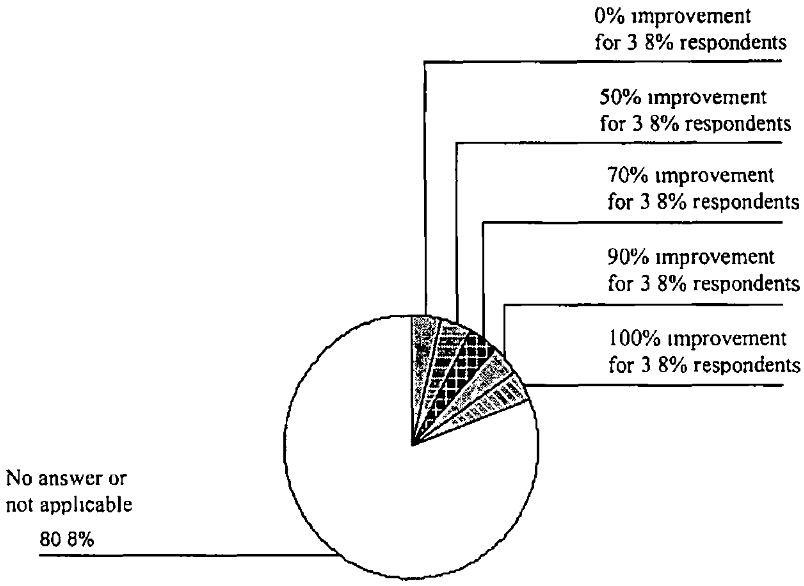

Fıgure 4 89 Achıevement of reduced admınıstratıve expenses

4 4 5 2 3 Small plants (productıon volume <1000 tons per annum) wıth medıum and low automatıon

In thıs category, however there are some companıes who ındıcated that they ımplemented medıum level of automatıon, but they dıd not report any sıgnıficant ımprovement ın the parameters related to theır busıness As for *Reductıon of the order processıng tıme, Shorter delıvery tıme Increased product qualıty, Increased productıon flexıbılıty, and Increased calculatıon and plannıng accuracy* they dıd not report any ımprovement Just 4 5% of companıes of thıs category ındıcated that they achıeved 75 percent ımprovement ın *ıncreased delıvery schedulıng effectıveness,* these companıes produce food ıngredıents About 4 5% of the companıes report 85 percent ımprovement ın *ıncreased procedure and ınformatıon transparency* Also these companıes produce food ıngredıents About 4 5% of the companıes who also produce food ıngredıents ındıcated that they achıeved 65 percent ın *reduced ınventory level* And about 4 5 saıd that they achıeved 90 percent ımprovement ın *reduced admınıstratıve expenses* Thıs observatıon can be consıdered as an ındıcator, that the small plants ın food ındustry can operate wıth low level of automatıon and avoıd the cost ınvolved wıth the ımplementatıon of medıum or hıgh level of automatıon

Table 4 15 Performance improvement by implementing medium/low automation

Company profile / Benefits	Large >100,000 tons	Medium 100,000 tons	Small <1000 tons	Human food	Food ingredient	Medium/low automation
Reduction of the order processing time	Yes	Yes	No	Yes	No	Yes
Increased delivery scheduling effectiveness	Yes	Yes	Yes	Yes	Yes ★	Yes
Shorter delivery times	Yes	Yes	No	Yes	No	Yes
Increased procedure and information transparency	Yes	Yes	Yes	Yes	Yes ★	Yes
Increased product quality	Yes	Yes	No	Yes	Yes ★	Yes
Reduced inventory level	Yes	Yes	Yes	Yes	No	Yes
Increased production flexibility	Yes	Yes	No	Yes	No	Yes
Increased calculation and planning accuracy	Yes	Yes	No	Yes	No	Yes
Reduced administrative expenses	Yes	Yes	Yes	Yes	Yes ★	Yes

★ *The companies who produce food ingredients belong to small plants category*

4 4 5 3 Obstacles to CIM implementation

As mentioned in Section 4 9 4 the three main obstacles for small/medium plants are cost, nature of business and technical skills, and the inference analysis indicate that the obstacles facing companies who produce human food, animal food and food ingredient For large companies the analysis shows that main two obstacles are cost, and nature of business The analysis also indicates that these companies are producing human food and food ingredient

4 5 Final comments

Based on the survey results, the outcomes can be summarised as follows

- The Irish food manufacturing can be classified into three categories
    - Animal food manufacturing (3 9%)
    - Ingredients food Manufacturing (20 8%)
    - Human food manufacturing (75 3%)

- The use of automation in the Irish food industry has been applied mostly in the processing/filling/wrapping operations (72% of companies), and in the packaging operation (35 1% of companies) It appears that there is a need to increase the automation in other areas of plants like raw material receiving and inspection, raw material pre-processing, and storage operation in order to enhance the productivity and the quality of the products

- The survey reflects that many of the CIM technologies have a low level of usage within the food manufacturers (see Figure 4 63) On the other hand, the questionnaire results have brought a promising trend of increasing the level of implementing CIM technologies in the near future The manufacturers showed more interest in applying the CIM technologies related to the production and operations management such as Production Ordering technique (PO) In fact, the administration of most of food manufacturers has considered the implementation of CIM technologies related to design and quality as a costly process
- Analysis of the results shows that companies who implemented medium or high level of automation specially large and medium companies have achieved

improvement in parameters (Reduction *of the order processing time, Shorter delivery time, Increase product quality, Increase production flexibility, Increased calculation and planning accuracy, increased delivery scheduling effectiveness, increase procedure and information transparency, reduce inventory level, and reduce administrative expenses*) which are related to productivity and profitability In other words the companies who achieved improvement in these parameters should increase their productivity, profitability and decrease the product cost Therefore in this study because the questionnaire did not include questions seeking information about productivity and profitability, the improvement achieved in the above parameters may be considered as the indicators that the companies who achieved improvement in these parameters would increase there productivity, profitability and decrease there product cost

- The analysis of the results illustrated that the large plants (volume production > 100,000 tons per annum) and medium plants (volume production 100 000 tons per annum) have achieved more improvement in the parameters (Reduction *of the order processing time Shorter delivery time, Increase product quality, Increase production flexibility, Increased calculation and planning accuracy, increased delivery scheduling effectiveness, increase procedure and information transparency reduce inventory level, and reduce administrative expenses*) by implementing high level of automation than medium level of automation

- The small plants in Irish food industry are operating with low automation to avoid cost involved in the implementation of automation

- The survey shows that the cost of implementing CIM (60 4%), nature of business (46 6%), and staff technical skills (34 5%) are the main obstacles towards applying automation as well as CIM technologies in small companies

Chapter 5

Conclusions and suggestion for future work

1 Conclusıons

Thıs study has demonstrated the current sıtuatıon wıth automatıon and ımplementatıon of CIM technologıes ın the Irısh food ındustry Thıs research has used two methods

- Postal tradıtıonal survey
- Web-based survey

The followıng conclusıons can be drawn

The response from the ındustry was more posıtıve ın postal survey than web-based survey However the web-based survey ıs less tıme and cost

The Irısh food manufacturıng can be classıfied ınto three groups

- Human food manufacturıng
- Ingredıents food manufacturıng
- Anımal food manufacturıng

The level of automatıon wıthın the food ındustry ıs extremely varıable Manufacturıng plants wıth hıgher productıon volumes (large plants) are generally hıghly automated and are motıvated for future development Whıle, manufacturıng plants wıth small productıon volumes (small plants) have less potentıal towards automatıon

The current automatıon applıcatıon ın the Irısh food ındustry does not depend on the computer technologıes only rather than usıng the sımple and straıghtforward automatıon applıcatıon such as conveyors, motors and cylınders

The survey results showed that, lower productıon, cost, ıs the most ımportant factor to motıvate manufacturers ınto ımplementıng new/hıgher technology such as mıcroprocessor/computer-based technology

The successful ımplementatıon of communıcatıon networks (e g LAN) ın Irısh food ındustry boosts the plans of applyıng modern technology such as CIM

However, the current level of implementation of CIM technologies in Irish food industry is still low, the expectations indicate that use of CIM technologies will increase in the Irish food industry

The CIM technologies (CAD, CAM, CAE, CAP, and CAQ) are not attractive to the manufacturers to implement in the near future However, the other technologies such as, PPC, PPP, VP, CPS, PO, and POM that are related to the production phase are likely to be used in the food industry business That comes from the fact that these activities and technologies are easier to be implemented in the factory floor

The nature of business and the cost are considered to be the main obstacles to implement new automation technologies such as microprocessor/computer-based technology or computer integrated manufacturing (CIM)

2 Recommendations for future research work

Based on the research results, some recommendations for further work are listed below

1 To conduct real case studies to assess how CIM has been used in selected food industries
2 To develop a guideline that allows companies to choose the most appropriate automation level to be implemented to justify the implementation cost
3 To develop publicity/information software that shows the importance of the use of Computer Integrating Manufacturing in food industries
4 To compare the use of CIM in advanced manufacturing countries and developing countries to determine the most appropriate approach to implement successful CIM in food industries

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APPENDIXES

Appendix A

Survey Questionnaire on Automation and Computer Integrated Manufacturing (CIM) in Irish Food Industry

As part of research project the School of Mechanical and Manufacturing Engineering of Dublin City University is attempting to assess the level of Automation and Computer Integrated Manufacturing in Food Processing Industry To assist us with this project we are requesting you to complete this questionnaire

Please answer all questions

This questionnaire is divided into 3 sections

Section A General Information

Section B Level of Automation

Section C application of computer integrated manufacturing (CIM)

A General information

Your name ______________________________

Company address ______________________________

____

Email address ______________________________

1 What kind of food is produced by your company (check one)?

- ❑ 1 Infant formula
- ❑ 2 Human food, other than (1)
- ❑ 3 Animal food
- ❑ 4 Food ingredients
- ❑ 5 Others (specify) ______________________________

2 What is the approximate amount of product(s) produced per year (check one)?

- < 1,000 tons
- 1,000 – 100,000 tons
- >100,000 – 1,000,000 tons
- > 1,000,000 tons

3 How many years has your company been in business (check one)?

- Less than 10 years
- 10-20 years
- 21-30 years
- 31-50 years
- More than 50 years

4 What the number of employees that your company employs (check one)?

- Less than 25
- 25 to 50
- 51 to 100
- 101 to 200
- 200+

B Level of automation

5 What is the level of automation at your plant (check one)?

- No automation
- Sparsely automated
- Somewhat automated
- Mostly automated
- Fully automated

6 What level of automation do you envisage at your plant within the next 5 years (check one)?

- No automation
- Sparsely automated
- Somewhat automated
- Mostly automated
- Fully automated

7 Approximately what level of your operation is automated using microprocessor/computer-based control systems (check one)?

- ☐ None
- ☐ Very small number of operations
- ☐ Some operations
- ☐ Most operations
- ☐ All operations

8 Please indicate the automated areas (check all that apply)

- ☐ Raw material receiving and inspection
- ☐ Raw material preprocessing
- ☐ Processing/ filling / wrapping
- ☐ Post process handling and inspection
- ☐ Packaging
- ☐ Warehousing and storage

9 Please rank the obstacles for implementation of microprocessor-based control systems on the scale of 1 to 5 (1 – not an obstacle, 5 – major obstacle)

10 1 Time 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐

10 2 Cost 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐

10 3 Technical skills of support staff 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐

10 4 Management commitment 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐

10 5the nature of business not suitable for automation

1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐

If some of the obstacles are not listed above please specify and rank them below

10 6 Other (specify) ____________________

1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐

10 What is the motivation to implement microprocessor/computer-based control technology at your location (check all that apply)?

- ☐ Access to process information
- ☐ Lower production cost
- ☐ Improved personnel safety
- ☐ Improved product safety
- ☐ Better quality
- ☐ Obsolescence of older technology

If some of the reasons are not listed above please specify them below

- ☐ Other (specify) ____________________
- ☐ Other (specify) ____________________

C application of computer integrated manufacturing (CIM)

11 Please indicate whether you are currently using, plan to use (within five years), or has no plan to use the following advanced technologies in your plant

TECHNOLOGIES	In Use	Plan to Use	No Plans
a) Computer-Aided Design (CAD)	☐	☐	☐
b) Computer-Aided Engineering (CAE)	☐	☐	☐
c) Computer-Aided manufacturing (CAM)	☐	☐	☐
d) Computer-Aided quality (CAQ)	☐	☐	☐
e) Computer-Aided planning (CAP)	☐	☐	☐

F) production planning and control (PPC)	☐	☐	☐
i) production program planning (PPP)	☐	☐	☐
ii) Volume planning (VP)	☐	☐	☐
iii) capacity planning and scheduling (CPS)	☐	☐	☐
v) production ordering (PO)	☐	☐	☐
vi) production ordering monitoring (POM)	☐	☐	☐

12 What kind of communication networks do you employ in your plant (check all that apply)?

- ☐ Local Area Network LAN
- ☐ Wide Area Network WAN
- ☐ Wireless Local Area Network WLAN
- ☐ Wireless Wide Area Network WWAN

13 The objectives of the computer integrated manufacturing investment and actual goal achievement (please indicate)

Objectives	Percentage of achievement (0 – 100)
Reduction of the order processing time	( )
Increased delivery scheduling effectiveness	( )
Shorter delivery times	( )
Increased procedure and information transparency	( )

Increased product quality	( )
Reduced inventory level	( )
Increased production flexibility	( )
Increased calculation and planning accuracy	( )
Reduced administrative expenses	( )

If some of objectives are not listed above please specify and indicate the percentage of achievement below

	( )
	( )
	( )

14 Obstacles to Adoption of computer integrated manufacturing(CIM)

Please rank the obstacles for implementation of CIM technology on the scale of 1 to 5 (1 – not an obstacle, 5 – major obstacle)

15 1 Time 1 □ 2 □ 3 □ 4 □ 5 □

15 2 Cost 1 □ 2 □ 3 □ 4 □ 5 □

15 3 Technical skills of support staff 1 □ 2 □ 3 □ 4 □ 5 □

15 4 Management commitment 1 □ 2 □ 3 □ 4 □ 5 □

15 5 nature of business 1 □ 2 □ 3 □ 4 □ 5 □

If some of the obstacles are not listed above please specify and rank them below

15 6 Other (specify) ______________________________

1 □ 2 □ 3 □ 4 □ 5 □

Appendix B

Source Code

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</CENTER></H1>

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<INPUT TYPE="hidden" NAME="your_name" VALUE="Ayed">

<INPUT TYPE="hidden" NAME="email_subject_line" VALUE="questionnaire">

<INPUT TYPE="hidden" NAME="required_fields" VALUE="your_email_address">

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questions">
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food industry survey</B></FONT></TD></TR></TBODY></TABLE></CENTER>

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School of Mechanical and Manufacturing Engineering of Dublin City University is
attempting to assess the level of Automation and Computer Integrated Manufacturing in
Food Processing Industry  To assist us with this project we are requesting you to complete
this questionnaire </b></center></marquee></font>
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one)</FONT></TD></TR></TBODY></TABLE></P>
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the
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one)</FONT></TD>
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1,000,000 tons
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your company has been in business</B> (check
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number of
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employees that your company employs ?</B> (check
one)</FONT></TD></TR></TBODY></TABLE></P>
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the level
of automation at your plant?</B> (check
one)</FONT></TD></TR></TBODY></TABLE></P>
<DD><INPUT name=q2d3 type=radio value=No automation> No automation
<DD><INPUT name=q2d3 type=radio value=Sparsely automated> Sparsely automated
<DD><INPUT name=q2d3 type=radio value=Somewhat automated> Somewhat
automated
<DD><INPUT name=q2d3 type=radio value=Mostly automated> Mostly automated
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level of
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automation do you envisage at your plant within the next 5 years ?</B> (check
one)</FONT>
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<DD><INPUT name=q2d4 type=radio value=No automation> No automation
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<DD><INPUT name=q2d4 type=radio value=Somewhat automated> Somewhat
automated
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1><B>Approximately what
 level of your operation is automated using microprocessor/computer-based control
systems?
</B> (check one)</FONT></TD></TR></TBODY></TABLE></P>
<DD><INPUT name=q2d5 type=radio value=None> None
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small number of operations
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<DD><INPUT name=q2d5 type=radio value=Most operations> Most operations
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  <TD align=left><FONT color=#0000bb face="arial, helvetica" size=-1><B>Please
indicate
     the automated areas</B> (check all that
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Raw material receiving and inspecton
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material preprocessing
<DD><INPUT name=q2d6 type=checkbox value=Processing/Filling/Wrapping>
Processing/Fillmg/Wrapping
<DD><INPUT name=q2d6 type=checkbox value=post processing handling and
inspecton> post
processing handling and inspecton
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control systems on the scale of 1 to 5 (1 – not an obstacle, 5 – major obstacle)</B>
(check one)</FONT></TD></TR></TBODY></TABLE></P>

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<DD><TR>
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staff
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commetment</FONT></TD>
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<DD><TR>
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business</FONT></TD>
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3<TD align=middle><INPUT name=q8e1 type=radio value=3></TD>
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them
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the
motivation to implement microprocessor/computer-based control technology at your
location</B>
(check all that apply)</FONT></TD></TR></TBODY></TABLE></P>
<DD><INPUT name=q2da type=checkbox value=Access to process information> Access
to process information
<DD><INPUT name=q2da type=checkbox value=Lower production cost> Lower
production cost
<DD><INPUT name=q2da type=checkbox value=Improved personnel safety> Improved
personnel safety
<DD><INPUT name=q2da type=checkbox value=improved product safety> Improved
product safety
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<DD><INPUT name=q2da type=checkbox value=Obsolescence of older technology>
Obsolescence of older technology
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  <TD align=left><FONT color=#0000bb face="arial, helvetica"
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five years), or has no plan to use the following advanced technologies in your plant
</B></FONT></TD></TR></TBODY></TABLE></P>
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  <TD align=middle width="15%"><FONT face="arial, helvetica"
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  <TD align=middle width="15%"><FONT face="arial, helvetica" size=-1><B>No
plans</B>
  </FONT></TD></TR>
 <TR>
  <TD><FONT face="arial, helvetica" size=-1><B>a </B> Computer-Aided Design
(CAD)</FONT></TD>
  <TD align=middle><INPUT name=q8a type=radio value=in use></TD>
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Engineering (CAE)</FONT></TD>
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manufacturing (CAM)</FONT></TD>
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(CAQ)</FONT></TD>
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(CAP)</FONT></TD>
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control (PPC)</FONT></TD>
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planning <DD> (PPP)</FONT></TD>
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(PO)</FONT></TD>
  <TD alıgn=mıddle><INPUT name=q8f4 type=radıo value=m use></TD>
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communication networks do you employ in your plant?</B>
(check all that apply)</FONT></TD></TR></TBODY></TABLE></P>
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Network (LAN)
<DD><INPUT name=num type=checkbox value=Wide Area Network> Wide Area
Network (WAN)
<DD><INPUT name=num type=checkbox value=Wireless Local Area Network LAN>
Wireless Local Area Network (WLAN)
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Wireless Wide Area Network (WWAN)
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   (please indicate ) </B></FONT></TD></TR></TBODY></TABLE></P>
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   <TD align=middle width="25%"><FONT face="arial, helvetica"
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processing time</FONT></TD>
  <DD><TD><center><INPUT maxLength=50 name=sara size=15></center></TD>
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scheduling effectiveness</FONT></TD>
  <DD><TD><center><INPUT maxLength=50 name=sara1 size=15></center></TD>
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times</FONT></TD>
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information transparency </FONT></TD>
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</FONT></TD>
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</FONT></TD>
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flexibility</FONT></TD>
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planning accuracy</FONT></TD>
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expenses </FONT></TD>
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    percentage of achievement below </B></FONT></TD></TR>
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Please rank the obstacles for implementation of CIM technology
on the scale of 1 to 5 (1 – not an obstacle, 5 – major obstacle)</B>
(check one)</FONT></TD></TR></TBODY></TABLE></P>

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  3<TD align=middle><INPUT name=saleh type=radio value=3></TD>
  4<TD align=middle><INPUT name=saleh type=radio value=4></TD>
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5<TD align=middle><INPUT name=saleh type=radio value=5></TD></TR>
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<TD><FONT face="arial, helvetica" size=-1><B>14 3</B> Technical skills of support
staff
    </FONT></TD>
1<TD align=middle><INPUT name=goma type=radio value=1></TD>
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3<TD align=middle><INPUT name=goma type=radio value=3></TD>
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commetment</FONT></TD>
1<TD align=middle><INPUT name=hade type=radio value=1></TD>
2<TD align=middle><INPUT name=hade type=radio value=2></TD>
3<TD align=middle><INPUT name=hade type=radio value=3></TD>
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<TD><FONT face="arial, helvetica" size=-1><B>14 5</B> Nature of
business</FONT></TD>
1<TD align=middle><INPUT name=libo type=radio value=1></TD>
2<TD align=middle><INPUT name=libo type=radio value=2></TD>
3<TD align=middle><INPUT name=libo type=radio value=3></TD>
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<TD align=left><FONT color=#0000bb face="arial, helvetica"
 size=-1><B>If some of the obstacles are not listed above please specify and rank
them below </b></FONT></TD></TR>
```

```
 <DD><TR>
  <TD><FONT face="arial, helvetica" size=-1><b>14 6</b> other (specify)
<INPUT maxLength=100 name=jomana size=15></FONT></TD></tr><p>
  <DD><TR>
  1<TD align=middle><INPUT name=trh type=radio value=1></TD>
  2<TD align=middle><INPUT name=trh type=radio value=2></TD>
  3<TD align=middle><INPUT name=trh type=radio value=3></TD>
  4<TD align=middle><INPUT name=trh type=radio value=4></TD>
  5<TD align=middle><INPUT name=trh type=radio value=5></TD></TR>
<p>
 <DD><TR>
  <TD><FONT face="arial, helvetica" size=-1><B>14 7</B> other (specify)
<INPUT maxLength=100 name=jomana2 size=15></FONT></TD></tr><p>
  <DD><TR>
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  2<TD align=middle><INPUT name=ahmed type=radio value=2></TD>
  3<TD align=middle><INPUT name=ahmed type=radio value=3></TD>
  4<TD align=middle><INPUT name=ahmed type=radio value=4></TD>
  5<TD align=middle><INPUT name=ahmed type=radio value=5></TD></TR>
<p>
<CENTER><INPUT type=submit value="Submit and get Results"><BR><FONT
color=red
face="arial, helvetica" size=-1>(wait for
results)</FONT></CENTER></FORM></center>
<HR>
</FORM>
</BODY>
</HTML>
</FORM>
</BODY>

</HTML>
```

LIST OF PUBLICATIONS

[1] Ayad K Mohamed and M S J Hashmi, "computer integrated manufacturing in food processing industry an overview", 2002, Proc IMC-19 Queens University, Belfast,

[2] Ayad K Mohamed and M S J Hashmi, "A Comparison of the effectiveness of traditional postal survey and web-based survey for industrial feed back", (accepted for publication in the proceeding of ICAMT 2004, Kuala Lumpur, Malaysia)

[3] Ayad K Mohamed and M S J Hashmi, "a survey on automation and the use of computer integrated manufacturing in food processing industry", (accepted for publication in the proceeding of ICAMT 2004, Kuala Lumpur, Malaysia)