MODELING THE IMPLEMENTATION OF ADVANCED MANUFACTURING TECHNOLOGIES IN THE CYPRIOT MANUFACTURING INDUSTRY

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Andreas Efstathiades

BRUNEL UNIVERSITY

Department of Mechanical Engineering

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BY A. EFSTATHIADES

Abstract

For the Cyprus Manufacturing Industry, previously committed to the production of medium quality standard products, the increased and changing nature of competitive pressures represents a fundamental challenge. The major problems the Cyprus manufacturing industry is facing appear to be labour shortages, together with low product competitiveness and poor production organization. It is widely believed that the introduction of Advanced Manufacturing technologies (AMTs) offers a means of resolving the above problems but their implementation is a risky venture. The main objective of the study was to examine the implementation of AMTs in the Cyprus Manufacturing Industry, identify the factors leading to successful application of these technologies and based on these factors develop an integrated process plan to facilitate their successful implementation.

A survey was conducted on a sample of 40 companies using personal interviews based on a purpose designed comprehensive questionnaire. The questionnaire encompassed the international trends in the management and implementation of AMT.

Successes and failures have been considered in terms of the Technical, Manufacturing and the Business aspects and influences of each technology. It has been found that the most important factors contributing to the successful implementation of AMT were the level of long term planning, the fitness level of AMT in the existing processes and the attention given to infrastructure preparation and human resource development.

Based on the success factors identified an integrated planning model has been developed. The model incorporates all the planning procedures and implementation parameters to be followed in order to ensure successful AMT adoption and implementation. The model addresses the three main stages of AMT adoption and implementation: (a) the planning phase, (b) the selection, transfer and pre-implementation phase and (c) the post implementation phase. For each phase the steps to be followed are fully explored and analysed. Finally the usefulness of the model in facilitating the successful application of AMT is illustrated through two case studies.

CONTENTS

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Abreviations

AMT	Advanced Manufacturing Technologies
CAD	Computer Aided Design
CAM	Computer Aided Manufacturing
CAD/CAM	Computer Aided Design/Computer Aided Manufacturing
NC	Numerically Controlled
CNC	Computer Numerically Controlled
FMSs	Flexible Manufacturing Systems
AGVs	Automatic Guided Vehicles
TQM	Total Quality Management
ISO	International Standard Organization
GT	Group Technology
MRP	Materials Requirements Planning
MRPII	Manufacturing Resources Planning
JIT	Just In Time
BS	British Standard
HR	Human Resource

CHAPTER 1

INTRODUCTION

INTRODUCTION

The changing competitive environment demands that producers must be able to supply products of high quality and design content, in greater variety and in smaller volumes. Increased automation, and the greater emphasis placed on product design, development and marketing, mean that being a low-cost producer, based on cheap labour, no longer assures national competitiveness [Dahlman (1989)]. Competitive advantage now depends on speedy and reliable delivery, high product quality and the ability to expand the range of products and services to fit customers changing needs [Dahlman (1989), Joynt (1991)].

Porter (1985) states that "technological change is one of the principal drivers of competition", while according to Ramanathan (1990) "the effective management of technology is the key to economic growth and competitiveness". Weil et al (1991) state that "technology has been found to be an input to a broader picture of manufacturing strategy and manufacturing based competitiveness". Manufacturers who compete against firms from other countries with substantially lower labour costs have three alternatives: automate, migrate or evaporate [Weil et al (1991), Denis (1985)]. Successful firms have recognized the fact that technology has become a key competitive tool for success and are trying to leverage it for competitive advantage. Although there is no clear path towards gaining a competitive advantage it is of general agreement that the implementation of Advanced Manufacturing Technology (AMT) is a critical component for success. According to Denis (1985) "the difference between a loser and a winner is the ability to apply new technologies and to build the company's future on the creativity and imagination of its brain resources through an adequate management". The most important competitive weapons, however, are not the technologies themselves, but their effective deployment, implementation and ultimately their management [Joint (1991), Porter (1985),Miller et al (1988), Bittondo (1988), Perrino et al (1991), Bessant et al (1986), Grindley (1991)]. As a result, a sound technology strategy should give emphasis to the process of AMT justification, the transfer of that technology to the manufacturing environment and finally the sound implementation in order to ensure Technical , Manufacturing and Business success.

For the case of Cypriot Manufacturing Industry, previously committed to the production of medium quality standard products, the increased and changing nature of competitive pressures represents a fundamental challenge. This challenge which was sharpened by the customs union agreement between Cyprus and the European Community signed in January 1988, and the implementation of the GATT agreement since January 1996, demands new approaches to technology, human resource development, company structure and managerial philosophy. A critical success factor for companies turning their attention to Europe will be "how successfully they anticipate, acquire and apply technology. This is not going to be an easy task" [Hieronymi et al (1990)]. The Cyprus Industrial Strategy (prepared by the Institute of Development Studies of Sussex University on behalf of the Government of Cyprus, in June 1987) attributed particular importance to the technological restructuring of the manufacturing sector. This strategy indicates that the introduction of AMT in the Cyprus industry is a must for its competitiveness and even its survival.

This thesis examines the process of Justification, Transfer and Implementation of AMT in the Cyprus Manufacturing Industry, it investigates and quantifies its impact on the Business and Manufacturing environment and analyzes the contributing factors to the Success or Failure of the technologies. Finally a process plan is presented which accomplishes the necessary steps for the successful implementation of AMTs.

Following this introductory chapter, chapter 2 presents the latest developments in Advanced Manufacturing Technology Management. It gives an outline of the Advanced Manufacturing Technologies and sets out the viewpoints regarding the planning of AMT and its impact on Business competitiveness. Emphasis is placed on the approaches to Strategic justification of AMT as well as the defensive and financial justification processes. Finally, the chapter presents the various factors affecting the transfer and implementation of AMT in the manufacturing environment with special reference made to infrastructure preparations and human resource considerations. An outline of the reasons for poor / unsuccessful implementation of Advanced Manufacturing Technologies is also presented.

Chapter 3 examines manufacturing industry in the context of the Cypriot economy. Specifically it examines the contribution of each activity of the industry to the manufacturing sector and their importance in terms of:

(a) employment,

(b) gross output,

(c) value added,

(d) gross output per person and

(e) value added per person.

The chapter then presents a quantitative picture of the historical evolution and development of the industry over the last ten years. Specific reference is made to the export performance of the industry. Finally, a profile of the manufacturing industry in 1994 is set out.

Chapter 4 gives a brief outline of the questionnaire which was prepared as a tool for the assessment of the implementation of Advanced Manufacturing Technologies in the Cyprus Manufacturing Industry. Information presented in this chapter is based on the review of the relevant international literature. This literature forms the basis on which the questionnaire was designed and used for the assessment of the implementation of Advanced Manufacturing Technologies, the investigation of their effectiveness, and the analysis of the attitudes of the managers in the implementation and management of AMT. Emphasis is given to the type of information each section of the questionnaire tries to extract. Finally, a description of the research methodology is presented accompanied by an analysis of the general characteristics of the sample (employment, gross output, etc.)

Chapter 5 establishes the framework in which Cyprus manufacturing industry is operating with emphasis given to the competitive priorities and manufacturing parameters. The level of development of various plant characteristics in the companies is investigated and correlated with the level of integrative cultures existing in the companies. Special emphasis is given to establishing the actual optimum level of competitive priorities a company should possess in order to safeguard its competitiveness in the market place. Further on, an examination of the level of importance given to each competitive priority and manufacturing parameter is established. Finally, the general impact of the introduction of AMTs on the manufacturing parameters and competitive priorities of the companies is calculated . Based on these results the relationship between the manufacturing parameters and competitive priorities is closely examined.

Chapter 6 presents the factors influencing the decision to introduce AMT in Cyprus Manufacturing Industry, examining both market related and defensive factors. Special reference is made to the relative influencing level of the companies' competitive priorities and the manufacturing parameters. An attempt is made to establish the impact of AMT introduction on the companies' product - market characteristics and specifically on the manufacturing parameters and competitive priorities. Finally the financial justification of AMTs is examined with special emphasis placed on the process of analysis followed during the planning phase .

Chapter 7 examines the transfer and implementation of AMT in the Cyprus Manufacturing Industry. Specifically, it analyses the management processes followed during the transfer of the technology in the manufacturing environment as well as the steps followed both before and after its implementation and actual productive operation. Special emphasis is given to the infrastructure preparation and the human resource considerations. The evaluation of the above factors is performed both before the installation of the technology in the manufacturing environment as well as after its productive operation. Further on, an attempt is made to investigate the relationship which exists between top management support and the level of infrastructure and workforce preparation performed during the implementation of AMTs.

Chapter 8 performs an assessment as to whether a specific application of AMT has experienced success or failure. The success and failure of AMT is proposed to be considered as a three stage process ie Technical success, Manufacturing success and Business success. Further on an attempt is made to determine the main reasons behind successes or failures.

Chapter 9 concentrates on the planning requirements for the adoption of Advanced Manufacturing Technologies in order to safeguard successful implementation. The review of the planning and implementation requirements are reinforced with the findings of this research project with a view to proposing a planning model for the acquisition of AMT. This model provides a framework for managers to assist in the correct justification and implementation of AMT to ensure Technical , Manufacturing and Business Success. The model incorporates all the planning procedures and implementation parameters to ensure successful AMT adoption and implementation.

CHAPTER 2

INTERNATIONAL DEVELOPMENTS IN THE MANAGEMENT OF AMT

2.1 Introduction

The application of computers and especially of Advanced Manufacturing Technologies (AMT) in the production process has brought about an industrial revolution over the last twenty years. The introduction of new technologies such as CAD, NC/CNC machines, robots as well as new manufacturing techniques such as JIT, MRP, Group Technology, Computer Aided Process Planning etc , have allowed producers to benefit from the kind of economies associated with volume production, remaining at the same time batch producers, and retaining their product flexibility, capable of responding to particular customer needs. The application of AMT has given the opportunity to producers to combine flexibility and automation with specialist high quality products [Tippett (1989)].

In Europe more successful application and implementation of AMT is found in France, Italy and Germany, with the UK being the slowest of the major European economies to respond to these trends [Tippett (1989)]. On the other hand, American and Japanese companies had a more forward-looking attitude towards technology and have developed competitive advantage by applying technology, which has led to fast economic growth and the creation of new jobs [Perrino et al (1991)]. As a result of the application of AMT small firms have been able to automate and compete with larger competitors, offering specialist services on the basis of high quality, fast turn around and small batch production of high value added components. Furthermore, manufacturers made possible the adaptation of machinery to customer needs rather than offering standardized products [The Cyprus Industrial Strategy - The Metal Working Sector in Cyprus (1987)].

The aim of this chapter is to present the latest developments in Advanced Manufacturing Technology Management. It gives an outline of the Advanced Manufacturing Technologies and sets out the viewpoints regarding the planning of AMT and its impact on Business competitiveness. Emphasis is placed on the approaches to Strategic justification of AMT as well as the defensive (based on operational factors) and financial justification processes. Finally, the chapter presents the various factors affecting the transfer and implementation of AMT in the manufacturing environment with special reference made to the infrastructure preparation and human factors consideration. An outline of the reasons for poor / unsuccessful implementation of Advanced Manufacturing Technologies is also presented.

2.2 Advanced Manufacturing Technologies

AMT is defined as any new manufacturing technique, the adoption of which is likely to lead to changes in a firm's manufacturing practice, management systems and approaches to design and production engineering of the product [Harrison (1986)]. Advanced Manufacturing Technologies are split into:

(a) Pure Technical Tools (hardware) and

(b) Management Tools (manufacturing practices-software) [Denis (1985), Burnham (1984)]. Investment in pure Advanced Technical Tools is unlikely to bring the expected benefits unless a parallel effort is made for the implementation of new management tools and techniques [Denis (1985)]. Much of the Japanese success in production lies not only in investments in technical tools but in a parallel systematic examination and streamlining of production in order to reduce inherent problems such as bottlenecks and other inefficiencies (i.e. applying production management systems) [Bessant et al (1986)].

Under the heading of Advanced Technical Tools (hardware) the following can be included:

(a) Computer Aided Design - CAD-,

(b) Computer Aided Manufacturing -CAM - NC - CNC,

(c) Computer Aided Design/Computer Aided Manufacturing - CAD/CAM ,

(d) Robotics,

(e) Flexible Manufacturing Systems -FMS's-, and

(f) Automated Guided Vehicles -AGVs-.

Under the heading Production Management Tools the following can be included:

(a) Just In Time -JIT-,

(b) Total Quality Management -TQM-,

(c) Group Technology -GT-,

(d) Material Requirements Planning -MRP-, and

(e) Manufacturing Resource Planning -MRPII-.

The above technologies which have been extensively discussed in the literature [Harisson (1990), Krajewski et al (1990), Nisanci (1985)] are explained further in Appendix "A".

2.3 Business Competitiveness and AMT Applications

The processes normally used to justify introduction of high technology machines, equipment, and systems into the organization, particularly in the manufacturing area, are proving to be one of greatest impediments to success [Tippet (1989)]. Recent Management theories stress the need for the manufacturing strategy of the business to be compatible with the firm's competitive strategy. Weil et al (1991) point out that the most important common finding in all the field studies examining AMT is that decisions about AMT implementation should be part of a broadly based Business Strategy. The link between technology application and Business strategy also relates to the competitive priorities and positioning of the enterprise. Success in the global market place requires companies to employ technology strategically by linking it to a firm`s competitive strategy. Such a link ensures that technology and strategy support one another enabling a company to better achieve its goals. [Zahra (1994)]

The target customer needs determine the manufacturing capabilities the firm must possess in order to offer a competitive customer service.[Dini et al (1994)] In 1970's the manufacturing objectives have been dominated by the drive to improve productivity. Now, the need to ensure that the manufacturing objectives complement the strategic objectives of the company is worthwhile recognized [Sweeney (1986)]. Manufacturing strategy must not be restricted to an internal examination of production. It should be concerned with manufacturing for the business, not just the business of manufacturing.[Yates (1985)]

The key to success is to go back to basics and to decide what the plant needs to achieve in order to create and keep a competitive advantage. Deciding what the plant needs comes from a knowledge of the market, not a knowledge of technology .[Yates (1986)]. Yates (1986) states that : " If one concentrates on technology needs and not on business needs he is unlikely to address the real issues, and consequently, he is unlikely to make significant improvements to his competitive edge.

Technological choices should clearly be driven by , and closely aligned with, the broader framework of competitive positioning decisions. In other words technological choices should be framed by the answer to the fundamental question: " how do we compete? what technologies support the product and market strategies? The development and use of technology must be guided explicitly by the Business strategy of the firm. Technology is a tool that has to be used in the strategy of an enterprise [Weil et al (1991),Haan et al (1993) , Erickson et al (1991) , Voss (1986)]. Erickson et al (1991) point out three questions which must be answered as follows:

(a) Are our Product / market strategies realistic?

(b) Do we have the technological capacity to support our product and market strategy? and

(c) What do we need to accomplish in order to build the technological strength that our strategies require?

The choice of Manufacturing technology used by a firm can either augment or constrain its manufacturing strategy and ultimately its competitive position Any changes to the manufacturing technology should be made after an assessment of the operational /

manufacturing benefits provided by the selected technology and how closely these match the manufacturing mission [Sweeney (1986)]

Evaluation of what type of AMT the Business needs should be done by examining how manufacturing can support the company's product / market characteristics and give the business a distinctive competitive edge. As a result, AMT must be used to revise completely the capability of manufacturing , improve manufacturing parameters and ultimately the company's order winning criteria (ie the distinctive features of the product or service that cause the customer to buy it) [Yates (1986)]. These order winning criteria can be grouped into four groups with seven dimensions as follows [Krajewski et al (1990)] :

- **Cost**

1. Low price

- **Quality**

2. High performance design / product features, close tolerances etc (ie quality as represented by the specification of the properties of the product and service)
3. Consistent quality (Demonstrated by the reliability with which actual products conform to specifications and requirements)

- **Time**

4. Fast delivery time (delivery dates quoted)
5. On time delivery (the reliability with which quoted delivery dates are met)

• **Flexibility**

6. Design / Product flexibility (tailoring of the product to meet specific customer requirements)
7. Volume flexibility (the ability to supply the product in the volumes required by customers without compromising delivery lead times or performance)

A set of design / manufacturing parameters that have been identified as major contributors to the above competitive priorities and are directly affected by the introduction and operation of AMT are the following [Catton (1986),Beaton (1985), Finnie (1986)]:

- Quotation and design lead times,
- Design to manufacture lead times,
- Ability to design and manufacture new products,
- Materials optimization due to improved design,
- Improved product quality due to improved design,
- Component and tooling standardization/reduction,
- Manufacturing throughput time,
- Scrap rate and rework,
- Change over time,
- Manufacturing lead times,
- Batch size improvements,
- Space and assets (as a result of stocks reduction, Work In Progress, etc),
- Plant down time (as a result of planned maintenance).
- Direct labour cost,

- Finished goods stocks.
- Raw materials stocks,
- Supervision utilization (Less routine administration),
- WIP (Work in progress),
- Average Order Quality Level (A.O.Q.L),
- Response to quality control traisability queries,
- Management time utilization.

2.4 Planning for the Introduction of Advanced Manufacturing Technologies

As stated AMT must be used to revise completely the capability of manufacturing, improve manufacturing parameters and ultimately the company's order winning criteria. Lowe (1993) states that the competitive benefits of manufacturing innovation sometimes seem intangible to strategists. Their focus is usually on cost saving for operational reasons. Delivery, quality and control were all deemed important, but rarely seemed to be put in their strategic content. Goldhar et al (1994) point out that the adoption of AMT gives firms a greater number of growth options to enter new markets and to create new products than firms relying on traditional manufacturing technologies and generic strategies. In effect AMT change the external risk propensity of the firm from risk - averse to risk - prone. That is, firms using AMT in effect create a series of "call options" to enter new markets and industries in the future. A growing body of research in the manufacturing literature suggests that firms are investing considerable sums in Advanced Manufacturing systems in order to deal with fast changing products and fragmentation of traditional markets. AMTs are giving many firms the potential to bridge the chasm between choosing either low-cost dedicated production, or high-variety differentiation. Such technologies are enabling firms to blend small-batch and custome-order operations with the low-cost efficiency of standardised mass production [Goldhar et al (1994)]. Many recent studies of industrial innovation focus on batch manufacturing as the area in which AMT can have the greatest effect [Rush et al (1992)]. It is also indicated that the application of AMT can be successful in both high volume low variety production, and very low volume high variety production. The advantage of AMT is its ability to provide increased flexibility whereas the diffusion of previous generations of technologies was heavily influenced by the need for lower labour costs.

Advanced Manufacturing Technologies (AMT) operate in two powerful ways to affect competitiveness [Bessant (1993)], firstly by changing the price structure (more efficient processes through better use of inputs such as raw materials, direct labour and energy) and secondly through its impact on non price factors. These might include design and marketing related, production related, finance related and quality related factors. It is becoming clear that whilst price factors remain an important determinant of competitiveness, non-price factors are having a major impact in world markets. Whereas the diffusion of previous generations of technologies was heavily influenced by the need to lower labour costs, the advantage of AMTs is their ability to provide increased flexibility in terms of reduction in the cost of working capital, increases in the responsiveness of delivery, lower rates of rework and scrap, the ability to increase the customization of the products etc. Labour which previously appeared on the cost side now is seen as a vital resource. Thus, the decision for the adoption of AMT apart from its likely impact on unit costs must take into consideration the above factors which are much more difficult to measure [Rush et al (1992)].

The processes used to justify the introduction of AMT into the organization are proved to be the greatest impediments to success [Tippet (1989)]. Accurate information concerning the benefits of AMT is limited and must be treated with caution, as we are in the early stages of diffusion. As a result, planning for AMT introduction is an essential but complex and difficult process.

2.4.1 Strategic Justification of Advanced Manufacturing Technologies

This viewpoint accepts that every technology decision should have a strategic impact on the Business. The need for technological innovations in production processes should be initiated as a result of changing strategic or business objectives which require an evaluation of current production processes. Such evaluations might occur as a result of:

(a) new product development,

(b) rapid increases / decreases in demand for the firm's products,

(c) the need to streamline costs,

(d) the need to improve product quality,

(e) changes in process technology etc.[Chen (1994), Munro (1988)].

Advanced Manufacturing Technology decisions should be justified by looking to see how manufacturing can give a distinctive competitive edge to the company. The strategic planning approach takes a long term comprehensive view of both business and technology issues. The firm should develop an integrated business plan which provides the vision and sense of direction for each organisational unit of the company to meet the strategic objectives [Kirton et al (1985)]. Companies should first identify the range of products / markets that are likely to be manufactured. In seeking to match products with technologies, management should be aware that adoption of AMTs. can bestow not only operational benefits such as improved quality, increased efficiency and shorter lead times, but marketing and strategic advantages as well. Benefits such as increased market share, reduced prices, improved responsiveness to changes in the market place, the ability to offer a continuous stream of customized products, faster product innovation and the improvement of the company's image have all been ascribed to the operation of flexible AMT [Chen (1994)]. The product - market characteristics determine the company's order - winner criteria that the firm must possess in order to offer a competitive advantage to the company. On the other hand these order- winner criteria determine the level of the design and manufacturing parameters the company must possess. The desired level of these parameters should be the decisive factor in the type of AMT justification and introduction.

2.4.2 Defensive Justification of Advanced Manufacturing Technologies

This view point refers to the traditional approach by which the introduction of AMT is seen as an operational concern rather than a strategic factor. As a result its justification is determined by purely operational concerns and / or problems faced in the manufacturing environment which must be extinguished. Such problems might be:

(a) Skilled labour shortages

(b) Solution to safety problems

(c) Main contractors requirements (The company operates as a subcontractor and the main contractor sets conditions to its subcontractors. Among these conditions could be the availability of AMT equipment)

(d) Vertical (backward) integrations due to problems faced with the supply of raw materials

2.4.3 Financial Justification of Advanced Manufacturing Technologies

It is internationally accepted that every technology investment should be financially justified. As a result AMT should be justified not only in accordance to business needs but also in accordance with financial viability. The financial evaluation of the expenditures in AMT helps the managers decide which of the possible AMT strategies to pursue and allows them to measure the exact effect of AMT on company profitability, cash flow and the degree of risk involved. Furthermore, it gives a proper evaluation and thus allows cost monitoring to ensure that the estimated benefits actually materialise. Finally, it establishes the output criteria and thus concentrates the people involved in what they are trying to achieve and how success will be measured [Catton (1986)].

The financial justification of AMT is not an easy task. Only after the likely impacts of the technologically feasible alternatives on the organization have been assessed, should any attempt be made to cost justify the proposed systems. The major considerations in economic justification of an AMT project are the quantification of costs and benefits. One of the biggest problems facing people who are considering integrated manufacture is how to justify the considerable investment involved [Chen (1994)]. While the costs (hardware, software, planning, training, operations etc.) are generally easily quantifiable, the benefits are often very difficult to quantify. In particular, major strategic benefits such as early entry to market, perceived market leadership, the ability to offer a continuous stream of customised products and improved flexibility, although extremely important for the growth and survival of the firm, are not readily convertible into cash values [Chen (1994)]. It is thus obvious that the most difficult task is to evaluate all the benefits that are likely to be achieved by the introduction of AMT. The benefits that should be quantified for financial justification can be divided into two major groupings:

(a) tangible benefits (direct benefits) and

(b) intangible benefits (indirect benefits). [Tippet (1989), Yates (1986), Catton (1986), Beaton (1985)].

The tangible (direct benefits) can be calculated easily and are readily acceptable. Such benefits can be:

(a) reduction in machines,

(b) reductions in labour cost,

(c) reductions in space requirements,

(d) reductions in processing time, and

(e) reductions in scrap and material costs.

The category of intangible (indirect benefits) includes all the benefits that are not easily or accurately quantified. Such benefits can be:

(a) design and marketing related benefits,

(b) production related benefits,

(c) finance related benefits,

(d) quality related benefits, and

(e) general benefits.[Catton (1986), Beaton (1985), Finnie (1986)]

The proposals for AMT acquisitions should not be justified solely through the normal investment appraisal systems of a company [Finnie (1986)]. Before proceeding to financial evaluation of AMT, all the benefits, tangible and intangible, should be quantified. This can be done through proper co-ordination between the various company departments, developed and promoted at top management level [Finnie (1986), Kirton et al (1985)].

In practice, financial justification of the introduction of AMT is very difficult to be achieved with existing cost and management accounting procedures. A number of arguments supporting the above statement can be summarised as follows: [Tippet (1989), Finnie (1986), Goldhar et al (1994)]

(a) It is not possible to produce reliable cash flow forecasts with the present state of knowledge of AMT characteristics, as is the case with conventional technologies.

(b) Many important intangible benefits arising from the introduction of AMT can not be quantified precisely.

(c) Many advantages of AMT are enjoyed and/or are visible only by changing the organizational structure. As a result AMT alone may not be financially viable.

Finnie (1986) suggests that "investments in the component parts of Advanced Manufacturing Systems must be viewed and evaluated in relation to the entire system and not on a stand alone basis". On the other hand, Catton (1986) states that "AMT strategies should not be implemented unless they can be cost justified". Tippett (1989) suggests that "the problem lies not in the basic logic of traditional DCF methods, but in how they are being applied in evaluating advanced technology investment opportunities". Rush et al (1992) states that "unless traditional investment criteria are disregarded in favour of a more strategic long term plan, the purchase of any automated manufacturing equipment is out of the question".

2.5 Implementation of Advanced Manufacturing Technologies. Successes and Failures

2.5.1 Transfer of Technologies

The process of technology selection/transfer is characterised as being a complicated process which requires skills and managerial know-how. As a result there is a need to put much effort and time, into the transfer phase of AMT introduction, since that process is highly delicate and costly. Very often the buyer of technology is in a weak position, especially when facing a stronger and more experienced supplier from an industrialised country. Djeflat (1988) suggests that the buyer can strengthen his bargaining power by following the steps outlined below:

- Breaking up the technological package as much as possible,
- Gathering correct information about the supplier and the product,
- Using group buying, and
- Avoiding any form of financing from the supplier.

Particular attention should be paid not only to the kind of AMT to be transferred but also to the type of contract to be used and the type of channel through which it should be transferred. There are two types of contract commonly used in the transfer of AMT. These are known as "Turnkey contracts" and "Product in hand contracts". In the "Turnkey contract" the whole implementation process is entrusted to a single foreign supplier who accepts the responsibility to implement the project of technology transfer up to the point where he hands the keys over to the client. In the "Product in hand" contract the responsibility of the supplier is not limited to the equipment installation but also includes the initial management and operation of the equipment and training of the operators [Love et al (1986)].

Advanced Manufacturing Technologies can be imported through the following channels:

(a) direct investments,

(b) joint ventures and

(c) state controlled import modes.

The most commonly used are *direct investments,* and *joint ventures.* Under the *joint venture* category there are three types of technology transfer, based on the level and type of contribution of the firms [Djeflat (1988)]. These are:

(a) supply of machines from the foreign firm,

(b) supply of patents, licenses or manufacturing processes, and

(c) supply of personnel to oversee the start up of the machines and provide technical assistance.

2.5.2 Implementation of Technologies

The performance of companies using AMT depends to a large extent on how well they implement it and not on the technology itself. There is a long way, however, from technology introduction to successful implementation. The way the technology is implemented has a serious effect on its performance and as a result on business performance [Ford (1988)]. Weil et al [(1991)] suggest that "changes in organisational structures and practices as well as worker skills and knowledge are needed for successful implementation of AMT". As technologies become more powerful and complex, the source of competitive advantage lies less in the particular hardware or software package purchased than in the ability to deploy it [Bessant (1993)].

The adequacy of a sound supporting infrastructure is characterised as one of the most important factors to be considered in implementing AMT into the company [Weil et al (1991), Zahra (1994), Love et al (1986), Edosomwan (1988),Swierezek (1991)]. The organisational infrastructure can be split into two elements [Tippet (1989)]:

(a) knowledge i.e. what the employees know, and

(b) policies i.e. the organizational rules, procedures, systems and structure.

As to the benefits which can be obtained through reorganisation, in most cases these benefits can be obtained independently of the introduction of new technologies [Rush et al (1992)]. There are many companies which managed to develop a competitive advantage just around their internal capabilities and their infrastructure even though their hardware (i.e. plants and equipment) were not exceptional. On the other hand, nobody managed to gain competitive advantage by employing technology on its own

[Giffi et al (1991)]. Bessant(1993) states that benefits from AMT arise not only from the equipment and software used but also from changed working practices, skills disposition, interfunctional relationships, planning and control procedures etc.

Three guide-lines can be used to ensure that the firm's infrastructure will support effectively the introduction of AMT [Tippet (1989)]:

(a) Gain a thorough understanding of the present infrastructure, understand the *AS-IS* situation. That is understand how the existing manufacturing processes are working. There are many companies which do not understand how they presently do their own business.

(b) Rationalize current processes, identify current foul-ups and bottle-necks and fix them by smoothing the present work flow and processes, the need for new systems may be reduced.

(c) Define an infrastructure project plan by taking into consideration all the existing supportive systems which must be modified, so as to be compatible and supportive of the new technology.

2.5.2.1 Human Resource Policies

There is no doubt that the human resource is the greatest asset for any organization, without which the use and development of technology will not happen. Effort should be made so as to minimise the negative impact of technology on human beings in order to achieve successful technology implementation [Tippett (1989), Zahra (1994), Edosomwan (1988), Swierezek (1991)]. Employees must be involved from the beginning by being updated about plans for new technology and the reasons why this new technology is needed. They must be aware of the impact the new technology will have on their job security, working conditions, promotion opportunities, job classifications, training requirements, etc. Special emphasis should be given to the involvement of the workforce to the maximum possible extent in the selection and implementation of the new technology [Tippett (1989), Giffi et al (1991), Edosomwan (1988), Towers (1986)]. Tippet (1989) suggests that "companies seeking to achieve successful technology implementations are finding it necessary to introduce some changes in basic Human Resource Management (HRM) areas, and in the overall role HRM professionals play in the implementation process".

The main problems/reservations which may appear with regard to the attitudes of the workforce are:

(a) fear of redundancy or job loss, and

(b) fear of being unable to cope with the new system.

The above reservations can be resolved by guarantees of no compulsory redundancies related to the introduction of new technology and by continuous training [Love et al (1986)]. Experience shows that even in cases where one of the objectives of the introduction of AMT was to eliminate the skilled workforce, it is realized that skilled workers are required if utilization of the system is to remain high [Rush et al (1992)]. In terms of workforce skills, the operators of AMT may regard themselves as more skilled, or on the other hand, they may see the job they now perform as more deskilled by the use of technology [Love et al (1986)]. In many cases the introduction of new technology has meant an increase in job satisfaction, and increased job security for the workers

[Rush et al (1992)]. The attitudes of the unions may also play a significant role in the introduction and implementation of AMT, as it may not be implemented without their co-operation [Love et al (1986)].

2.5.3 Reasons for Poor/Unsuccessful Implementation of AMT

The successful implementation of AMTs can offers a number of measurable and unmeasurable benefits: [Rush et al (1992), Giffi et al (1991)]

- Lead time reduction by 30-74%,
- work in progress reduction by 25-68%,
- stock turnover increase by 350%,
- machine utilization increase by 52%,
- component price reduction by 25%,
- production output increase by 150%,
- set up time reductions by 35%,
- direct labour savings by 15%,
- indirect labour savings by 15%,
- throughput time reduction by 70%,
- scrap reduction by 10%,
- overall manufacturing cost savings of 10 - 15 %.

In addition to these measurable benefits there a number of other unmeasurable ones such as flexibility increase, cycle time reduction, quality increase, asset integration, customer satisfaction etc. Giffi et al (1991) indicates that benefits from the implementation of AMT rarely accrue when continuous improvements in both structural and infrastructural elements are not performed in tandem.

The reasons for poor or unsuccessful implementation of AMT have been the central point of many surveys. Shaw et al (1986) give the following reasons for the unsuccessful implementation of new technology:

(a) Lack of management commitment,

(b) Poor communication and incomplete involvement of employees,

(c) Inaccurate inventory records and engineering data,

(d) Inadequate detailed planning,

(e) Unsuitable organization structure,

(f) A piecemeal approach to investment,

(g) Insufficient training,

(h) Under - resourced implementation program,

(i) Lack of involvement with equipment suppliers, and

(j) Under estimation of software requirements.

Giffi et al (1991) mention the following as being some of the most important reasons for unsuccessful implementation of AMT:

(a) Lack of top management commitment and middle management initiative

(b) Inadequate education and training

(c)Plans that do not address strategic variables

Zairi (1992) emphasizes the importance of the lack of management commitment to the failure of AMT implementation together with the inadequate allocation of financial and human resources, the lack of manufacturing strategy and the unavailability of vital skills. Bessant et al (1986) mention as the main reason for failure "the incompatibility between the technology and the organization into which it is to fit, which includes false assumptions about rationality in organizational decision making, a lack of understanding of both the technology and the user organizations involved, inappropriate matching of technology to organizational strength and weaknesses, and the lack of suitable infrastructures within organizations to accommodate AMT". There is a growing consensus that the lack of an appropriate organizational infrastructure proves to be the greatest impediment to the effective implementation of new manufacturing technologies, while knowledgeable management commitment has been found to be critical for the successful implementation of these technologies. This management commitment could be estimated by the level of allocations to training during the modernization phase. Essential role in project success plays the appointment of a technology champion. Some researchers indicate that even in the absence of a champion, an appropriate organizational structure can lead to a successful implementation. Failure to remove organizational barriers between functional areas, contributes to integration difficulties.[Chen (1994)]. Evidence suggests that many implementation efforts, whilst strongly managed in the technical and financial area, fail through a lack of strategic management of the necessary organizational development.[Bessant (1993)]

Voss (1988) presenting the findings drawn from an 18 month study into successes and failures in AMT, proposed two levels of success in implementing such technologies: the Business success and the Technical success. Technical success is defined as "the use of the technology with low levels of down time", whereas Business success is defined as "the realization of all the benefits and ultimately the translation of these benefits to competitive advantage".

Empirical studies on the experiences of plants adopting AMTs indicate that technical success alone does not necessarily lead to realization of the major strategic and business benefits expected [Chen (1994)]. The following are suggested by Voss (1988) as factors leading to faster and more easy achievement of Technical success:

(a) Top management support,

(b) Links with suppliers,

(c) Cross functional implementation teams,

(d) Planning,

(e) Workforce involvement and human factors,

(f) Skills and training, and

(g) Keeping management informed.(The managerial personnel at lower levels should be informed about plans for new technologies)

Factors suggested as leading to faster and easier achievement of Business success (i.e. realization of the full benefits) and hence competitive advantage are as follows:

(a) Taking a strategic view, linking manufacturing technology to manufacturing policies,

(b) Changing the way manufacturing is managed (The existing way of managing the manufacturing process could not be compatible with the new environment) .

(c) Approaches to managing the workforce (The Human Resource Management practices could not foster the implementation of new technologies. Special emphasis should be given to Human Resource Management issues).

(d) Managing the learning process, (Attention should be given to the way the training is to be provided to the affected personnel)

(e) Taking an integrated approach, (a piecemeal approach in changing things should be avoided) and

(f) Changing the organization (Changes in the companies organizational structure) .

Concluding, Voss (1988) mentions the following as the prime reasons for failure to realize the full benefits from the introduction of new technologies:

(a) Lack of strategic view and failure to link this, if it exists, with manufacturing policies,

(b) Failure to manage the learning process involved in new manufacturing technology, and

(c) Failure to manage the workforce in an appropriate manner.

On the other hand, Chen (1994) presenting the results of a survey into the application of AMT in manufacturing firms in the United States mentions that the more successful projects tended to expend greater effort on the individual implementation activities. The differences in the mean level of effort for the activities of developing a long term automation strategy, ensuring vendor commitment during and after installation, and the hiring of AMT experts were not significant in discriminating between successful and non successful projects. The technically successful plants were also found to expend significantly greater effort on strategic investment appraisals and the development of performance measures prior to installation [Chen (1994)]. Moreover Chen (1994) states that the more successful adopters of AMT had exhibited significantly higher levels of effort on the following operational planning activities:

(a) Establishing multi disciplinary planning teams

(b) Establishing multi disciplinary Implementation teams

(c) Considering likely impact on customers

(d) Considering likely impact on suppliers

(e) Top Management involvement

Also from the above survey is extracted that the application of both Strategic and financial appraisal methods is required to attain both Business and Technical Success

2.6 Summary

The introduction of AMT by organizations is a critical component for success. Although there is no clear path towards gaining competitive advantage it is widely recognized that successful firms are trying to leverage AMT for competitive advantage. It is emphasized that the most important competitive weapons are not the technologies themselves but the effective justification, transfer, implementation and ultimately the management of these technologies.

All the information presented in this chapter is based on the review of the relevant international literature. This information forms the basis on which a questionnaire has been designed and used for the evaluation of the Implementation of AMT in Cyprus Manufacturing Industry, the investigation of their Success or Failure, and finally the formation of an integrated plan for the implementation of AMT in the manufacturing environment.

CHAPTER 3

THE CYPRIOT MANUFACTURING INDUSTRY'S ROLE IN THE WIDER ECONOMY

3.1 Introduction

Cyprus was traditionally an agricultural island with a number of small mines. Since its independence in 1960 the Cypriot industrial development was slow. With the events of 1974, the year of the Turkish invasion of Cyprus, there was a separation of much of the agricultural and major mining concerns in the occupied northern part of the island from the Cyprus economy, which has led to the collapse of the industry.

With economic help from various countries, Cyprus started building up its economy giving emphasis to the housing of the 200,000 refugees and to the development of the hotel and tourism industry. Manufacturing industry being initially a support industry to the tourism and construction industries, experienced a real growth following the growth of these sectors. The construction boom of the 70s and the tourist boom of the early 80s had an immediate impact on manufacturing. After a long period of sustained growth, Cypriot manufacturing started facing and will continue to face increasing difficulties. Between 1985 - 1997 and especially the last five years industry started facing major problems arising from competitive pressures within the local and export markets. These pressures have been sharpened by a Custom Union agreement between Cyprus and the European Union and the implementation of the GATT agreement. The removal of the trade barriers (GATT agreement) as well as the reduction of the import duties (Custom Union agreement) exposed the previously protected Cypriot economy to international competition. It is therefore expedient to examine the performance of the industry over the last decade since this period will provide a more realistic picture of the strengths and weaknesses of manufacturing industry and its economic contribution to the Cyprus economy.

The aim of this chapter is to examine the manufacturing industry in the context of the Cyprus economy. Thus, it is proposed to examine the contribution of each sector of the industry to the broad manufacturing sector and their importance in terms of:

(a) employment,

(b) gross output,

(c) value added,

(d) gross output per person and

(e) value added per person.

The chapter then presents a quantitative picture of the historical evolution and development of the industry over the last ten years. Specific reference is made to the export performance of the industry. Finally, a profile of the manufacturing industry in 1994 is set out. All the findings presented are based on information extracted from surveys of the Department of Statistics and Research and the analysis of information collected from various other sources [The Cyprus Industrial Strategy (1987), Industrial statistics 1995 (1996) and the Yearbook of Labour Statistics (1995)]. It is noted that the information tabulated in this chapter is not taken directly from the above publications. This information is extracted from the above publications and is presented in such a manner as to allow a graphical presentation and extraction of valuable conclusions.

3.2 A profile of the Cyprus Manufacturing Industry and its role in the Cyprus Economy

The Cyprus Manufacturing Industry consists of some 6443 firms operating in eight broad sectors as follows:

1. Food. Beverages and tobacco
2. Textile, Wearing, Apparel and Leather
3. Wood and wood products including furniture
4. Paper and paper products, printing and publishing

5 Chemicals, petroleum, Rubber and plastic products

6. Non metallic mineral products
7. Metal products, machinery and equipment
8. Other Manufacturing Industries

Table 3.1 Analysis of the Cyprus manufacturing sector -1994-

Industry sector	Gross output £000,s	%	Value added £000,s	%	Employment no.	%	Gross output / person £	Value added / person £	Value added / gross output %
1.Food, Beverages & Tobacco	342467	30.2	138916	31.4	9237	21.1	37075	15039	40.5
2.Textile, Wearing Apparel & Leather	177262	15.6	75537	17.1	12202	27.8	14527	6190	42.6
3.Wood & Wood prod. including Furniture	100820	8.9	44554	10.1	5939	13.5	16976	7502	44.2
4.Paper & paper prod. Printing & publishing	76098	6.8	31881	7.2	2864	6.5	26570	11131	41.9
5.Chemicals & chem. petroleum, Rubber & plastic products	175155	15.4	45971	10.3	3196	7.3	54804	14383	26.2
6.Non metallic & Mineral products	94969	8.5	43791	9.9	2864	6.5	33159	15290	46.3
7.Metal products Machin & Equip.	134712	11.9	52526	11.9	5878	13.4	22918	8936	39
8.Other manuf. industries incl. Cottage ind.	31036	2.7	9383	2.1	1722	3.9	18023	5448	30.2
Totals/Average	1132519	100	442559	100	43902	100	25796	10080	39

Source: Cyprus Industrial Statistics 1995

The above sectors represent a form of product grouping from which the manufacturing industry can be identified. Table 3.1 presents the eight sectors with the related parameters (number of enterprises, employment, Gross Output and Value Added).

The total employment in the manufacturing sector in 1994 was 43902 people with a total Gross output of 1.13 billion pounds and Value added of 0.443 billion pounds. The average Value Added of the sector is 39% . The Cyprus Manufacturing Industry is dominated by the Textile, Wearing, Apparell and Leather sector which account for

29.6% of all the manufacturing companies with 27.8% of the total employment, followed by the Food, Beverages and tobacco Industries with 13.4% and 21.1% respectively. In terms of the Gross Output and Value Added, Food, Beverages and Tobacco are the leading industries with 30.2% of the total Gross output and the 31.4% of the Value added. It is quite interesting to note that the contribution of the Textile, Wearing, Apparel and Leather industries to the Gross Output and Value Added is only 15.6% and 17.1% respectively, despite its dominance in terms of the number of companies and the employment levels. This has a negative impact on the average Gross output and Value Added per person for the industry. The sector with the highest Gross Output per Person is the Chemicals and Chemical, petroleum, Rubber and Plastic Products Industry with £54804 followed by the Food, Beverages and Tobacco industries with £37075. The highest Value Added per person is found in the Non Metallic Mineral products industries which is £15290 followed again by the Food, Beverages and Tobacco industries with £15039.

In terms of the Value Added over Gross Output the industry with the highest value is the Non - Metallic Mineral products (46.3%) followed by the Wood and Wood Products including Furniture Industries (44.2%). The lowest value appears on the Chemicals and Chemical ,Petroleum, Rubber and Plastic products (26.2%), which is balanced by the high Gross Output per person of the Industry (double that of the Manufacturing average) as a whole.

Interestingly, the Census of Industrial Production (1992) indicated that consumer goods industries account for 64.6% of the total number of Manufacturing enterprises. 75.6% of employment and 70.3% of Gross Output. These Industries consist mainly of Food, Beverages, Tobacco, Footwear, Clothing and Other non durable consumer goods industries, reflecting the light structure of Manufacturing in Cyprus. Intermediate goods industries account for 29.7% of the total number of manufacturing enterprises, 19.3% of total employment and 25.4% the gross output. These industries cover mainly construction materials and petroleum products. Investment goods industries account for a small proportion of manufacturing employment, 5.0% and Gross Output, 4.3%. These Industries include inter-alia, motor vehicle assembling, turbine pumps and agricultural machinery.

3.3 Size and Structure of the Industry.

One of the salient features of the manufacturing sector in Cyprus is that it is dominated by small scale producing units. In 1994 the Average Gross Output per enterprise was £175775 with an average Value Added of £68688.

Table 3.2 Characteristics of manufacturing industries in a sample of countries

Country	No of Comp.	Empl. 000,s	Gross Outp. £000000,s	Value Add. £000000,s	ValueAdd/ Gross Outp (%)	Gross Output. /person. £000000,s	Value Add/ person £000000, s
Cyprus	7173	43	1107.7	416.1	37.5	25760	9676
German	44150	7056	583576.72	291419.43	49.9	82706	41300
Greece	8141	317	11411.20	4030.5	35.3	35997	12714
U.K	139294	4314	252949.96	106646.75	42.1	58634	24721
Japan	415142	11157	1579065.1	637768.59	40.3	141531	57163

Source: Cyprus Industrial Statistics 1995

As can be seen in table 3.2 the Cyprus Manufacturing Industry when compared to the manufacturing industries of countries like Germany, U.K, Japan, and Greece, has the lowest Gross Output per person and Value Added per Person. Interestingly, the Gross Output per Person in Japan is 5.5 times higher than that of Cyprus, that of Germany 3.2 times, that of U.K 2.3 times and that of Greece 1.4 times higher. In terms of Value Added per Person Japan is the leader the value being nearly 6 times higher, followed by Germany with 4.2 times higher and U.K and Greece with 2.5 and 1.3 times respectively higher than that of Cyprus.

The analysis of the Cyprus Manufacturing industry in terms of company size is shown in Table 3.3

Table 3.3 Manufacturing industry characteristics by company size

	Totals	0-4	5-9	10-19	20-29	30-49	50<
No. of establishments	6443	4577	845	472	253	159	137
	100%	71%	13.1%	7.3%	3.9%	2.5%	2.1%
Employment	47397	8173	5438	6429	5918	6070	15369
	100%	17.2%	11.4%	13.6%	12.5	12.8%	32.4%
Gross Output £ 000,s	1107707	121827	109176	139575	117422	134635	485072
	100%	11%	9.8%	12.6%	10.6%	12.1%	43.8%
Value Added £000,s	416064	50831	37671	49060	39417	49219	189866
	100%	12.2%	9%	11.8%	9.5%	11.8%	45.6%

Source: Cyprus Industrial Statistics 1995

The 84.1% of the firms employ less than 10 people. This amounts to 28.7% of the total employment and contributes only 20.8% and 21.3% of the total Gross Output and Value Added of the sector respectively. 13.7% of the firms employ between 10 to 50 people accounting for 38.8% of the total employment , 35.35% of the total Gross Output and 33.1% of the Value Added of the sector. Only 137 firms (2.1%) employ more than 50 people which accounts for the 32.4% of the total employment, the 43.8% of the Gross Output and the 45.6% of the Value Added of the sector.

The above analysis highlights the fact that the manufacturing industry is dominated by small firms. It is very important to point out that the average firm size in the industry is 7.4 employees/firm. Table 3.4 shows the average number of employees/firm for all the manufacturing industry sectors.

Table 3.4 Manufacturing industry sub-sectors analysis

Sector	Sub-sector	No. of employees/ company
Food , Beverages & Tobacco	1.Food	7.8
	2 Beverages	58.6
	3.Tobacco Manufacturers	102.7
Textile, Wearing Apparel& Leather	1.Textiles	12.1
	2.Wearing Apparel except footwear	7.9
	3.Leather and Fur products	10.9
	4.Footwear	15.5
Wood and Wood Products including furniture	1.Wood and Cork Products Except Furniture	2.7
	2.Furniture and Fixtures (Wooden)	6.1
Paper and Paper products, Printing & Publishing	1.Paper and Paper Products	15.6
	2.Printing, Publishing and Allied industries	8.7
Chemicals and Chemical, petroleum Ruber and Pastic products	1.Industrial Chemicals	14.1
	2.Other Chemical Products	15.1
	3.Petroleum Refinery	52.3
	4.Ruber Products	9.7
	5.Plastic Products n.e.c.	36.2
Non Metallic Mineral Products	1.Pottery, China and Earthernware	3.4
	2.Glass and Glass products	6.1
	3.Other Non-Metallic Mineral Products	14.9
Metal products, Machinery &Equipment	1.Metal Products Except Machinery	4.3
	2.Machinery except Electrical	6.2
	3.Electrical Machinery and Apparatus	9.8
	4.Transport Equipment	6
	5.Manufacture of Photographic and Optical Goods	9.5
Other Manufacturing Industries	1.Other Manufacturing Industries	3.6
Average		7.4

Source: Cyprus Industrial Statistics 1995

3.4 Regional Distribution of the Manufacturing Industry

Having looked at the industry in terms of its size, structure and employment characteristics it is now proposed to look at the regional distribution of the industry in terms of number of firms and employment. Table 3.5 shows the regional distribution in terms of the above parameters.

Table 3.5 Regional distribution of the manufacturing industry

Source: Cyprus Industrial Statistics 1995

Region	Firms		Employees		No. of employees /firm
	no.	%	no.	%	
Nicosia	2821	43.8	24055	50.7	8.5
Limassol	1885	29.2	13342	28.1	3.6
Larnaca	1055	16.4	7370	15.6	6.9
Paphos	466	7.2	1843	3.9	7.1
Famagusta	216	3.4	787	1.7	3.9
Totals	6443	100	47397	100	

The larger concentration of firms (43.8%) is in the Nicosia area with 50.7% of the total employment. In the Limassol area there are 29.2% of the firms with 28.1% of the employment, while in the Larnaca area there are 16.4% of the firms with 15.6% of the employment.

In Paphos there are 7.2% of the firms with 3.9% of the employment, whereas in the Famagusta area there are 3.4% of the firms with 1.7% of the employment.

The largest firms are found in the Nicosia area with a ratio of employees/firm of 8.5. This ratio for the Limassol area is 7.1, for Larnaca 6.9 and for Paphos and Famagusta 3.9 and 3.6 respectively.

Most of the companies are found in the Nicosia area since that region has the higher population. A quite high number of companies are found in Limassol, because most companies re-established there from the Famagusta and Kyrenia areas after the events of 1974. The only region which did not experience manufacturing growth is the Paphos area. The main reason appears to be the traditional agricultural character of the region, the lack of appropriate infrastructure and the relatively long distance from the Nicosia area, Larnaca airport and the ports.

3.5 Performance of the Manufacturing Industry 1985 - 1995

Cypriot Manufacturing Industry's performance in the period 1985 - 1995 is as illustrated in tables 3.6 and 3.7

Table 3.6 Performance of the Cyprus manufacturing industry 1985-1995

Year	Gross output £000,s	Value added £000,s	Price deflator 1990=1	Gross output (1990 prices) £000,s	Value added (1990 prices) £000,s	Employment no.	Gross output/ person £	Value added/ person £
1985	685923	231867	0.777	882783	298413	44839	19687	6655
1986	670863	240509	0.780	860080	308344	43805	19634	7039
1987	752338	273710	0.801	939248	341710	45244	20759	7552
1988	839055	308639	0.873	961168	353538	47254	20340	7481
1989	915922	331652	0.958	956077	346192	48037	19903	7206
1990	1000787	361773	1	1000787	361773	48546	20615	7452
1991	1054105	379833	1.036	1017475	366634	48000	21197	7638
1992	1108774	416865	1.078	1028547	386702	48147	21362	8031
1993	1062975	413318	1.103	963712	374721	44783	21519	8367
1994	1132519	442559	1.129	1003116	391992	43902	22848	8928
1995e*	1186768	465634	1.165	1018684	399685	43972	23166	9089

*estimated values

Source: Cyprus Industrial Statistics 1995

Table 3.7 Annual growth of manufacturing industry 1985-1995 (constant market prices of 1990)

Year	Gross output %	Value added %	Employment %	Gross output per person %	Value added per person %
1986	-2.6	3.3	-2.3	0.2	5.7
1987	9.2	10.8	3.2	5.7	7.3
1988	2.3	3.4	4.4	-2.0	-0.9
1989	-0.5	-2.0	1.6	-2.1	-3.6
1990	4.6	4.5	1.0	3.5	3.4
1991	1.6	1.3	-1.1	2.8	2.5
1992	1.0	5.4	0.3	0.7	5.1
1993	-6.3	-3.1	-6.9	0.7	4.2
1994	4.1	4.6	-1.9	6.1	6.7
1995e	1.5	1.9	0.16	1.4	1.8

Source: Cyprus Industrial Statistics 1995

During this period Manufacturing Industry expanded further, but at a lower rate of growth than in the period 1975 - 1985. The main reason for this appears to be the significant weakening of external demand for manufactured products.

Employment in manufacturing industry experienced steady growth in the period 1986 - 1990 followed by a sharp decline (-6.9%) in 1993 . The highest annual increase occurred in 1987 and 1988 the values of which increased to 3.2% and 4.4% respectively. The total decline in the employment in the period 1985 - 1995 is -1.9%. The annual changes in employment are shown in Figure 3.1.

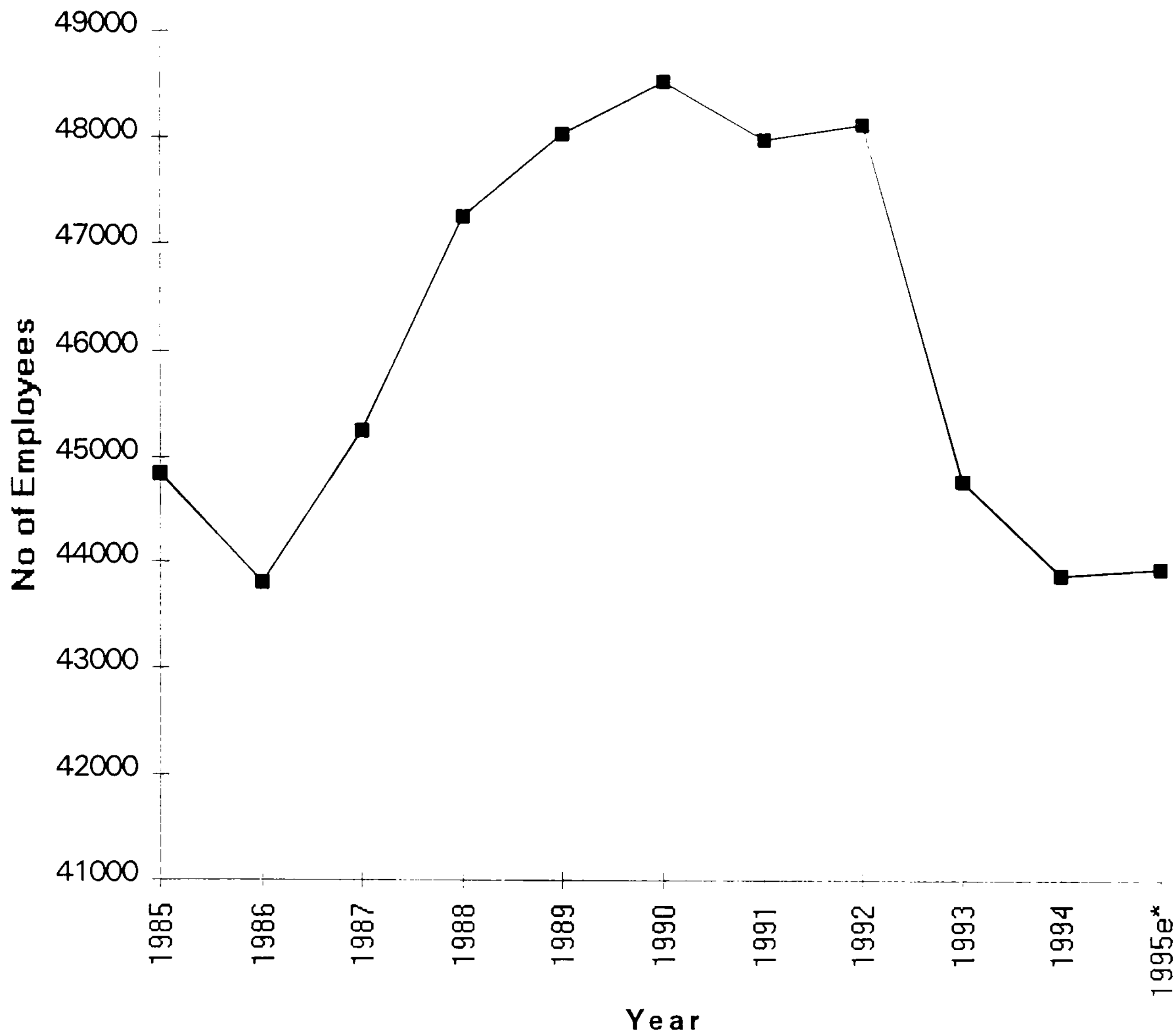

Fig. 3.1 Employment in the Cyprus manufacturing industry 1985 - 1995

Source: Cyprus Industrial Statistics 1995

In the period 1985 - 1995 there was a real increase in the **Gross Output** of the value of 15.4% . The highest increase occurred during 1987 and 1990 which amounts to 9.2% and 4.6% respectively, with a sharp decrease of 6.3% during 1993. The Annual changes in Gross Output and Value Added are shown in figure 3.2.

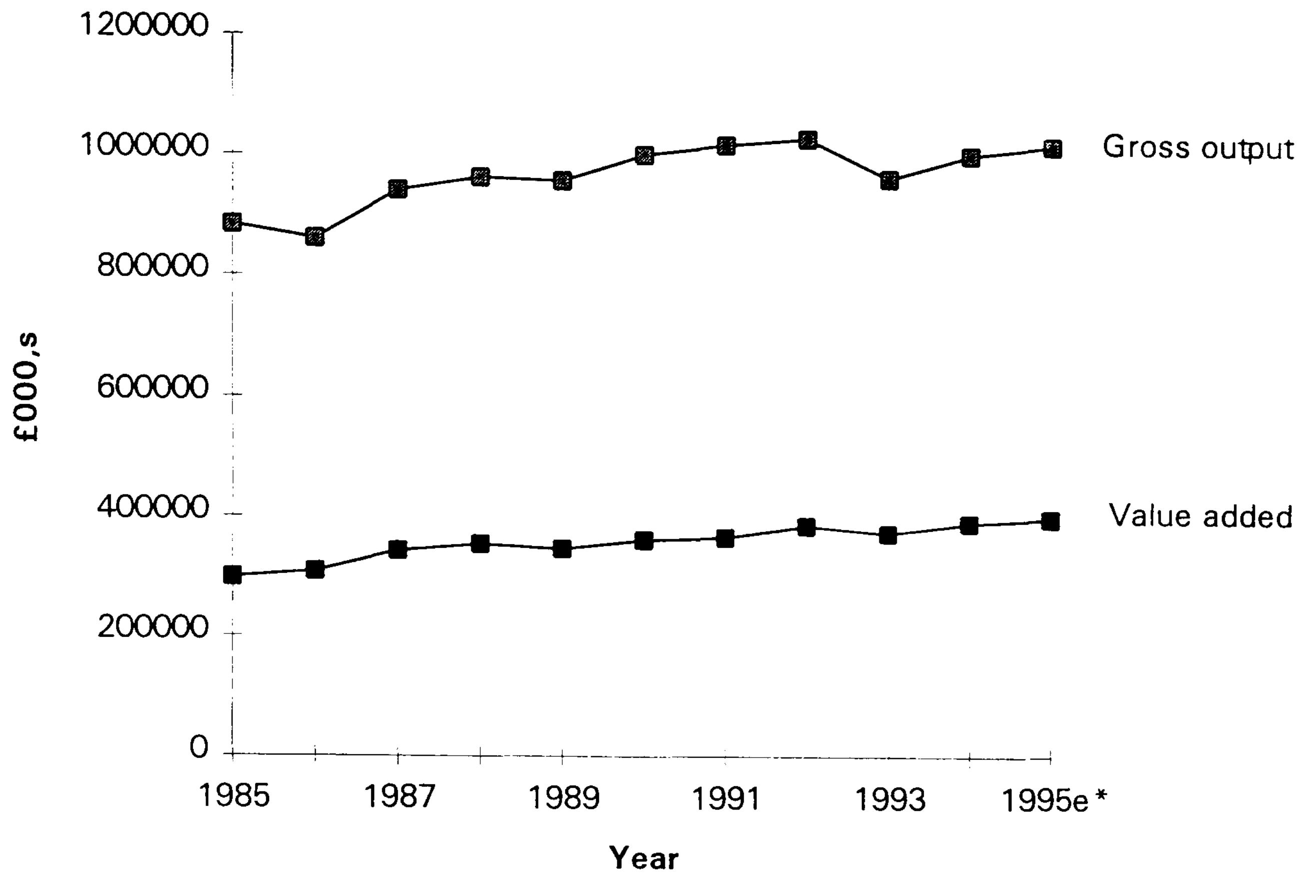

Fig. 3.2 Performance of the Cyprus manufacturing industry 1985-1995: Gross output & Value added

Source: Cyprus Industrial Statistics 1995

In terms of **Value Added** during this period there was again a low but steady increase of a value of 33.4% . The highest growth occurred during 1987 and 1990 with the value of 10.8 % and 4.5% respectively. Negative growth of -2% and -3.1% occurred during 1989 and 1993 respectively.

Gross Output per person has shown a cumulative increase of 17.7%. the annual growth rates occurred during 1987 and 1994 the values being 5.7% and 6.1% respectively. Drop in the Gross output per person occurred during the successive years of 1998 and 1989of the value of 2.0% and 2.1% . The annual changes in Gross Output per Person and Value Added per person are shown in Figure 3.3.

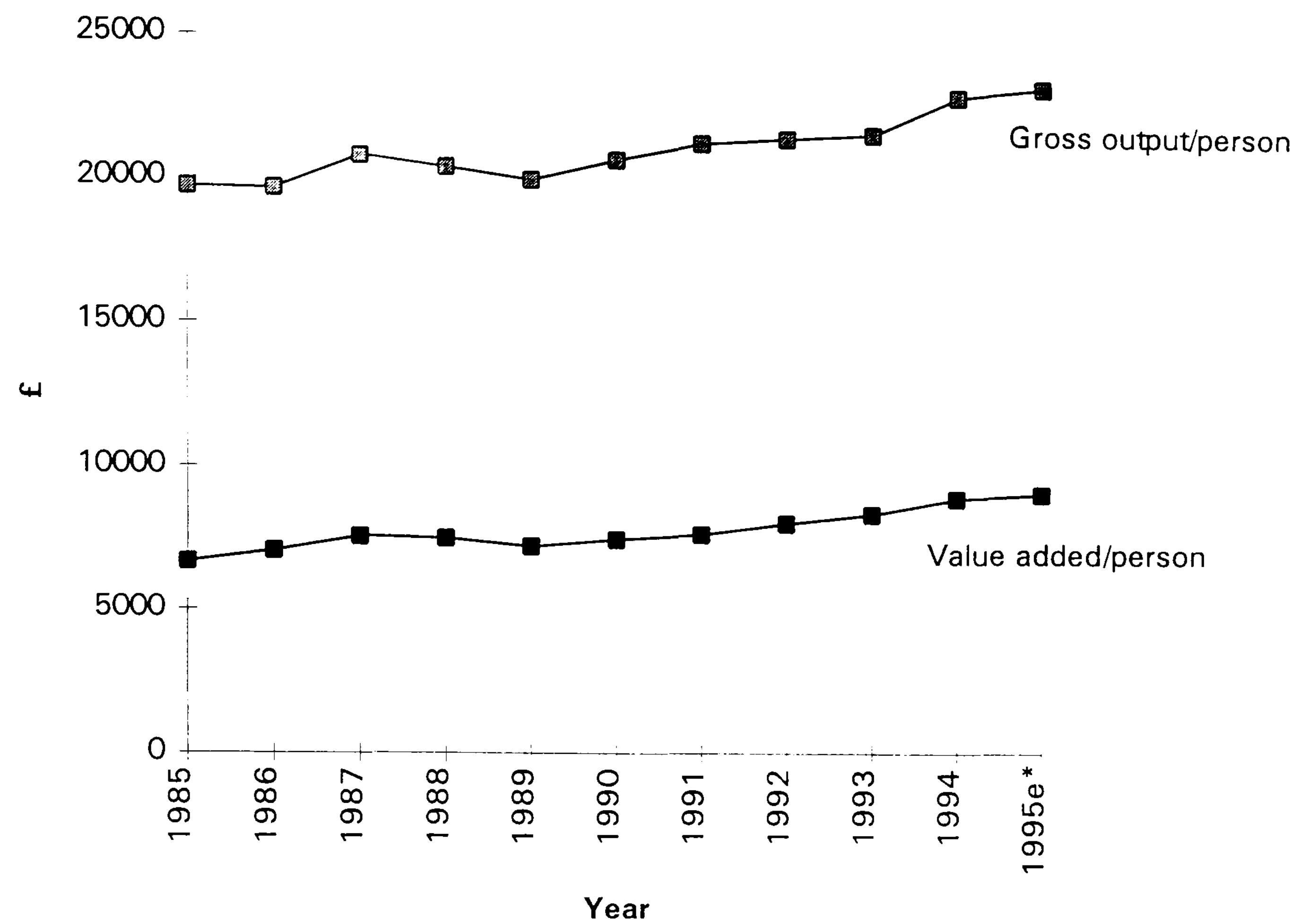

Fig.3.3 Performance of the Cyprus manufacturing industry 1985 - 1995 : Gross output/person & Value added/person

Source: Cyprus Industrial Statistics 1995

In the period 1985 - 1995 **Value Added per person** experienced a cumulative growth of 36.5% which is quite high compared with the other parameters. Again the highest increase occurred during 1987 and 1994 with the values being 7.3% and 6.7% respectively. Negative values occurred during 1988 and 1989 being -0.9% and -3.6% respectively.

The annual rate of growth of all the significant parameters described earlier, in the decade 1985 - 1995 shows a declining trend. As shown from figure 3.4 the sharpest decline of these parameters occurred during 1989 and 1993.

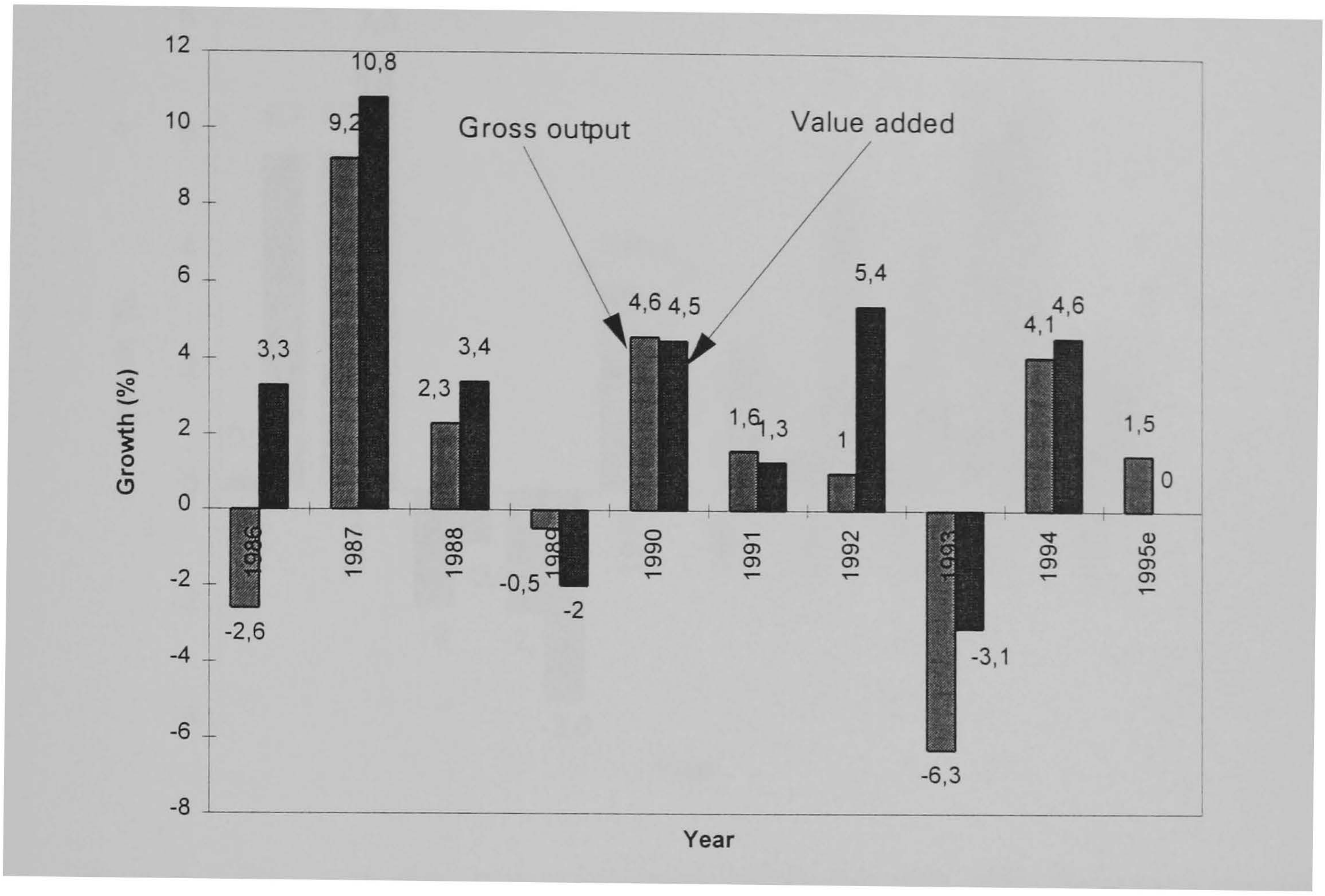

Fig. 3.4 Annual Growth of the Cyprus manufacturing industry 1985 - 1995: Gross output and Value added

Source: Cyprus Industrial Statistics 1995

The main reasons for this decline could be attributed to both the sharp decline in exports occurred during the above period and to the penetration in the local market by overseas manufacturers possessing significant competitive advantages. The above decline was realized in 1993 with a time lag of almost 2 years from the recession in Western Europe and the Gulf war. This time lag could be attributed to the small size of the Cypriot economy and on the other hand to the effort of the western companies to penetrate the home market, effort which was strengthened due to the recession in their traditional markets.

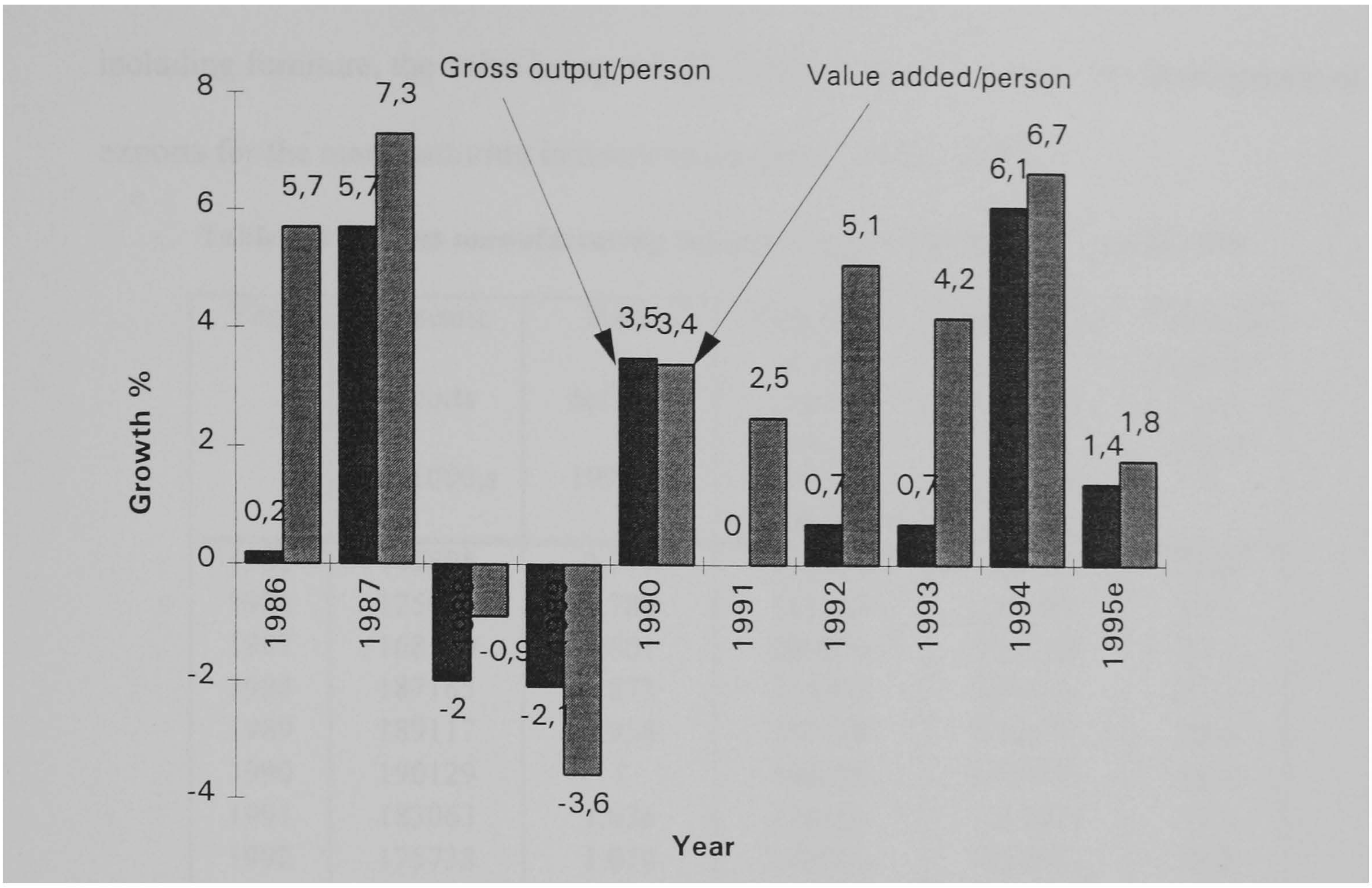

Fig. 3.5 Annual growth of the Cyprus manufacturing industry 1985 - 1995: Gross output/person & Value added/person

Source: Cyprus Industrial Statistics 1995

3.6 Manufacturing Exports from Cyprus

The Cyprus Manufacturing Industry is a locally oriented Industry. On average only 15% of the gross output is exported. From this amount 90% goes to Arab markets while the remainder goes to the E.U and other areas. During 1994 the Textile, Wearing Apparel and leather industries experienced the highest value of domestic exports being £57 million followed by the Food, beverages and tobacco industries with £39 million. The industry with the higher percentage of exports to Gross output is Textile, wearing Apparel and Leather industry with 31.9%, followed by the Chemicals and chemical, petroleum, rubber and plastic products industry with 15.8%. The industry with the lowest percentage of exports to Gross output are the Woods and wood products including furniture, the value being 3.02%. Tables 3.8 and 3.9 show the development of exports for the manufacturing industry in the period 1985 - 1995.

Table 3.8 Cyprus manufacturing industry exports development 1985-1995

Year	Domestic exports fob £000,s	Price deflator 1990=1	Domestic exports constant prices 1990 fob £000,s	Gross output constant prices 1990 fob £000,s	Domestic exports/ gross output %
1985	149808	0.777	192803	882783	21.8
1986	125911	0.780	161424	860080	18.7
1987	168130	0.801	209900	939248	22.3
1988	187165	0.873	214392	961168	22.3
1989	189117	0.958	197408	956077	20.6
1990	190129	1	190129	1000787	18.9
1991	183063	1.036	176701	1017475	17.3
1992	175738	1.078	163022	1028547	15.8
1993	157170	1.103	142493	963712	14.7
1994	165893	1.129	146937	1003116	14.6
1995e*	163807	1.165	140606	1018684	13.8

e*=estimated values
Source: Cyprus Industrial Statistics 1995

Table 3.9 Annual growth of exports for the Cyprus manufacturing industry 1985-1995

Year	Exports (constant prices 1990 (%)	Exports over gross output (%)
1986	-16.2	-14.2
1987	30.0	19.2
1988	2.1	0
1989	-7.9	-7.6
1990	-3.7	-8.2
1991	-7.1	-8.4
1992	-7.7	-8.7
1993	-12.6	-6.9
1994	3.1	-0.6
1995e*	-4.3	-5.4

Source: Cyprus Industrial Statistics 1995

Examining the period 1985-1995 on an annual basis the lower value of exports is estimated to have been in 1995 (£14million) and the higher in 1988 (£21million). The higher ratio of exports over Gross output occurred during 1987 and 1988 (22.3%) and the lower is estimated to have been during 1995. The annual changes in exports and exports/Gross Output are shown in figures 3.6 and 3.7.

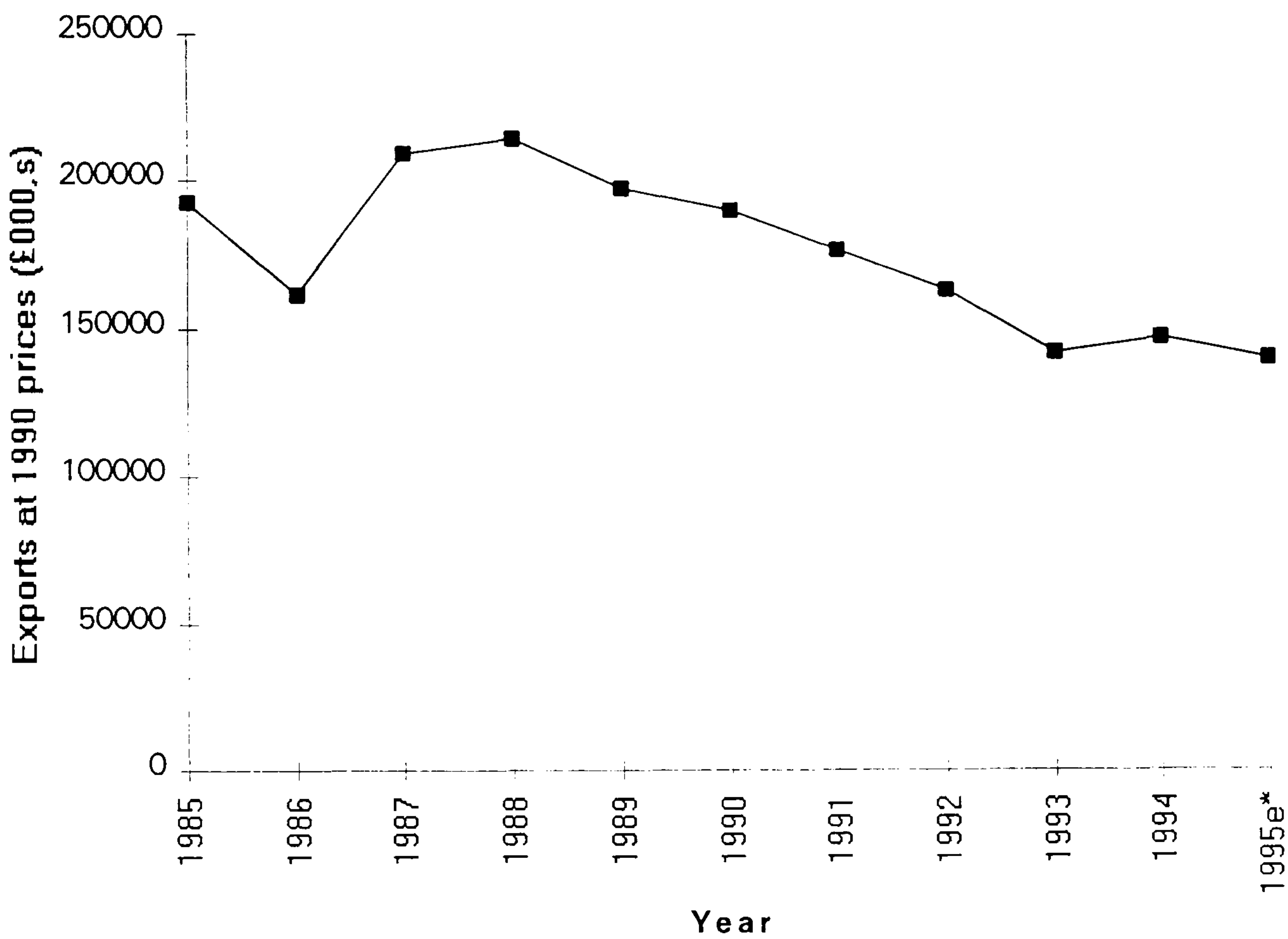

Fig.3.6 Cyprus manufacturing industry exports development

Source: Cyprus Industrial Statistics 1995

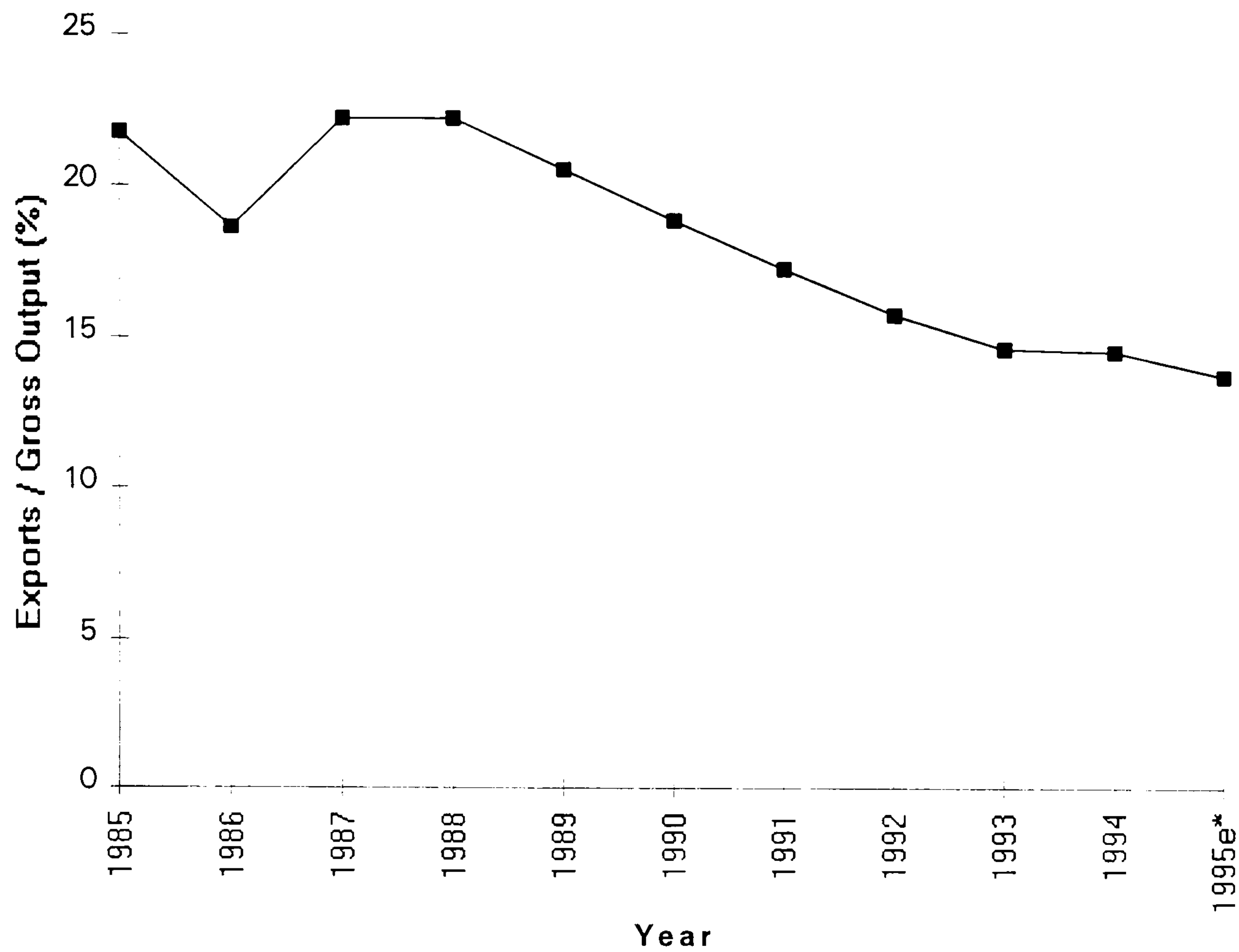

Fig. 3.7 Cyprus manufacturing industry exports/gross output development

Source: Cyprus Industrial Statistics 1995

In recent years there has been a rather steady decline of manufactured exports. In the period 1985 - 1995 there was a sharp decrease in exports of the order of -27% and a sharp decrease in the ratio of exports/gross output of -36.7%. In 1986 there was the highest annual decline of exports and exports over gross output of -16.2% and -14.2 respectively, while in the following years 1987, and 1988 the value of exports had experienced a cumulative growth of 32.1% and the value of Exports over gross output a growth of 19.2%.

This rather sharp and steady decline of exports during the past years could be attributed to the oil crisis which led to a fall in demand in the Arab markets, and the penetration of these markets by overseas firms possessing distinct competitive advantages in product quality and price (France, Italy, Japan, Korea etc). The growth of exports is shown in Figure 3.8

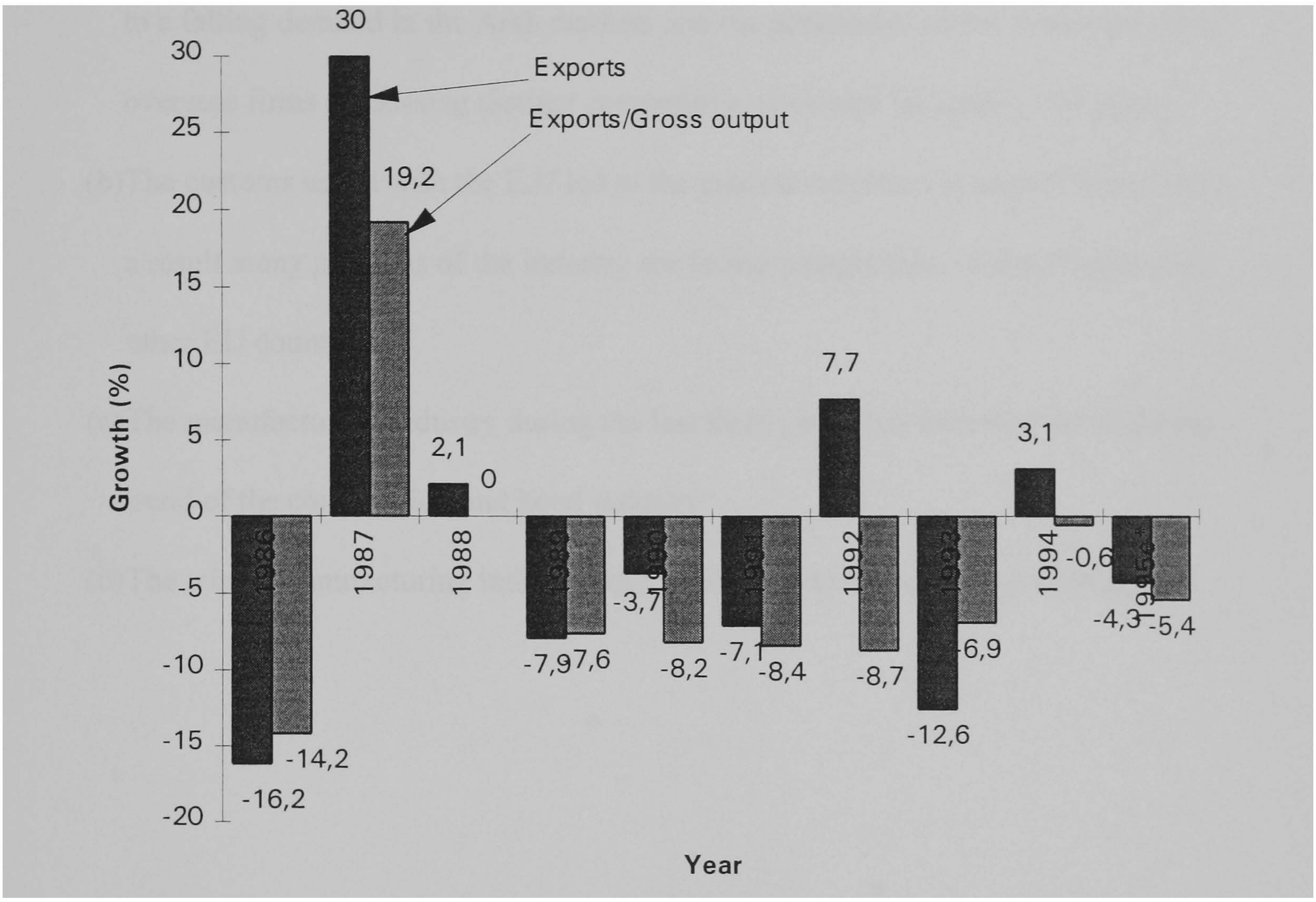

Figure 3. 8 Annual growth of exports of the Cyprus manufacturing industry: Total exports & exports/gross output

Source: Cyprus Industrial Statistics 1995

3.7 Summary

It is apparent that the Cypriot manufacturing industry experienced real growth during the period 1974 - 1990 with the gross output being 12.9% of the total manufacturing gross output. During the period 1985-1995, the industry started facing increasing difficulties. All the parameters (gross output, value added, employment, etc.) during the last years experienced a declining trend. The reasons for that decline can be summarised as follows:

(a) In recent years there has been a decline of exports due to the oil crisis which has led to a falling demand in the Arab markets and the penetration of the Arab markets by overseas firms possessing distinct competitive advantage (in quality and price).

(b) The customs union with the E.U led to the gradual reduction of import duties and as a result many products of the industry are facing competition within Cyprus from other EU countries.

(c) The manufacturing industry during the last three years has followed the declining trend of the construction and hotel industry .

(d) The whole manufacturing industry suffers from acute skilled labour shortages.

CHAPTER 4

QUESTIONNAIRE DESIGN

AND RESEARCH METHODOLOGY

4.1 Introduction

The primary aim of this chapter is to give a brief outline of the questionnaire which was prepared as a tool for the assessment of the implementation of Advanced Manufacturing Technologies in the Cypriot Manufacturing industry. A description of the research methodology is presented accompanied by an analysis of the general characteristics of the sample (employment, gross output, etc.)

4.2 Research Methodology

A specifically designed comprehensive questionnaire was used as a basis of extracting information from the companies. The questionnaire was based on recent developments in the subject and was designed after a thorough study of international literature. A set of management activities performed during the process of Justification, Transfer and Implementation of AMTs in the Cyprus Manufacturing Industry were examined followed by an investigation and quantification of the impact of AMT on a comprehensive set of company performance indicators grouped as competitive priorities and manufacturing parameters.

Competitive priorities are the features and characteristics of the products that are visible to the customer and attracts him to buy it. These include: price, quality consistency, product performance, delivery lead times, delivery performance, product design flexibility and volume flexibility.

Manufacturing parameters are those parameters in the production environment that affect directly the competitive priorities and are expected to be influenced by the introduction of AMT in the manufacturing environment. These include the quotation and design lead times, the design to manufacture lead times, the ability to design and manufacture new products, the manufacturing throuput time, the change over times, the manufacturing lead times, the batch size, the direct labour cost, WIP (Work In Progress), the average level of product quality etc.

Based on the impact of AMT on the above indicators which was measured on a 10 point scale, the level of success of each technology was established. The success was identified using a purpose developed formula which takes into consideration the impact of the technology on the specific indicator, the degree of influence this indicator had on the introduction of the technology as well as the importance level of the indicator on the company performance. Based on the level of success and the management activities identified in the process of Justification, Transfer and Implementation, a regression analysis was carried out to determine the factors contributing to the success or failure of the implementation of AMT. After a critical examination of the success and failure factors and the influence level of AMTs on the above mentioned indicators, an integrated planning model was devised to provide the framework and all the necessary information for the Cypriot manufacturers to identify their needs, justify and select the most appropriate AMT to satisfy their strategic plans and competitive priorities.

4.3 Questionnaire Administration

As stated before the questionnaire was based on the recent developments in the subject and was designed after a thorough study of international literature. Its structure includes four sections. each one addressing separate issues.

Sections A and B deal with the general characteristics of the companies and the application of Advanced Manufacturing Technologies. Section C determines the impact of AMT on the company products , competitive priorities and manufacturing parameters, while sections D and E examine the management process followed during the introduction and operation of AMT in the manufacturing environment. A brief description of each section of the questionnaire is given below, while the full questionnaire is presented in Appendix "B".

Section A : General Characteristics of the Companies

This section includes questions which aimed to extract information of a general nature, and relate to the introduction and implementation of Advanced Manufacturing Technologies. In detail it yields information on :

- The employment characteristics of the companies
- The manufacturing characteristics
- The operational characteristics and
- The production plant characteristics

Section B: Advanced Manufacturing Technologies: Present and Future Applications

This section examines the level of application of AMT in the surveyed companies. In particular it investigates the present and future applications of CAD systems, NC and CNC machines , CAD/CAM systems, Robotics, Flexible Manufacturing Systems (FMS), Automatic Guided Vehicles (AGVs), Manufacturing Resources Planning Systems (MRP) etc.

Section C: Impact of AMT on Company Competitiveness - Successes and Failures of AMT

This section examines the impact of AMT on company competitiveness. In detail, it extracts information on :

- The impact of AMT on product - market characteristics
- The impact of AMT on the company's competitive priorities
- The impact of AMT on the manufacturing parameters and
- The estimated and the real situations as to the level of competitive priorities a company should possess

Section D: AMT Planning Factors

This section examines the level of planning for the implementation of AMT . In detail the following are addressed:

- The factors influencing the decision to introduce AMT
- Problems in financial Justification of AMT
- The planning level of the AMT Transfer process
- The planning level of the AMT Implementation process

Section E : AMT Operational Factors

This section examines the management process followed during the Transfer and Implementation of AMT in the manufacturing environment. Specifically, it addresses the following:

- Technology selection and transfer issues
- Infrastructure preparation issues

* Workforce preparation issues etc.

4.4 Sample Characteristics

The survey was conducted on a sample of 40 companies using personal interviews based on the aforementioned questionnaire. The surveyed population consisted of firms in the Machine Tools, Pumps manufacturers, Metal and Wooden Furniture manufacturers, Refrigerator manufacturers, printing industries, and Ice Cream manufacturers. It is interesting to mention that the above sample covers nearly all the companies in the Cypriot Manufacturing Industry which have introduced AMT. The surveyed technologies are shown in Figure 4.1 below.

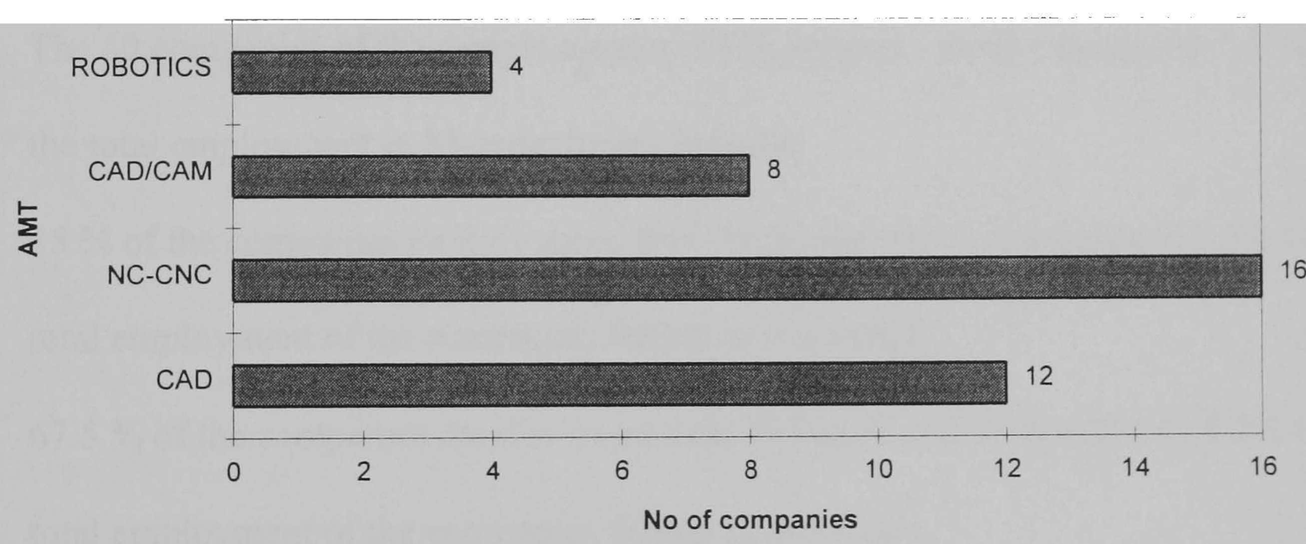

Figure 4.1 Surveyed technologies

The sample has the employment characteristics shown in table 4.1

Table 4.1 Employment characteristics

Employment (Range)	Total no of companies	Total no of employees	No. of employees in the mfg dept	Mfg dept employees / total no. of employees
0 - 9	2	6	4	66.67%
10 - 19	11	164	121	73.78%
20 - 49	13	462	333	72.08%
50 - 99	8	500	384	76.8%
100+	6	1290	1056	81.86%
Totals	40	2422	1898	78.36%

Some useful and informative details about the sample profile are given below:

- The 40 companies of the sample employ 2422 persons, which amounts to 5.5 % of the total employment in Manufacturing Industry
- 35 % of the companies employ more than 50 people which amounts to 11.6% of the total employment of the companies falling in this range.
- 67.5 % of the companies employ more than 20 people which amounts to 8.2% of the total employment of the companies falling in this range.
- The average number of employees / firm is 60.5, compared to 7.4 of the total industry, while the ratio of the employees employed in manufacturing activities to total number of employees is 78.36%

The Gross Output characteristics of the sample are shown in Figure 4.2.

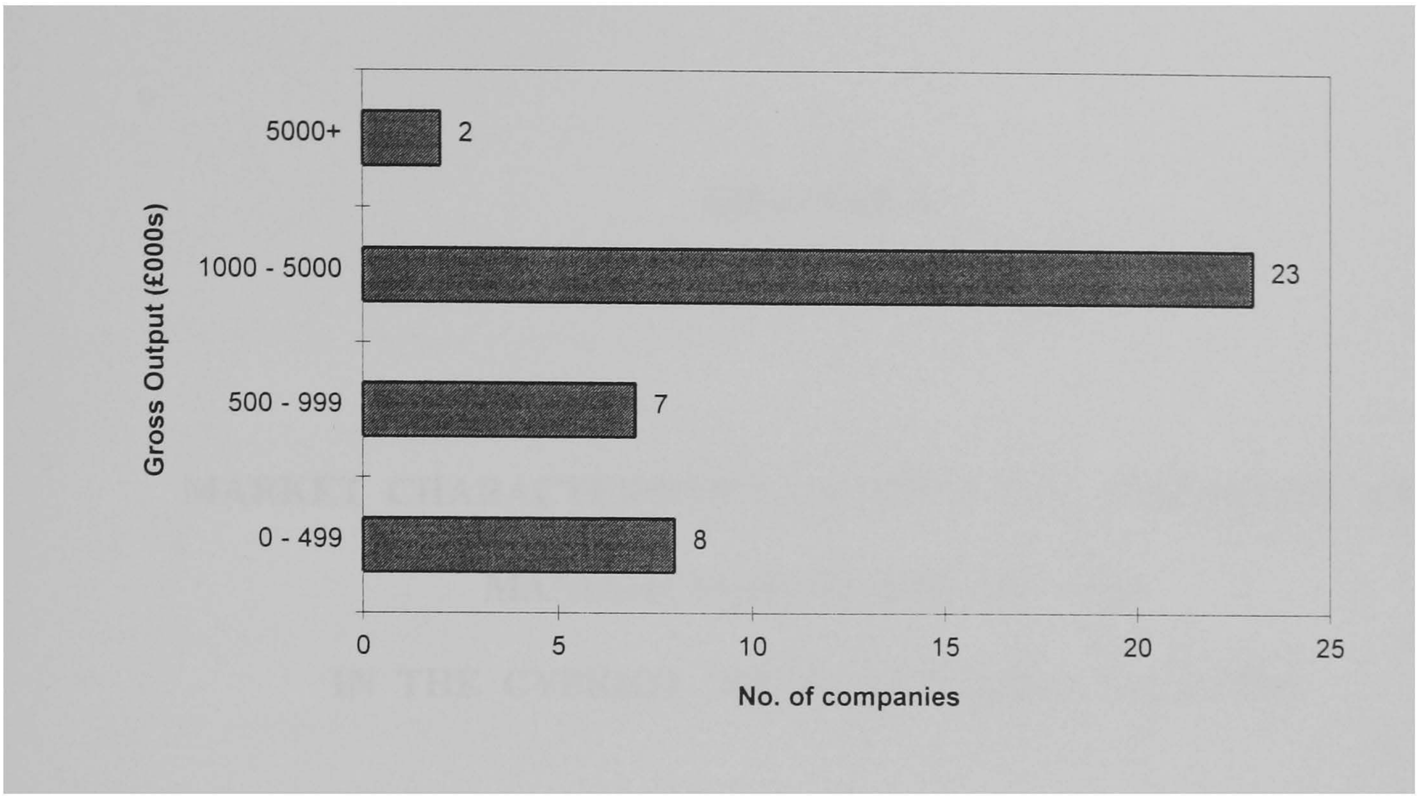

Figure 4.2 Gross Output Characteristics

The total gross output accounts for £ 64.3 million, which is 5,67 % of the total gross output of the industry. The majority of the companies (57.5%) have an annual turnover in the range of £ 1 million to £ 5 million. The average value added of the sample as a percentage of gross output is 61.9% which is much higher than that of the sector's average which is 39%.

It is obvious from the above that the companies which are more likely to introduce AMT are the larger ones both in terms of number of employees and Gross Output.

CHAPTER 5

MARKET CHARACTERISTICS, COMPETITIVE PRIORITIES AND MANUFACTURING PARAMETERS IN THE CYPRIOT MANUFACTURING INDUSTRY

5.1 Introduction

The aim of this chapter is to establish the framework in which Cypriot manufacturing Industry is operating with emphasis given to the competitive priorities and manufacturing parameters. The level of existence of various plant characteristics of the companies is investigated and correlated with the level of integrative cultures present in the companies. Special emphasis is given to establishing the actual optimum level of competitive priorities a company should posses in order to safeguard its competitiveness in the market place. Further on, an examination of the level of importance given to each competitive priority and manufacturing parameter is established. Finally, the general impact of the introduction of AMTs on the manufacturing parameters and competitive priorities of the companies is calculated . Based on these results the relationship between the manufacturing parameters and competitive priorities is closely examined.

Correlation analysis is used to examine the above relationships.
The coefficient of correlation is estimated from the formula

$$r = Sxy / Sx. Sy = \Sigma dx . dy / (\Sigma dx . \Sigma dy).$$

It ranges from -1 to +1, and is a measure of the degree of linear association of the two variables. If $r = 0$ the two variables are un-correlated but not necessarily un-associated. [Brookes et al (1969)] As a rule , in our analysis factors with a correlation coefficient greater than 0.3 and level of significance below 0.05 where considered as highly correlated. Further on descriptive statistics (mean values and standard deviations) where used to show the importance level of the factors. The factors where scored in a 10 point scale (1= not important or low level , 10 = very important or high level). Low standard deviation indicates the high cohesiveness of the factors (low spread)

5.2 Manufacturing Plant Characteristics

Table 5.1 shows the manufacturing plant characteristics appearing in the Cypriot manufacturing companies which proceeded with the introduction of a form of AMT. The research results reveal that the capacity utilization of the firms which proceeded with the adoption of AMT is up to 74% with a standard deviation of 16.9% . The plant flexibility is quite high, its mean value being up to 8.1 with standard deviation 1.1. The technology intensity of these companies have a mean value of 7.9 with a standard deviation of 1.3 . All the companies which proceeded with the adoption of AMT have a high degree of vertical integration, the mean value being 8.15 with a standard deviation of 2.1. It is important to mention the low standard deviation of the above obviously high values showing the high cohesiveness of the plants in those companies. An interesting finding is the low level of sub-contracting that takes place both in terms of a company subcontracting work or acting as a subcontractor.

Table 5.1 Manufacturing plant characteristics

Variable	Mean	Std.Dev	N
A231	7.38	1.69	40
A232	8.10	1.10	40
A233	7.90	1.32	40
A234	8.15	2.08	40
A235	1.85	1.63	40
A236	1.43	1.38	40

A231 Capacity Utilization
A232 Plant Flexibility
A233 Technology Intensity
A234 Degree of vertical integration
A235 Degree of subcontracting
A236 Degree of operating as a subcontractor

A careful consideration of the above results indicates the high correlation that exists between technology intensity, plant flexibility and capacity utilization of the plant. This is also reinforced by the correlation coefficient matrix shown on Table 5.2. The matrix indicates a strong relationship between "Technology intensity" and degree of "vertical integration" with a correlation coefficient of 0.43. A high correlation coefficient of 0.38 also exists between "technology intensity" and "plant flexibility"indigating thus the Cypriot manufacturer is investing in flexible technologies.

Table 5.2 Correlation matrix of companies manufacturing plant characteristics

	A231	A232	A233	A234	A235	A236
A231	1.00000					
A232	.06180	1.00000				
A233	-.12101	.37726	1.00000			
A234	.04919	.08248	.42650	1.00000		
A235	-.05366	.12276	.11260	.12042	1.00000	
A236	-.16962	.14006	.13735	.05775	-.00516	1.00000

A231 Capacity Utilization
A232 Plant Flexibility
A233 Technology Intensity
A234 Degree of vertical integration
A235 Degree of subcontracting
A236 Degree of operating as a subcontractor

5.3 Company Cultures and Manufacturing Plant Characteristics

Table 5.3 Shows the level of existence of integrative company cultures in the companies which proceeded with the implementation of AMTs.

Table 5.3 Company cultures

Variable	Mean	Std Dev	N
A241	8.32	.83	40
A242	7.78	1.21	40
A243	7.55	1.39	38
A244	7.58	1.45	40
A245	6.75	2.08	40
A246	8.20	1.44	40
A247	8.03	1.23	40

A241 Receptivity to new ideas
A242 Faster approval
A243 Collaboration between departments
A244 Abundant praise and recognition
A245 Advance warning of changes, open circulation of information
A246 Extra resources available
A247 Attitude that we are always learning

The results reveal that in general the cultures in the companies which proceeded with the implementation of AMTs are quite open and integrative. A culture which is widely spread is that of "receptivity to new ideas" followed by the "provision of extra resources".

A bivariate correlation between the companies cultures and the level of the manufacturing plant characteristics could provide interesting results. Table 5.4 shows the correlation matrix between plant characteristics and companies cultures.

Table 5.4 Correlation matrix of companies cultures and production plant characteristics:

	A231	A232	A233	A234	A235	A236
A231	1.00000					
A232	-.00472	1.00000				
A233	-.19689	.31428*	1.00000			
A234	.01566	.03471	.40217*	1.00000		
A235	-.06218	.13769	.12683	.12625	1.00000	
A236	-.30084*	.06975	.05473	.00585	.15853	1.00000
A241	.11093	.33479*	.33979	.22559	.02932	-.13845
A242	.35753*	.14890	.17378	.13390	.15522	-.02201
A243	.06224	.20667	.29933	-.00607	.06742	-.18335
A244	.20531	.38456*	.45243*	.04737	.12897	-.07962
A245	.18900	.25099	.24561	.19105	-.15284	.04209
A246	.16168	.45163*	.40679*	.23722	.06401	.08358
A247	.14950	.28858	.56341*	.35808*	.09157	-.06167

A231 Capacity Utilization
A232 Plant Flexibility
A233 Technology Intensity
A234 Degree of vertical integration
A235 Degree of subcontracting
A236 Degree of operating as a subcontractor
A241 Receptivity to new ideas
A242 Faster approval
A243 Collaboration between departments
A244 Abundant praise and recognition
A245 Advance warning of changes, open circulation of information
A246 Extra resources available
A247 Attitude that we are always learning

* $P < 0.05$

The results reveal a relatively strong relationship between the companies ability for "fast approval" with plant "capacity utilization", giving a correlation coefficient of 0.36. Companies which give special attention to providing "extra resources" when the need arises experience high "plant flexibility". High "plant flexibility" exists in companies where "praise and recognition" is abundant and the "management receptivity to new ideas" is high. The correlation coefficient between these factors is 0.45, 0.38 and 0.33 respectively.

Companies where the attitude that "we are always learning" is high and the "praise and recognition" is abundant, managed to achieve higher plant "technology intensity" than others. The respective correlation coefficients are 0.45 and 0.38. High plant "technology intensity" is found also in companies which give special attention to providing "extra resources" when the need arises (correlation coefficient 0.41). The results also reveal that for companies that are highly "vertically integrated" the "attitude towards continues learning" is high giving a correlation coefficient of 0.36.

5.4 Manufacturing Parameters and Competitive Priorities. Level of Importance

Table 5.5 shows the level of importance of the competitive priorities in the companies, that proceeded with the implementation of a form of AMT.

Table 5.5 Level of importance of competitive priorities

Variable	Mean	Std Dev	N
D111	7.60	1.17	40
D112	9.47	.75	40
D113	9.25	.74	40
D114	8.95	1.15	40
D115	9.28	.93	40
D116	8.57	1.38	40
D117	8.03	1.46	40

D111 Price
D112 Consistent quality
D113 Performance design
D114 Delivery Lead time
D115 Delivery performance
D116 Product / Design flexibility
D117 Volume flexibility

The results of the survey reveal that the most important Competitive priority of Cypriot Manufacturing Industry is the "Quality Consistency" with a mean value of importance 9.47 and standard deviation 0.75. The "delivery performance" parameter is also very important for the industry with a mean value of 9.28 and standard deviation 0.93. A very interesting finding is that "product price" is the competitive priority with the lowest level of importance, its mean value being 7.60 and standard deviation 1.17. These results are in line with the results presented by Bessant (1993) in his paper entitled " The lessons of failure: learning to manage new manufacturing technology". In that paper Bessant , presents the results obtained from a survey conducted by business schools in Europe, the USA and Japan. In that survey senior executives of European manufacturing firms rated their main competitive priorities. They rated Quality as the most important priority followed by delivery promises and flexibility. Price factor got low scoring.

Table 5.6 list the level of importance of the manufacturing parameters .

Table 5.6 Level of importance of manufacturing parameters

Variable	Mean	Std Dev	N
D121	8.08	2.02	39
D122	8.00	1.62	40
D123	8.37	1.81	40
D124	8.18	1.74	40
D125	8.52	1.32	40
D126	7.77	1.51	40
D127	9.08	.92	40
D128	8.37	1.58	40
D129	8.60	1.52	40
D1210	8.92	1.19	40
D1211	7.90	1.50	40
D1212	6.95	2.23	40
D1213	8.07	1.80	40
D1214	8.75	1.30	40
D1215	6.77	2.19	39
D1216	7.95	1.54	40
D1217	7.90	1.30	40
D1218	7.52	1.85	40
D1219	9.57	.59	40
D1220	8.92	1.12	40
D1221	8.50	.99	40

D121 Quotation and design lead times
D122 Design to manufacture lead times
D123 Ability to design and manufacture new products
D124 Materials optimization due to design
D125 Improved product quality due to design
D126 Component and tooling standardisation
D127 Manufacturing throuput time
D128 Scrap rate and rework
D129 Change over time
D1210 Manufacturing lead times

D1211 Batch size
D1212 Space and assets
D1213 Plant down time
D1214 Direct labour cost
D1215 Finished goods stocks
D1216 Raw materials stocks
D1217 Supervision utilization (less routine administration
D1218 WIP (Work In Progress)
D1219 A.O.Q.L (Average Order Quality Level
D1220 Response to quality control traisability quiries
D1221 Management time utilization

In terms of the manufacturing parameters the most important parameter of the industry is the "Average Order Quality Level" (A.O.Q.L) of the product, its mean value being 9.57 and standard deviation 0.59. Another important parameter is the "manufacturing throughput time" with a mean value of 9.08 and again a low standard deviation of 0.92 . The high mean values of these parameters are in line with the high values given to the "consistent quality", "performance design" and "delivery performance" competitive priorities. A high correlation exists between "A.O.Q.L" and "performance design" of 0.42 and between "Manufacturing throughput time" and "Delivery performance" parameters of 0.40.

5.5 Competitiveness of Companies that have Adopted AMT. Impact of AMT on Manufacturing Parameters and Competitive Priorities

In general, the competitiveness of the manufacturing companies that proceeded with the implementation of AMT is quite high. The adoption of AMTs had a positive influence on the competitive priorities and to the companies' manufacturing parameters.

Table 5.7 shows the level of competitive priorities of the companies that proceeded with adoption of AMTs before and after the installation and operation of these technologies.

Table 5.7 Level of Competitive Priorities before and after the implementation of AMTs

Variable	Mean (before AMTintroduct.)	Std Dev (before AMTintroduct.)	Mean (after AMT introduction)	Std Dev (after AMT introduction)	N
C1141	6.18	1.12	7.59	1.19	39
C1142	5.97	1.53	8.69	1.00	39
C1143	6.15	1.51	8.28	1.10	39
C1144	5.49	1.75	8.08	1.31	39
C1145	5.92	2.01	8.23	1.35	39
C1146	5.55	1.98	8.03	1.38	38
C1147	5.51	1.67	8.36	.90	39

C1141 Price
C1142 Consistent quality
C1143 Performance design
C1144 Delivery Lead time
C1145 Delivery performance
C1146 Product / Design flexibility
C1147 Volume flexibility

Particularly, the implementation of AMTs shifted the mean value of the "price" parameter from 6.18 to 7.59, the value of the "quality consistency" from 5.97 to 8.69, that of "performance design" from 6.15 to 8.28. The mean values of "delivery lead times" shifted from 5.49 to 8.08 , the "delivery performance" from 5.92 to 8.23, the "product/design flexibility" from 5.55 to 8.03 and finally the "volume flexibility" from 5.51 to 8.36.

The level of manufacturing parameters before and after the implementation of AMTs are shown in table 5.8 below.

Table 5.8 Level of Manufacturing Parameters before and after the implementation of AMTs

Variable	Mean (before AMTintroduct.)	Std Dev (before AMTintroduct.)	Mean (after AMT introduction)	Std Dev (after AMT introduction)	N
C11521	6.81	1.72	7.83	1.06	36
C11522	5.95	1.69	7.66	1.26	38
C11523	5.56	1.90	7.97	1.35	39
C11524	6.59	1.52	7.62	1.11	39
C11525	6.54	1.39	7.51	1.10	39
C11526	6.05	1.47	7.74	.99	39
C11527	5.62	1.27	7.97	1.04	39
C11528	6.05	1.82	7.69	1.56	39
C11529	5.68	1.73	8.16	1.24	38
C115210	5.97	1.35	7.95	1.02	39
C115211	5.76	1.50	7.95	1.29	38
C115212	6.41	1.76	6.90	1.64	39
C115213	7.45	1.55	7.82	1.16	38
C115214	5.72	1.19	7.69	1.13	39
C115215	7.00	2.12	7.49	1.73	39
C115216	6.18	1.96	6.46	1.86	39
C115217	6.28	1.64	7.59	1.02	39
C115218	6.18	2.02	7.33	1.49	39
C115219	6.15	1.18	8.41	1.02	39
C115220	6.51	1.80	7.90	1.17	39
C115221	6.36	1.65	7.56	1.25	39

C11521 Quotation and design lead times
C11522 Design to manufacture lead times
C11523 Ability to design and manufacture new products
C11524 Materials optimization due to design
C11525 Improved product quality due to design
C11526 Component and tooling standardisation
C11527 Manufacturing throughput time
C11528 Scrap rate and rework
C11529 Change over time
C115210 Manufacturing lead times
C115211 Batch size
C115212 Space and assets,
C115213 Plant down time,
C115214 Direct labour cost
C115215 Finished goods stocks
C115216 Raw materials stocks,
C115217 Supervision utilization (less) routine administration
C115218 WIP (Work In Progress)
C115219 A.O.Q.L (Average Order (Quality Level
C115220 Response to quality control traicability queries
C115221 Management time utilization

It is obvious from the results that the introduction of AMTs had a quite positive impact on these parameters. The mean value of the "A.O.Q.L" parameter has shifted from 6.15 to 8.41, the "direct labour cost " from 5.72 to 7.69 and the "ability to design and manufacture new products" from 5.56 to 7.97. The "scrap rate and rework" has shifted from 6.05 to 7.69 , the "change over times" from 5.69 to 8.16, the manufacturing throuput times from 5.62 to 7.97 etc.

Table 5.9 below gives the estimated and the actual optimum levels of the competitive priorities a company should posses in order to be able to compete in the market place.

Table 5.9 Estimated and Actual Optimum Levels of Competitive Priorities

Variable	Mean (estimated.)	Std Dev (estimated.)	Mean (actual)	Std Dev (actual)	N
C221	7.70	1.42	8.13	1.60	40
C222	9.38	.90	9.30	.85	40
C223	9.13	.88	9.15	.80	40
C224	9.07	.89	9.30	.79	40
C225	9.25	.98	9.48	.78	40
C226	8.43	1.20	8.70	.99	40
C227	8.15	1.21	8.30	1.18	40

C221 Price
C222 Consistent quality
C223 Performance design
C224 Delivery Lead time
C225 Delivery performance
C226 Product / Design flexibility
C227 Volume flexibility

The results reveal the highly competitive market (in terms of price, quality, delivery times, and product / volume flexibility), in which the Cypriot manufacturing industry is exposed and is called to compete with. A comparison of these figures with the actual achievement of the industry after the introduction of AMTs (table 5.7) shows that the companies which have implemented AMTs managed to become quite competitive but still there is room for improvement. Interestingly the optimum level of the "price" priority is estimated to be 8.13 while the achieved level is 7.59. The optimum level for the "quality consistency" is 9.30 while the achieved one is 8.69. For the "performance design" the optimum level is 9.15 with the achieved being 8.28 .

The average industry level of these parameters could be estimated by the level of their existence in the sample companies before the introduction of AMTs. The level of these parameters is quite low reflecting the poor condition of the industry. The mean value of the "price" indicator is 6.18 with a standard deviation of 1.12 , the value of "consistency in quality" is 5.97 with a standard deviation of 1.53 and the "performance design" down to 5.49 with 1.75 standard deviation.

The results of the estimated and the actual mean levels of the competitive priorities a manufacturing product should have to be competitive reveals a quite large shifting of nearly all of the competitive priorities showing thus the high **unexpected** competition which the Cypriot manufacturing industry is facing. In more detail there is an increase in the level of price factor from 7.7 to 8.13 indicating thus the price sensitiveness of the market. An interesting finding is the small degrease of quality related factors, but nevertheless these are still the most important ones. The highest value (9.48) is given to the "delivery performance" parameter which shows the time consciousness of the market.

A critical examination of the above results could give the framework on which the Cypriot manufacturing companies should base the formulation of their Business Strategies in order to achieve business competitiveness.

5.6 The Impact of Manufacturing Parameters on Competitive Priorities. Relationship Levels.

One of the major objectives of the survey was to determine the impact each AMT has on the companies' manufacturing parameters and finally on their competitive priorities. Based on these cascaded impacts it is then possible to proceed to establish the relationship which exists between the manufacturing parameters and competitive priorities. In order to establish that, the cascaded impacts of the manufacturing parameters on the competitive priorities were calculated, followed by the calculation of the respective correlation. The correlation matrix is shown in Table 5.10. A critical examination of that table reveals the following for each of the competitive priorities:

(i) *Price*

The correlation coefficient shows that the manufacturing parameter with the greatest effect is the *scrap rate and rework* with a correlation coefficient of 0.6, followed by the *manufacturing throughput time* and *A.O.Q.L* parameters with correlation coefficients of 0.57 and 0.56 respectively. Important contributing factors with positive influence to the price parameter are the *direct labour cost* and the *improved batch size* with correlation coefficients of 0.47 and 0.40 respectively.

Table 5. 10 Correlation coefficients between changes in manufacturing parameters and changes in competitive priorities

	CC1141	CC1142	CC1143	CC1144	CC1145	CC1146	CC1147
CC1141	1.00000						
CC1142	.46770*	1.00000					
CC1143	.22273	.51245*	1.00000				
CC1144	.41561*	.69800*	.46484*	1.00000			
CC1145	.38759*	.53877*	.52954*	.80875*	1.00000		
CC1146	.04890	.32491*	.61114*	.55884*	.55757*	1.00000	
CC1147	.33500*	.39186*	.39484*	.50322*	.54006*	.40482*	1.00000
CC11521	-.31748*	-.04968	.30720*	.23599	.16454	.36827*	.14057
CC11522	.13217	.33234*	.54719*	.54933*	.35867*	.59400*	.33907*
CC11523	.00445	.28397	.63073*	.41709*	.41570*	.69703*	.31770*
CC11524	-.10190	.18659	.11464	.33052*	.03384	.06993	-.02462
CC11525	-.04395	.21161	.47824*	.33356*	.36542*	.38961*	.28656
CC11526	.36062*	.36400*	.31547*	.43098*	.30969*	.28717	.10239
CC11527	.57351*	.58443*	.26166	.53156*	.47902*	.15485	.48559*
CC11528	.59460*	.19391	.07383	.06341	.12195	-.20018	.14921
CC11529	.22143	.19929	.23520	.35390*	.37561*	.58002*	.69041*
CC115210	.33142*	.20247	.10409	.27742	.20895	.03924	.41717*
CC115211	.40182*	.32364*	.25421	.35455*	.50242*	.26815	.77803*
CC115212	.23211	.15202	.26128	.29076	.31881*	.28429	.29811*
CC115213	-.02927	.08069	-.22099	.18653	.00894	.21730	-.02608
CC115214	.47097*	.35745*	.27134	.26330	.44086*	.22229	.39127*
CC115215	.31759*	.09246	.02830	.27061	.17970	.26015	.23651
CC115216	-.13792	-.29751	-.23561	-.29718	-.12313	.02390	-.11499
CC115217	-.03231	.28829	.15881	.19347	.12660	.20865	.10404
CC115218	.14863	.07339	.07912	.14479	.24044	.14711	.30306*
CC115219	.56769*	.48902*	.34473*	.52064*	.45212*	.32112*	.49158*
CC115220	-.09706	.14685	.01193	.24477	.16171	.23090	.07249
CC115221	-.11249	.17966	.08770	.17583	.17351	.14492	-.03119

CC1141 Price
CC1142 Consistent quality
CC1143 Performance design
CC1144 Delivery Lead time
CC1145 Delivery performance
CC1146 Product / Design flexibility
CC1147 Volume flexibility
CC11521 Quotation and design lead times
CC11522 Design to manufacture lead times
CC11523 Ability to design and manufacture new products
CC11524 Materials optimization due to design
CC11525 Improved product quality due to design
CC11526 Component and tooling standardisation
CC11527 Manufacturing throughput time
CC11528 Scrap rate and rework
CC11529 Change over time
CC115210 Manufacturing lead times
CC115211 Batch size
CC115212 Space and assets
CC115213 Plant down time
CC115214 Direct labour cost
CC115215 Finished goods stocks
CC115216 Raw materials stocks
CC115217 Supervision Utilization (less routine administration
CC115218 WIP (Work In Progress)
CC115219 A.O.Q.L (Average Order Quality Level)
CC115220 Response to quality control traicability queries
CC115221 Management time utilization

Note: The factors represent impacts * $P< 0.05$

(ii) *Consistent Quality*

The improvement of the *manufacturing throughput times* as well as the *Average Order Quality Level* influence positively the product quality consistency, the respective correlation coefficient values being 0.58 and 0.49. A significant positive impact has the *component and tooling standardization* parameter with a correlation coefficient of 0.36. The reduction of *raw material stocks level* has a negative influence on product quality consistency. A possible reason for that could be that the reduction of the raw material stocks to very low levels leads to the starving of the manufacturing process regarding the availability of the required materials to the required quality.

(iii) *Performance Design*

The performance design priority is highly influenced by the *ability to design and manufacture new products* parameter, with a correlation coefficient of 0.63. The *improvement of product quality from the design stage* as well as the *reduction of the design to manufacture lead times* have high positive influence with correlation coefficients of 0.49 and 0.55 respectively. An interesting finding is the high positive correlation coefficient (0.31) which relates the *quotation and design lead times* parameter with the performance design competitive priority. This correlation indicates that investing in technologies which improve the quotation and design lead times influences positively the product performance.

(iv) *Delivery Lead Times*

Delivery lead times are affected positively by improvements on *design to manufacturing lead times*, *component tooling standardization* and improvements in the *manufacturing throughput times*. The correlation coefficient for the above parameters are 0.55, 0.43 and 0.53 respectively. An interesting finding is the positive impact exerted on *delivery lead times* by the investment in technologies which increase the *Average Order Quality Level* of the products (correlation coefficient 0.52).

(v) *Delivery Performance*

Batch size improvement has the highest impact on the delivery performance of the companies. Their correlation coefficient is 0.50 followed closely by the *manufacturing throughput time* parameter and the *ability to design and manufacture new products* with 0.48 and 0.41 respectively. Interestingly, technologies which reduce the *direct labour cost* are found to have a positive influence on the delivery performance of the companies (correlation coefficient 0.44).

(vi) *Product Design Flexibility*

The manufacturing parameter which has the greater impact on the product design flexibility is the *ability to design and manufacture new products* with a correlation coefficient 0.70. High correlation also exists between the *design to manufacturing lead times* and product design flexibility, with a coefficient of 0.60. This is followed by the *reduction in change over times* with correlation coefficient of 0.58.

It is quite obvious from the above findings that investments in technologies with positive impact on the design to manufacture lead times and the ability to design and manufacture new products parameters will influence positively the product design flexibility.

(vii) *Volume Flexibility*

The parameter which exerts the greatest influence on the companies' volume flexibility is the *batch size improvement* with a correlation coefficient of 0.78. This is the highest correlation coefficient found the analysis. The *change over times* followed by the *manufacturing throughput times* and *manufacturing lead times* also have a high degree of influence on the companies volume flexibility with correlation coefficients of 0.69, 0.48 and 0.42 respectively. An interesting finding is the relatively high correlation coefficient which relates the volume flexibility and the *Average Order Quality Level* (0.49). This finding implies that there is a form of relationship between the product quality level and the companies' ability to produce small and large batches.

The above relationships are of critical importance in the formulation of the companies' manufacturing and ultimately technology strategies. Establishing the expected level of competitive priorities the level of the related manufacturing parameters can be estimated. Using these results, the appropriate technology strategies can be formulated in order to support the required changes in the manufacturing parameters.

5.7 Summary

The results indicate that in the companies which proceeded with implementation of Advanced Manufacturing Technologies they managed to achieve relatively high levels of favourable plant characteristics. Specifically, the capacity utilization of the plant was found to be 74% while the plant flexibility and technology intensity achieved have mean values of 8.1 and 7.9 respectively.

The most important competitive priority of the Cypriot manufacturing industry has been found to be the "quality consistency" followed by the "delivery performance" parameter. The "product price" parameter is the competitive priority with the lowest level of importance. In terms of the manufacturing parameters high level of importance is given to the " Average Order Quality Level" parameter followed by the "manufacturing throughput time".

In general, the competitiveness of the manufacturing companies which proceeded with the implementation of AMT is quite high. The adoption of AMTs was found to have a positive influence to the competitive priorities and the manufacturing parameters of the companies.

The value of the actual optimum levels of the competitive priorities (the required levels a company should possess in order to be competitive) which a company should posses reveals the highly competitive market in which the Cypriot manufacturing industry is exposed and is called to compete with. The companies proceeded with the introduction of AMT managed to increase the levels of their competitive priorities but still there is gap from the optimum ones. As a result we can say these companies, with the introduction of AMT, became more competitive but still there is a room for improvement.

The impact levels of manufacturing parameters on the competitive priorities show a high correlation between the “scrap rate and rework” , the “direct labour cost” and the “manufacturing throuput time” , with the “price” parameter. With respect to the consistent quality , this is influenced highly from the “component tooling standardization” the “manufacturing throuput time” as well as the “Average Order Quality Level” parameter. The “performance design” is influenced by the “ability to design and manufacture new products” as well as the “ improvement of product quality from the design stage” and the “component tooling standardization” parameters. “Delivery lead times” are affected by improvements on “design to manufacturing lead times”, “component tooling standardization” and improvements on the “manufacturing lead times” parameters. “Batch size improvement”, “manufacturing throughput times”, and “component tooling standardization” have a high impact on the companies’ “delivery performance”. The manufacturing parameter which influences significantly the “product design flexibility” is the “ability to design and manufacture” new products”, followed by the “design to manufacture lead times” and the “component tooling standardization” parameter. “Volume flexibility” is obviously highly influenced by the “batch size” followed by the “manufacturing throughput time”, the “manufacturing lead times” and the “work in progress” parameters.

CHAPTER 6

STRATEGIC PLANNING OF AMT INTRODUCTION IN CYPRIOT MANUFACTURING INDUSTRY

6.1 Introduction

The aim of this chapter is to analyze the factors influencing the decision to introduce AMT in the Cyprus manufacturing industry and determine the impact of the technologies on these factors. Specifically the chapter addresses the influencing level and the effects of AMT implementation on the product / market characteristics of the companies. Emphasis is given on the effects of AMT implementation on the companies' manufacturing parameters and to the competitive priorities that are visible by the end user. The problems associated with the financial justification of the technologies are also critically examined. Finally the chapter investigates the level of planning performed for the transfer and implementation of AMTs in the manufacturing environment.

6.2 Factors Influencing the Decision to Introduce AMT - Justification .

The most important point that is widespread in all the field studies that examined AMT is that decisions about AMT implementation should be part of a broadly based Business strategy. The link between technology application and Business strategy also relates to the competitive priorities and positioning of the enterprise [Zahra S.A (1994)]. Table 6.1 shows the influencing level of the market related factors in the decision to introduce AMT.

Table 6.1 Level of influence of market related factors to the introduction of AMT

Variable	Total	CAD	CNC	CAD/CAM	ROBOTICS
D211	7.07	5.33	7.76	7	9.50
D212	3.10	1.17	4.00	3.25	4.00
D213	4.80	2.33	5.00	5.88	6.00
D214	1.70	.67	2.82	1.50	.00

D211 Increasing / maintaining market share
D212 Entering new markets with existing products
D213 Introducing new products to existing markets
D214 Entering new markets with new products

Companies where invited to score on a ten point scale the level of influence of each individual factor shown, on the introduction of AMT (1 = no influence, 10 = very high influence).

The results reveal that the main reason for the introduction of AMT in the Cyprus manufacturing industry, 29 out of 40 companies studied, is to increase / maintain the existing market share, followed by the desire to introduce new products to existing markets, 13 companies out of 40 studied. The above results show the heavy local competition (either from local products or foreign imports) the Cypriot manufacturing industry is facing and the need to survive in the local market.

Table 6.2 shows the degree of influence the defensive factors (factors which arise from problems that the company is facing) had on the introduction of AMTs.These factors could include main contractors requirements, skilled labour shortages, safety problems, replacement of old equipment, need for vertical integration etc.

Table 6.2 Level of influence of defensive factors on the introduction of AMT

Variable	Total	CAD	CNC	CAD/CAM	ROBOTICS
D221	.00	0.00	.00	.00	.00
D222	5.15	3.25	6.29	4.25	8.50
D223	.45	.00	.18	.87	2.00
D224	.00	.00	.00	.00	.00
D225	.25	.00	.59	.00	.00
D226	.57	.00	.00	2.00	1.75

D221 Main contractors requirement
D222 Solution to skilled labour shortage problem
D223 Solution to a safety problem
D224 "Me too approach"
D225 Replacement of existing (old) equipment.
D226 Vertical integration (sub - contractor replacement etc.)

The results suggest that the introduction of AMT is also strongly influenced by the need to solve the skilled labour shortage problem that the manufacturing industry faces, (23 out of 40 companies studied). Two (2) companies where seeking to solve a safety problem and three (3) of them invested in order to integrate vertically.

It is obvious from the above breakdown analysis that the introduction of each individual AMT technologies were influenced by both market related and defensive factors. More information and descriptive statistics pertaining the reasons for AMT introduction is given in Appendix "C".

6.2.1 Level of influence of the Competitive Priorities and Manufacturing Parameters on the Introduction of AMT

As stated evaluation of what technology a business needs should be done by looking to see how manufacturing can support the companies' product / market characteristics and give the business a distinctive competitive edge. As a result AMT must be used to revise completely the capability of manufacturing, improve manufacturing parameters and ultimately the companies' competitive priorities [Yates A (1986)]. Table 6.3 shows the level of influence of the companies competitive priorities to the introduction of AMTs.

Table 6.3 Level of influence of the competitive priorities on the introduction of AMT

Variable	Total	CAD	CNC	CAD/CAM	ROBOTICS
D231	5.10	1.83	7.12	5.13	7.75
D232	8.58	6.92	9.53	8.25	9.25
D233	6.65	6.67	6.24	7.75	2.25
D234	6.70	5.42	7.29	6.50	8.25
D235	6.50	5.17	7.12	6.25	8.25
D236	6.65	8.00	6.29	6.75	6.00
D237	6.13	5.42	6.59	6.13	6.50

D231 Price
D232 Consistent Quality
D233 Performance design
D234 Delivery Lead time
D235 Delivery performance
D236 Product design flexibility
D237 Volume flexibility

The results reveal that "consistent quality" , "performance design" and "delivery lead times" were the most important reasons given by the respondents for introducing AMT. The lower score is given to the price factor thus indicating that AMT is not generally seen as contributing significantly to cost reduction. This agrees with the findings of Weil et al (1991). In their paper the authors present the results obtained from a survey conducted by the Australian Bureau of statistics (ABS) on the status of the Australian manufacturers` current and planned AMT.

An examination of the results relating to the introduction of individual AMT technologies reveals:

The quality and flexibility factors exert a very high influence on the decision to introduce CAD technology in the manufacturing environment. Specifically the introduction of CAD is inspired by the drive for "product design flexibility", followed by the aim to increase "quality consistency" and "performance design" levels. Cost related parameters were found not to exert any significant influence on the introduction of CAD technology.

Quality and time parameters were found to be the most important drivers for the introduction of CNC and CAD / CAM technologies in the manufacturing environment. The drive for "quality consistency" and reduction of "delivery times" feature very highly on the priorities of the Cypriot Manufacturer.

The introduction of Robotics technology was found to be influenced by the need to produce products with consistent quality with reduced delivery lead times and at lower cost. Product volume and design flexibility were found to be less important . Table 6.4 illustrates the level of influence that the manufacturing parameters exert on the introduction of AMT. Again these parameters have been ranked from one to ten with the table giving the average of the responses in the questionnaire.

Table 6.4 Level of influence of the manufacturing parameters on the introduction of AMT

Variable	Total	CAD	CNC	CAD/CAM	ROBOTICS
D241	2.72	6.00	.59	3.43	.00
D242	3.57	5.67	1.00	7.25	.00
D243	6.22	6.50	5.47	7.25	2.75
D244	2.92	4.00	.94	4.88	1.50
D245	3.32	4.58	1.00	7.63	.00
D246	4.22	4.17	5.00	4.25	1.75
D247	6.70	5.25	7.76	6.75	8.50
D248	5.25	3.50	6.47	4.63	6.00
D249	6.35	4.50	7.41	6.63	8.75
D2410	5.62	4.00	6.18	5.75	8.25
D2411	5.22	5.00	7.41	2.00	4.00
D2412	2.32	1.33	2.29	3.25	5.00
D2413	.75	.50	.65	.00	4.75
D2414	6.52	5.42	7.88	4.38	9.00
D2415	2.00	1.92	1.94	1.13	7.50
D2416	1.20	2.33	1.29	.00	3.00
D2417	3.88	6.08	2.88	2.75	6.25
D2418	1.85	2.58	1.47	2.13	4.00
D2419	7.75	5.33	8.94	8.13	9.25
D2420	4.67	6.33	4.29	3.50	4.75
D2421	3.73	4.92	3.18	3.25	6.75

D241 Quotation and design lead times
D242 Design to manufacture lead times
D243 Ability to design and manufacture new products
D244 Materials optimization due to design
D245 Improved product quality due to design
D246 Component and tooling standardisation
D247 Manufacturing throuput time
D248 Scrap rate and rework
D249 Change over time
D2410 Manufacturing lead times
D2411 Batch size
D2412 Space and assets
D2413 Plant down time
D2414 Direct labour cost
D2415 Finished goods stocks
D2416 Raw materials stocks
D2417Supervision utilization (less routine administration
D2418 WIP (Work In Progress)
D2419A.O.Q.L (Average Order Quality Level)
D2420 Response to quality control traisability queries
D2421 Management time utilization

It can be seen that one of the most important manufacturing parameters is the "Average Order Quality Level" illustrating the interest of the Cypriot manufacturer to improve the quality of his products. Other important parameters were found to be the "standardization of components and tooling", the reduction of "change over times", the reduction of "manufacturing lead times" and the "ability to design and manufacture new products". Specifically the introduction of CAD technologies in the manufacturing environment was aimed at improving the companies' "ability to design and manufacture new products", improve the "ability to traice quality queries" and finally reduce the "quotation and design lead times".

CNC machines were introduced in order to improve the "Average Order Quality Levels" of the products, and reduce the "manufacturing lead times", " throughput times" and the "direct labour costs". The reduction of "changeover times" and "batch size improvement" also exerted a high degree of influence on the introduction of these technologies.

The improvement on the "product quality level" together with the "reduction of design to manufacture lead times" and improvements in the companies' "ability to design and manufacture new products" influenced significantly the introduction of CAD / CAM technologies.

The introduction of robotics was influenced heavily by the "Average Order Quality Level" of the products and the "direct labour" cost. High influence was also expected by the desire to reduce "manufacturing throughput times", "manufacturing lead times" and "change over times".

6.3 Impact of AMT on the Product Market Characteristics

Table 6.5 shows the results of the questionnaire on the impact of AMT on the product/market characteristics. It can be seen that the implementation of AMT in the Cypriot manufacturing industry managed in the majority of cases to increase / maintain the existing market share.

Table 6.5 Impact of AMT on product / market characteristics

Variable	Total	CAD	CNC	CAD/CAM	ROBOTICS
C1131	6.35	5.25	6.71	7.38	5.50
C1132	1.90	1.33	3.00	1.13	.00
C1133	4.00	2.08	3.71	5.50	5.00
C1134	1.27	1.50	1.71	.00	1.00

C1131 Increasing / maintaining market share
C1132 Entering new markets with existing products
C1133 Introducing new products to existing markets
C1134 Entering new markets with new products

Specifically 23 out of 40 companies studied managed to achieve this goal to a considerable degree with an achievement mean value of 6.35. A smaller number of companies,15 out of 40, managed to introduce new products to existing markets but with a lower degree of success.

The implementation of CAD technologies had a considerable impact on increasing/maintaining market share, while their effect on the other market characteristics was not quite obvious. Similar results were for the implementation of CNC machines .

The introduction of CAD/CAM technologies and Robotics had considerable impact on both increasing/maintaining market share and introducing new products to existing markets. These findings agree with many other research results suggesting that firms are investing considerable sums in Advanced Manufacturing Systems to deal with fast changing products and fragmentation of traditional markets [Goldar J.D et al (1994)].

It is quite obvious from the above findings that the main objective of the Cypriot manufacturing industry is to maintain its market share by placing considerable effort on dealing with the fast changing products.

6.4 Impact of AMT on the Competitive Priorities and Manufacturing Parameters.

As stated, AMT must be used to revise completely the capability of manufacturing, improve manufacturing parameters and ultimately the companies competitive priorities. Table 6.6 presents the impact of AMT on companies' competitive priorities.

Table 6.6 Impact of AMT on competitive priorities

Variable	Total	CAD	CNC	CAD/CAM	ROBOTICS
CC1141	1.41	.67	1.76	2.14	1.50
CC1142	2.72	1.50	2.88	4.43	2.75
CC1143	2.13	1.67	1.76	3.71	1.25
CC1144	2.59	1.50	2.24	5.00	3.00
CC1145	2.31	1.50	2.06	4.14	2.75
CC1146	2.47	2.17	2.12	4.33	2.00
CC1147	2.85	2.08	3.12	3.57	2.50

CC1141 Price
CC1142 Consistent Quality
CC1143 Performance design
CC1144 Delivery Lead time
CC1145 Delivery performance
CC1146 Product design flexibility
CC1147 Volume flexibility

It is apparent from the results that the implementation of AMT has considerable impact on the companies competitive priorities. That impact is fairly uniformly distributed among all the parameters, the greatest being the **flexibility** and **quality** ones. The impact of AMT on cost parameters is lower but still significant.

Specifically CAD technology influenced considerably the flexibility factors ("Product design flexibility" and "volume flexibility") followed by the quality and time factors. The cost parameter is not highly influenced.

CNC machines influenced to a high degree the flexibility factors and especially the "volume flexibility", followed by the time and quality parameters. They also had an effect on the cost factors.

CAD/CAM technologies had the highest impact on nearly all the competitive priorities. The time parameters were highly influenced followed by the quality and the flexibility ones. The parameter that experienced the highest impact was the "delivery lead time". Again the cost factors were not significantly influenced by the introduction of CAD/CAM.

Robotic technologies had the highest impact on reducing delivery lead times and improving quality and least impact on the price of the finished goods.

The implementation of AMT in the manufacturing environment had a considerable effect on the manufacturing parameters. Table 6.7 shows the relative impact each AMT had on each of the manufacturing parameters specified.

It is apparent from the results that the parameter that was most significantly influenced by the implementation of AMT was the "change over time" followed by improvements in the "ability to design and manufacture new products" and reduction of "manufacturing throughput times". Considerable impact was also exerted on the "Average Order Quality Level" of the products as well as the "batch sizes".

Table 6.7 Impact of AMT on manufacturing parameters

Variable	Mean	CAD	CNC	CAD/CAM	ROBOTICS
CC11521	1.03	1.83	.13	1.83	.00
CC11522	1.71	1.25	.94	4.14	.33
CC11523	2.41	2.00	1.88	4.43	1.00
CC11524	1.03	1.00	.12	2.57	1.25
CC11525	.97	1.25	.41	1.86	.00
CC11526	1.69	1.33	1.65	2.86	1.00
CC11527	2.36	1.08	2.59	3.86	2.50
CC11528	1.64	.67	1.88	2.86	1.25
CC11529	2.47	1.55	2.94	3.14	2.00
CC115210	1.97	1.25	2.12	3.00	2.00
CC115211	2.18	1.27	2.71	2.43	2.00
CC115212	.49	.00	.71	1.00	.50
CC115213	.37	.55	.41	.43	1.00
CC115214	1.97	1.33	2.35	2.14	2.75
CC115215	.49	.58	.53	1.00	.25
CC115216	.28	.50	.29	-.29	1.50
CC115217	1.31	1.08	1.41	1.86	1.75
CC115218	1.15	1.17	1.12	1.14	2.00
CC115219	2.26	1.17	2.71	3.14	2.00
CC115220	1.38	1.42	1.47	1.14	1.25
CC115221	1.21	1.33	1.12	1.71	1.25

CC11521	Quotation and design lead times	CC115212	Space and assets
CC11522	Design to manufacture lead times	CC115213	Plant down time
CC11523	Ability to design and manufacture new products	CC115214	Direct labour cost
CC11524	Materials optimization due to design	CC115215	Finished goods stocks
CC11525	Improved product quality due to design	CC115216	Raw materials stocks
CC11526	Component and tooling standardisation	CC115217	Supervision utilization (less routine administration)
CC11527	Manufacturing throuput time	CC115218	WIP (Work In Progress)
CC11528	Scrap rate and rework	CC115219	A.O.Q.L (Average Order Quality Level)
CC11529	Change over time	CC115220	Response to quality control traisability queries
CC115210	Manufacturing lead times	CC115221	Management time utilization
CC115211	Batch size		

The greatest impact of CAD technologies is exerted on the ability of the companies to "design and manufacture new products" and the "quotation and design lead times" . To a lesser extend they influenced positively the "change over times", the companies ability to "respond to quality control traisability queries" and the "utilization of the management time". Manufacturing parameters which are directly related with manufacturing cost issues were not significantly influenced by the CAD introduction. It is obvious that CAD technology does not purport to reduce the manufacturing cost.

The introduction of CNC machines influenced positively the "change over times", improved the "batch size" and the "Average Order Quality level" of the products. It had a lower degree of influence on the "manufacturing throughput time" and the "manufacturing lead times".

CAD/CAM technologies had a strong impact on nearly all the competitive priorities. They influenced positively the companies' ability to "design and manufacture new products" and led to a considerable reduction in the "design to manufacture lead times". A very high improvement was realized in the "manufacturing throughput time", the "change over times", the "manufacturing lead times" and the "Average Order Quality Level" of the products. CAD/CAM had also positive impact on the levels of "scraps and reworks", on the standardization of "components and tooling", on "materials optimisation from the design" process and improvement on the "batch size".

Robotic technologies influenced positively the level of the "manufacturing lead times", and to a lesser extend the "manufacturing throughput time", the "change over times", the "manufacturing lead times" and the "batch size".

6.5 The Financial Justification of AMT

It is internationally accepted that every technology investment should be financially justified. As a result, AMT should be justified not only in accordance to business needs but also in accordance to their financial viability.

The results reveal that 20 companies out of 40 proceeded with financial justification of the investment in AMT. The results reported by Primrose et al (1985) support the above findings. They state that stating that "few FMS systems were subject to detailed financial evaluation prior to installation"[33]. Table 6.8 presents the major problems which appeared during the financial justification of AMT in the Cypriot Manufacturing Industry, whilst in table 6.9 the level of difficulty in the evaluation of the intangible benefits is illustrated. Descriptive results are shown in Appendix "C".

Table 6.8 Problems in financial justification of AMT

Variable	Mean	Std Dev.	Minimum	Maximum	N
D51	1.67	2.07	1.00	9.00	40
D52	1.48	1.50	1.00	8.00	40
D53	5.82	2.65	.00	9.00	39

D51 Problem faced by accountants
D52 Problem faced by the managers
D53 Difficulties in the evaluation of costs and benefits of such investments (difficulties in the evaluation of intangible benefits)

The main problem faced in the financial justification of AMT appears to be the difficulties in the evaluation of the intangible benefits which are likely to be achieved by the introduction of AMT. In fact, certain characteristics of the equipment could not be evaluated, and as result it was very difficult to quantify and evaluate all the benefits that are likely to be achieved by the introduction of AMT. The high standard deviation indicates the spread of the individual scoring demonstrating the fact that there were companies facing considerable problems. In detail, 27 out of 40 companies were faced problems and difficulties in the evaluation of the costs and benefits of such investments. Interestingly, no problem arose from accountants or the managers. The managers did not experience any problem since nearly all the companies are family owned and the decision to proceed with the introduction of AMT is taken directly by them. In most of the companies the general manager acts as well as production and operations manager.

Table 6.9 Difficulty level in evaluation of intangible benefits

Level of difficulty	No of companies	Percent (%)
1.00	2	5.0
2.00	3	7.5
3.00	5	12.5
4.00	2	5.0
5.00	5	12.5
6.00	1	2.5
7.00	6	15.0
8.00	10	25.0
9.00	5	12.5

The above findings agree with those of Tippet (1989) in his paper entitled "Technology Implementation management". Tippet's paper investigating the application of AMT in the Australian manufacturing industries indicated that typical justification processes take into consideration direct labour and material savings and they neglect to consider potential savings from areas such as inventory reduction, space reduction, higher quality, reduced accounts receivable, reduced requirement for material handling, and many others.

6.6 Process Analysis. Fitness of AMT into the Process

One of the major steps in justifying the introduction of AMT into the manufacturing environment is the determination of the fitness level of AMT into the process. By the fitness level we mean the compatibility of the existing production processes and manufacturing philosophy with the new equipment. Table 6.10 shows the survey results of the level of process analysis carried out and the actual level of fitness of AMT into the process.

Table 6.10 Level of process analysis and fitness level of AMT into the manufacturing process.

Variable	Mean	Std Dev	Minimum	Maximum	N
D41	6.37	3.01	1.00	10.00	38
D42	7.90	1.71	3.00	10.00	40
D43	7.59	2.17	1.00	10.00	39
D44	8.30	1.70	3.00	10.00	40

D41 Process analysis
D42 Knowledge of AMT characteristics
D43 Determination of the fitness of AMT into the process
D44 Fitness level of AMT into the process n= Number of companies

The results reveal that the process analysis is not always carried out during AMT justification. The high standard deviation of the mean value shows that there are companies which proceeded with the adoption of AMT without performing process analysis. In, general however there is an awareness of the specific AMT characteristics. and the actual fitness level of the technology within the manufacturing environment is quite high.

6.7 Planning the Selection, Transfer and Implementation Process

Table 6.11 indicates that Cypriot manufacturers before acquiring a new technology do obtain information from alternative technology vendors and familiarize themselves with the state of the art technologies and their various constituents.

Table 6.11 Level of planning for utilization of the technology selection and buying related factors

Variable	Mean	Std Dev
D61	7.03	2.78
D62	7.40	2.56
D63	7.38	2.62

D61 Information about of alternative sources
D62 Knowledge of the various constituents of the technology
D63 Knowledge of the different production units or different manufacturing practices (knowledge of the state of the art technology)
n=40

The results presented in Table 6.12 indicate that planning for overcoming budgetary constrains is quite strong. However, technical and workforce infrastructure planning is not that strong and the relatively high standard deviation of the mean indicates two extreme levels. Interestingly in 12 out of 40 companies studied planning is almost non-existent.

Table 6.12 Planning for overcoming constrains during AMT implementation.

Variable	Mean	Std Dev
D71	8.05	1.65
D72	6.35	2.82
D73	6.56	2.86

D71 Budgetary constrains
D72 Technical and workforce infrastructure constrains
D73 Lack of local technical support.

Table 6.13 presents the planning levels of infrastructure preparation for the support of the new technology.

Table 6 .13 Level of planning for infrastructure preparation

Variable	Mean	Std Dev
D821	6.38	3.02
D822	5.78	3.34
D823	5.82	3.34
D824	4.95	3.38
D825	5.21	3.34

D821 Infrastructure project plan
D822 Improvements on existing activities
D823 Simplification and planning to achieve smooth flow through the manufacturing process
D824 Policies / procedures modifications
D825 Pattern work organization changes

The results reveal that infrastructure preparation to support AMT implementation is weak. Companies are reluctant to plan for changes to their policies and procedures, or to improve existing activities to make them more suited to the new technology.

Similar results are observed in planning for Human Resource practices and especially in planning to overcome workforce reservations and perceptions (see table 6.14).

Table 6.14 Level of planning for Human Resource Development.

Variable	Mean	Std Dev
D831	6.00	3.42
D832	5.91	3.55
D841	7.18	2.67
D842	8.08	1.84
D843	8.13	1.84
D844	8.15	1.93
D845	7.28	2.94

D831 Overcoming workforce reservations
D832 Overcoming operators perception as being more skilled or deskilled
D841 Personnel utilization
D842 Timing of training to be given
D843 Level of training to be given
D844 Type of training to be given
D845 Learning process

Interestingly, the planning for workforce training appears to be at quite high levels indicating the relative importance given to the training function.

6.8 Summary

The main reasons for AMT introduction in the Cypriot manufacturing industry are first to increase/ maintain the existing market share, followed by the desire to introduce new products to existing markets. Another reason is the need to solve skilled labour shortage problems which manufacturing industry faces.

Amongst the manufacturing parameters the main drivers for AMT introduction were the need to improve the Average Order Quality Levels of the products followed by the expected reduction in the manufacturing lead times and the direct labour cost. Other important factors were the reduction of change over times and the ability of the companies to design and manufacture new products.

The implementation of AMT in the Cypriot manufacturing industry managed in the majority of cases to increase/maintain the existing market share and influenced considerably the competitive priorities of the companies. That impact of AMT was uniformly distributed across all the parameters.

The main problems faced in the financial justification of AMT appears to be the difficulties in the evaluation of the intangible benefits which are likely to be achieved by AMT introduction. In fact certain characteristics of the equipment could not be evaluated, and as result it was very difficult to quantify and evaluate all the benefits that could accrue from the introduction of AMT.

The levels of planning to prepare the infrastructure to support AMT implementation were found to be low. Companies were reluctant to plan for changes to their policies and procedures.

CHAPTER 7

ADVANCED MANUFACTURING TECHNOLOGY TRANSFER AND IMPLEMENTATION IN CYPRIOT MANUFACTURING INDUSTRY

7.1 Introduction

This chapter examines the transfer and implementation process of the AMT in the Cyprus Manufacturing Industry. Specifically it analyses the management process followed during the transfer of the technology into the manufacturing environment as well as the steps followed both before and after its implementation and actual productive operation. Special emphasis is given to the infrastructure preparation and the human factors consideration.

7.2 Technology Transfer

The process of technology selection and transfer is quite complicated and requires skills and managerial know-how. The international practice reveals that the technology could be transferred mainly through three different channels as follows:

(a) Direct investment

(b) Joint Ventures with foreign companies and

(c) State import mode (the Government takes a central role in the selection and transfer of the technology)

On the other hand the type of contract signed could be extended to:

(a) The supply of technical personnel to start up production or to provide technical assistance,

(b) Turnkey contract adoption,

(c) Product in hand contract implementation and

(d) Provision of an indicative technical service to operate the technology.

The results of the questionnaire indicate that all the Advanced Manufacturing Technologies were transferred to the companies under the joint venture channel and the contract signed in the majority of cases was the turnkey one. In only three cases the contract provides for an indicative technical service to operate the technology. No direct investment channel or state import mode was used, indicating that (i) no foreign investments have been made in the Cypriot manufacturing industry, and (ii) no public technology transfer schemes are in existence. On the other hand "the Turnkey contract" signed in the majority of cases strengthens the view that there is a lack of local support for imported AMT. More information is given in Appendix "D".

During the selection and transfer process special emphasis should be given to the factors which strengthen the buyer's power. Table 7.1 presents the level of consideration of the above factors during the transfer of AMT in the Cypriot Manufacturing industry

Table 7. 1 Factors considered during the selection and transfer process

Variable	Mean	Std Dev	N
E41	1.00	.00	40
E42	1.70	2.34	40
E51	3.35	3.36	40
E52	8.03	2.54	40

E41 Group Buying
E42 Break the technological package
E51 Foreclosing options at the selection stage due to budgetary constrains
E52 Proper information about the supplier and the product

From the results it is obvious that the Cypriot manufacturer who decides to invest in AMT tries to get proper information about the supplier and the product. He tries to familiarize himself with the different production units, and the various constituents of the technologies. Although Cyprus is far away from the AMT manufacturers, the Cypriot manufacturer tries to be informed about the various types of AMT. As to the other factors, it is found that nearly all the manufacturers proceed with the adoption of the technology which is more applicable to their manufacturing needs thus avoiding foreclosing options at the selection stages due to budgetary or any other constraint. On the other hand they avoid group buying and braking the technological package. It is interesting to mention that breakage of the technological package was done by only two companies. This breakage was found to be an impediment to the fast adaptation of the technology to the local conditions.

7.2.1 Factors Hindering the Technology Transfer Process

The technology transfer process is hindered by factors which can be classified as Supplier related, Government related and Company related factors. The results from the questionnaire are given in tables 7.2, 7.3, and 7.4 respectively.

Table 7.2 Company related factors

Variable	Mean	Std Dev	N
E331	3.50	3.04	40
E332	2.03	2.06	40
E333	2.05	2.25	40
E334	4.15	2.69	40

E331 Lack of staff
E332 Limited managerial resources
E333 Management have little experience outside their own particular company
E334 Lack of knowledge in the workforce

The results reveal that company related factors had the highest negative influence on the technology transfer process. Among these the lack of knowledge/skills in the workforce related to the technologies as well as the lack of staff were the most important.

Table7.3 Supplier related factors

Variable	Mean	Std Dev	N
E311	1.50	1.78	40
E312	1.20	1.26	40
E313	1.93	2.13	40
E314	1.58	1.69	40
E315	1.18	.64	40
E316	2.33	2.49	40

E311 Bureaucratic delays with foreign countries instituted by individuals or groups unknowledgeable about technology transfer
E312 Cultural and social deference's from supplier of technology
E313 Distance from the supplier of technology
E314 Lack of communication with the supplier of technology
E315 Lack of trust and goodwill with the supplier of technology
E316 Lack of support (technical) from the supplier of technology

As to the supplier related factors the major negative influence is the distance from the supplier of technology. From the Government related factors the lack of clearly defined technology transmission channels seem to have the highest influence on the adoption of AMT.

Table 7.4 Government related factors

Variable	Mean	Std Dev	N
E321	1.25	1.58	40
E322	1.08	.47	40
E323	1.28	1.58	40
E324	1.00	.00	40
E325	1.00	.00	40

E321 Government intervention and regulations
E322 Taxation effect
E323 The transmission channels
E324 Lack of appropriate legislation
E325 Frequent changes in current policies and commercial laws

7.3 Infrastructure Preparation

The performance of companies using AMT depends to a large extent on how well they implement it and not on the technology itself [Ford.D (1988)] . Weil et al (1991) state that "changes in organizational structures and practices as well as worker skills and knowledge are needed for successful implementation of AMT".

Table 7.5 Improvements on existing activities

Variable	Mean (before AMT operation)	Mean (after AMT operation)
E611	3.39	5.44
E612	3.00	4.38
E613	2.43	4.59
E614	2.49	3.86

E611 Operation activities
E612 Transport activities
E613 Inspection activities
E614 Storage activities

The adequacy of a sound supporting infrastructure is characterized as one of the most important factors to be considered in implementing AMT into the companies. Table 7.5 shows the level of improvements in the infrastructure performed by the companies both before and after the AMT introduction.

The results reveal that the improvements in the companies' manufacturing activities before the installation of the specific technologies were in fact insignificant. To a small degree, changes were implemented in the operation activities rather than activities related to the materials handling and storage, or activities related to the testing and inspection of the finished product. One the other hand substantial changes are performed on the above activities after the installation and actual productive operation of the technologies.

As to the level of modifications performed on the companies' policies and procedures the results are disappointing (Table 7.6).

Table 7.6 Level of policies / procedures modifications

Variable	Mean (before AMT installation)	Mean (after AMT installation)
E621	1.63	3.54
E622	1.29	2.46
E623	1.00	3.92
E624	1.28	4.51
EA625	1.38	3.18
E626	1.89	5.32
E627	1.82	5.90
E628	1.42	3.36
E629	1.18	1.87

E621 Procedures covering materials handling
E622 Procedures covering purchasing
E623 Procedures covering testing
E624 Procedures covering quality control
E625 Procedures covering inventory control
E626 Procedures covering design
E627 Procedures covering scheduling
E628 Procedures covering training
E629 Wages and salary systems

Before the implementation of the technologies improvements on the above policies / procedures were not taken place to a considerable degree. A greater level of changes was performed after the installation and productive operation of the technologies in the manufacturing environment.

Specifically, modifications to a higher degree were performed on procedures covering work scheduling and design. Changes to wages and salary systems as well as purchasing practices did not take place.

Changes in work organization procedures are shown in table 7.7

Table 7.7 Pattern work organization changes

Variable	Mean (before AMT installation)	Mean (after AMT installation)
E631	1.19	4.86
E632	1.56	2.94
E633	1.69	4.06
E634	1.59	5.97
E635	1.53	5.31
E636	3.05	3.79
E637	1.21	4.87

E631 Changes in management decision making structure
E632 Formulation of small autonomous working groups
E633 Closer working relationships between departments
E634 Interim targets setting on which the process of implementation shall be evaluated
E635 Changes in the manufacturing philosophy
E636 Changes in the plant layout
E637 Converged individual roles

The results show that modifications performed before the implementation of technologies are non-significant with the greatest being on plant layout. It is obvious that the implications for the plant layout and equipment are the more visible ones, and the easiest to be performed.

After the AMT implementation and their actual productive operation the level of modifications performed on the pattern work organization are quite significant. In actual fact during the actual productive operation of the technologies companies are forced to perform these changes in order to realize the benefits. In detail, companies are forced to proceed with changes in the manufacturing philosophy, and to set interim targets against which the process of implementation would be evaluated. Companies are also proceeding to a certain degree to changes in management decision making structure, and to introducing closer relationship between the various departments in order to support the implementation of AMTs.

7.4 Human Resources Policies

There is no doubt that the human resource is the greatest asset for any organization, without which the development and use of the technology will not happen. Table 7.8 shows the level of workforce preparation to support AMT introduction and implementation both before and after the technology installation and actual productive operation. The findings show that in the majority of cases the implementation process is carried out without the formulation of representative cross functional implementation teams(ie teams formulated with personnel from all the company departments). However in every case there was always a person appointed as the project champion for promoting the project.

Table 7.8 Level of workforce preparation

Variable	Mean (before AMT installation)	Mean (after AMT installation)
EA81	3.68	3.76
EA82	8.88	8.85
EA83	6.31	6.83
EA84	6.97	7.64
EA85	2.33	5.97
EA86	2.92	4.55
EA87	5.71	7.24

EA81 Representative cross functional implementation team
EA82 Project champion for promoting the project
EA83 Keeping employees informed about AMT plans and the reasons why they are needed
EA84 Employees knowledge about the anticipated impact the AMT will have on job security, working conditions, promotion opportunities
EA85 Workers involvement in the AMT process
EA86 Attention / changes to supportive human resource practices
EA87 Awareness of the other executives as to the characteristics of AMT and their impact to the product output

The information given to the employees about the plans for AMT introduction and the reasons behind these investments was found to be a reasonable level both before and after the productive operation of the technology. As a result they were informed about the anticipated impact the AMT would have on job security, working conditions, promotion opportunities etc. The area where the Cypriot manufacturer did not perform particularly well was in the involvement of the workers in the selection of the AMT technologies, and giving the appropriate attention to human resource practices which support the implementation of such technologies. In general more attention to human resource practices was given after the AMT implementation and during the actual productive operation.

Table 7.9 shows the level of reservations the employees have about the introduction and implementation of AMT, while table 7.10 shows the utilisation of the personnel and their perception towards the implications on operators skills.

Table 7.9 Workforce reservation

Variable	Mean (before AMT installation)	Mean (after AMT installation)
EA911	3.21	2.31
EA912	5.69	2.67
EA913	3.71	2.72
EA914	3.13	2.54
EA915	3.84	3.13
EA916	1.00	1.00

EA911 Fear of redundancy or job loss
EA912 Fear of being unable to cope with the new system
EA913 Trying to minimize the threads to their skills and employment levels
EA914 Specialists feel threaded by newcomers trained in later developments
EA915 Preference of continuing familiar operations and responsibilities
EA916 Union reservation towards AMT introduction

Interestingly the workforce did not appear to show considerable reservations or fear with regard to new technologies. The expressed fear of redundancy or job loss was small and it became even lower after the actual productive operation of the AMT. At the very first stages the fear of being unable to cope with the new system was relatively high, while after the implementation and operation of the technologies this was minimized. In a small number of cases and especially before the introduction of the technology in the manufacturing environment a tendency for continuing familiar operations and responsibilities was apparent. In certain cases specialists felt threaded by newcomers trained in later developments and as a result they were actually trying to minimise the threads to their skills and employment levels by trying to justify that this technology is not needed. In all cases the above reservations were eliminated as the technology was introduced in the manufacturing environment, and they had no negative implications on the working conditions.

As to the attitude of the unions to the introduction of AMT, no problems were experienced and no one viewed unions as being anti-technology.

The above findings are in agreement with the results of the survey performed by Zairi et al (1992). In the above survey Zairi et al present the results from a survey on consultancy companies which were involved in AMT implementation projects. Similar findings were reported by Love et al (1986) in their paper entitled: "Problems of new technology deployment in the mechanical engineering and printing Industries". In that paper are presented the results of a study in a sample of 15 companies which have implemented new technologies. Emphasis is given to the areas of dissemination of information, workforce adaptation, union reaction and training strategies.

Table 7.10 presents the level of utilization of the personnel in the implementation of AMT and the implication to their skills and attitudes.

Table7.10 Personnel utilization and skills / attitudes

Variable	Mean (before AMT installation)	Mean (after AMT installation)
EA921	6.56	8.65
EA931	7.80	8.44
EA932	1.10	4.96

EA921 Operators perception on skill level
EA931 Utilization of existing personnel
EA932 Recruitment of newly appointed personnel

The results show that the existing personnel is highly utilized by almost all the companies proceeding with the introduction of Advanced technologies. The recruitment of newly appointed personnel was done in very few cases where the availability of personnel with the necessary skills was limited. In terms of workforce skills it was found that the operators have a tendency to regard themselves as being more skilled as a result of using the new advanced technologies. Interestingly, this perception was realized and before the actual introduction and productive operation of the technologies in the manufacturing environment.

7.5 Training Provision to the Operators

Table 7.11 shows the level of technical knowledge of the employees to operate the Advanced Manufacturing Technologies , while Table 7.12 shows the type of training provided to the above personnel. The results reveal that the existing (before the installation of the technology) technical knowledge of the employees to operate AMTs was very low, while through the provision of adequate training the final achieved level was of the required standards.

Table 7.11 Level of technical knowledge of the employees

Variable	Mean	Std Dev
E1011	1.33	1.49
E1012	7.79	1.67

E1011 Existing technical knowledge of the employees to operate AMTs
E1012 Achievement of technical knowledge of the employees

Most of the training provided to the users was delivered by specialists from the equipment suppliers . This was achieved either by organizing in-house training courses given by experts from the equipment suppliers in the company, or by sending engineers and operators abroad to receive the training. Exception to the above rule was the CAD training. This was achieved either by organizing in company training courses with experts from Cyprus or by sending the operators to open courses organized by various institutions in Cyprus . It is important to mention that in the majority of cases the training was given after the installation of the technology within the manufacturing environment.

Table 7.12 Type and level of satisfaction with the training provided

Variable	No of companies		CAD		CNC		CAD/CAM		ROBOTICS	
	(before AMT install.)	(after AMT install.)	(before AMT install.)	(after AMT install.)	(before AMT install.)	(after AMT install.)	(before AMT install.)	(after AMT install.)	(before AMT install.)	(after AMT instal.)
E1031	13	4	0	0	9	2	3	2	1	0
E1032	3	29	0	5	2	13	1	7	0	4
E1033	0	3	0	3	0	0	0	0	0	0
E1034	1	2	1	2	0	0	0	0	0	0

E1031 Training abroad
E1032 In house training with experts from abroad
E1033 In house training with experts from Cyprus
E1034 Private institutions in Cyprus

The learning process followed (the way manufacturers approach and solve the learning problems faced) during the AMT implementation are examined and the results are shown on table 7.13. Four different learning processes are identified as follows:

(a) Make it work approach,

(b) Minimize output approach,

(c) Leave well enough approach and

(d) Learn and improve approach.

The results reveal that in the majority of cases was the learn and improve approach which is followed and the learning levels achieved were very satisfactory.

Table 7.13 Learning process followed

Variable	Mean	Std Dev
E121	1.38	1.68
E122	2.23	2.94
E123	1.00	.00
E124	7.33	3.06

E121 Make it work approach
E122 Minimize output approach
E123 Leave well enough approach
E124 Learn and improve approach

Table 7.14 shows the level of support given by the suppliers.

Table 7.14 Suppliers support

Variable	Total		CAD		CNC		CAD/CAM		ROBOTICS	
	(before AMT install.)	(after AMT install.)	(before AMT install.)	(after AMT install.)	(before AMT install.)	(after AMT install.)	(before AMT install.)	(after AMT install.)	(before AMT install.)	(after AMT instal.)
E111	7.29	7.58	6.22	6.20	7.14	8.06	8.86	8.57	7.50	7.50
E112	4.60	7.23	3.67	5.40	3.88	7.94	9.50	8.25	5.00	8.25

E111 Support given by the equipment manufacturer
E112 Dependency on the supplier for AMT operation, software system modifications or upgrading

The support given by the equipment manufacturers both before and after the installation of the technologies was found to be high. The level of dependency on the supplier for AMT software system modifications or up-grading was found to be quite high. The highest support was found to be given by the CAD/CAM technology manufacturers whilst the lower by the CAD providers. This CAD/CAM support was a continues one and it did not reduce after the introduction of the technology into the manufacturing environment.

During the process of implementation of AMTs it is very important to proceed with on going adjustments , measurements and control in order to realize the full benefits from the AMT introduction. Table 7.15 shows the level of implementation of these adjustments by the Cypriot manufacturers during the process of introduction of advanced technologies in their organizations.

Table 7.15 On going adjustments on AMT implementation

Variable	Total	CAD	CNC	CAD/CAM	ROBOTICS
E131	6.93	6.40	6.53	8.38	6.50
E1321	7.07	6.80	6.82	7.88	6.75
E1322	7.23	7.00	6.88	8.13	7.00
E1323	6.74	6.44	6.63	8.00	5.67

E131 Planning and budgeting to realize the benefits
E1321 Periodic evaluation of achievements relative to interim targets
E1322 Identification of the nature and extend of shortfalls and the reasons for them as the basis for considering proposed remedial efforts
E1323 Analysis to cover shortcomings not only on the performance of AMT but also in the effectiveness of supporting procurement, marketing and other managerial efforts

The level of planning and budgeting in order to realize the full benefits from the acquisition of the technologies is found to be performed at satisfactory levels. Higher attention is given to the identification of shortfalls during the process of AMT implementation and the examination of the reasons behind them, in order to propose remedial efforts.

In general the Cypriot manufacturer tries to perform to the best of his knowledge and skills all the necessary improvements so as to realize the benefits from the introduction of advanced technologies. Specifically it was found that highest effort was made in the introduction and operation of CAD / CAM technologies which obviously are the most complicated and expensive ones.

7.6 Top Management / Workforce Support During the Implementation Process

In the implementation process management and workforce support is of crucial importance to the success of AMT. Table 7.16 shows the level of support provided by each level of personnel involved.

Table 7.16 Management / Workforce support

Variable	Mean (before AMT installation)	Mean (after AMT installation)
E71	8.49	8.67
E72	8.39	8.54
E73	7.00	8.13

E71 Top management support
E72 Operations manager support
E73 Users support

The results reveal that the support given by almost all the levels of personnel is high. This support is throughout the process of technology justification, transfer and implementation. Tables 7.17, 7.18 and 7.19 shows the correlation matrices covering management support, infrastructure preparation and workforce preparation which were existing during the implementation of Advanced Manufacturing Technologies.

Table 7.17 Relationship between top management support, operations manager support and technology operators support

	EB71	EB72	EB73
E71	1.00		
E72	.78	1.00	
E73	.67	.75	1.00

E71 Top management support
E72 Operations manager support
E73 Users support

The correlation matrix between the level of support shown, the infrastructure preparation and the human resource factors gives quite interesting results.

The level of top management support has very high positive influence on the support given by the operation managers and the technology operators ($r = 0.78$ and 0.68 respectively). In the same way the support given by the operation managers influences highly the level of support given by the operators ($r = 0.75$)

Table 7.18 Relationship between Management/Operators support and Infrastructure preparation

	EB71	EB72	EB73
E621	.08	.15	.39
E622	.13	.19	.23
E623	.28	.30	.35
E624	.22	.26	.27
E625	.12	.10	-.16
E626	.13	.21	.14
E627	.26	.32	.02
E628	.28	.41	.23
E629	.12	.28	.25
E631	.32	.50	.42
E632	.11	.11	.06
E633	.13	.35	.27
E634	.26	.26	.27
E635	.13	.12	.15
E636	.17	.17	.24
E637	.26	.21	.09

E71 Top management support
E72 Operations manager support
E73 Users support
E621 Procedures covering materials handling
E622 Procedures covering purchasing
E623 Procedures covering testing
E624 Procedures covering quality control
E625 Procedures covering inventory control
E626 Procedures covering design
E627 Procedures covering scheduling
E628 Procedures covering training
E629 Wages and salary systems
E631 Changes in management decision making structure
E632 Formulation of small autonomous working groups
E633 Closer working relationships between departments
E634 Interim targets setting on which the process of implementation shall be evaluated
E635 Changes in the manufacturing philosophy
E636 Changes in the plant layout
E637 Converged individual roles

In general the correlation matrix shows a low but positive relationship between Management/Workforce support and the level of improvements on the infrastructure preparation activities. Specifically, the results reveal a relatively strong relationship between the top management , operation managers and operators' support with the level of changes in the management decision taking structure i.e. shortening of management hierarchies, delegating autonomy to shop floor, increasing of the effectiveness of communications by reducing the time necessary to take and convey a decision (r = 0.32, 0.50, 0.42 respectively) .Strong relationship also exists between operation managers support and the level of changes performed on procedures covering testing and purchasing , as well as on the level of changes performed on the design and manufacturing activities.(r = 0.30, 0.32 and 0.35 respectively).

Table 7.19 Relationship between Management/Operators support and Workforce preparation

	E71	E72	E73
E81	.01	.11	.08
E82	.52	.56	.65
E83	.27	.20	.14
E84	.39	.40	.16
E85	.22	.30	.14
E86	.47	.60	.42
E87	.34	.29	.29

E71 Top management support
E72 Operations manager support
E73 Users support
EA81 Representative cross functional implementation team
EA82 Project champion for promoting the project
EA83 Keeping employees informed about AMT plans and the reasons why they are needed
EA84 Employees knowledge about the anticipated impact the AMT will have on job security, working conditions, promotion opportunities
EA85 Workers involvement in the AMT process
EA86 Attention / changes to supportive human resource practices
EA87 Awareness of the other executives as to the characteristics of AMT and their impact to the product output

As to the human resource factors and workforce preparation (table 7.19) the strong positive relationship that exists between them and top management and operations managers support is obvious. Specifically a very strong relationship exists between the managers and operators support and attention/changes performed to supportive human resource practices i.e. organizational structure, payment systems, motivation level ($r = 0.47$, 0.60,and 0.42 respectively). A high relationship exists also between the level of top management support given and the level of awareness of the other executives of the companies as to the characteristics of AMT and their implication to the product output ($r = 0.34$).

Table 7.20 shows the relationship between Management / Operators support and the level of performing on - going adjustments during AMT implementation. It is very interesting to see the strong relationship that exists between the management and operators support with the level of ongoing adjustments performed during the implementation of Advanced Manufacturing Technologies. The correlation coefficient varies between 0.49 and 0.68.

Table 7.20 Relationship between Management/Operators support and on going adjustments during AMT implementation

	E71	E72	E73
E131	.65	.49	.43
E1321	.67	.59	.57
E1322	.68	.62	.56
E1323	.64	.61	.61

E71 Top management support
E72 Operations manager support
E73 Users support
E131 Planning and budgeting to realize the benefits
E1321 Periodic evaluation of achievements relative to interim targets
E1322 Identification of the nature and extend of shortfalls and the reasons for them as the basis for considering proposed remedial efforts
E1323 Analysis to cover shortcomings not only on the performance of AMT but also in the effectiveness of supporting procurement, marketing and other managerial efforts

7.7 Summary

The Cypriot manufacturer who decides to invest in AMT tries to get proper information about the supplier and the product. Nearly all the manufacturers proceeded with the adoption of the technology which is more applicable to their manufacturing needs thus avoiding foreclosing options at the selection stages due to budgetary or any other constraint.

The manufacturers also avoid group buying and braking the technological package. Breakage of the technological package was done by only two companies and was found to be an impediment to the fast adaptation of the technology to local conditions.

The highest negative influence to the technology transfer process was exerted by company related factors, especially the lack of knowledge in the workforce related to the technologies as well as the lack of trained and experienced staff.

Improvements in the companies' manufacturing activities before the installation of the specific technologies were found to be insignificant. One the other hand substantial changes were performed on these activities after the installation and actual productive operation of the technologies.

As to the level of modifications performed on the companies' policies and procedures the results indicated that before the implementation of the technologies the level of improvements on the above policies/procedures were insignificant. A greater level of change was, however, performed after the installation and productive operation of the technologies in the manufacturing environment.

Interestingly the workforce did not appear to show considerable reservation or fear with regards to new technologies. The expressed fear of redundancy or job loss was small and it became even lower after actual productive operation of the AMT.

The area where the Cypriot manufacturer falls behind western counterparts is in the involvement of the workers in the selection of the AMT technologies, and giving appropriate attention to supportive human resource practises. In general, more attention to human resource practices was given after the implementation of AMT and during the actual productive operation.

CHAPTER 8

SUCCESSES AND FAILURES OF AMT

IN THE CYPRIOT MANUFACTURING INDUSTRY

8.1 Introduction

The aim of this chapter is to perform an assessment of the successes or failures of specific applications of AMT. Successes and failures will be considered in terms of the Technical, the Manufacturing and the Business aspects and influences of the technology. The main reasons behind the successes or failures are also considered. An attempt was made to prepare linear regression models integrating the various factors with each individual level of success of AMT. The approach followed for the prediction of the regression equation is the forward stepped approach. In order to facilitate the process a factor analysis was performed on the original variables investigated in chapters six and seven in order to condense them into a smaller set of factors with a minimum loss of information.

8.2 Assessment of the Implementation of Technologies - Successes and Failures.

The implementation of AMT should be continuously and systematically assessed in order to realize the full benefits. In this study the level of the success of the various technologies is considered as a three stage process as follows:

(a) The achievement of Technical Success

(b) The achievement of Manufacturing Success and

(c) The achievement of Business Success

The term Technical Success is defined as the use of the technology with low levels of down time during its operation. The companies were invited to score on a 10 point scale the level of down time with reference to a specific application of AMT

(1= considerable down time, 10= no down time). If the score was more than 5 then the company was considered to have achieved Technical success in the application of a specific AMT.

The term Manufacturing Success is defined as the realization of the full attainable by each technology manufacturing benefits in relation to the level of importance of these parameters.

The following methodology was developed and was used to determine whether a company managed to achieve Manufacturing Success for a specific AMT. Manufacturing Success was considered to be a function of the influence level of the specific technology, the actual impact on specific manufacturing parameters and their level of importance. The following formulae was used to determine the level of manufacturing success for each AMT.

$$M.S = \Sigma (a \times b / c) / n$$

where:

M.S = Level of manufacturing success

a = Level of impact of the specific AMT on the specific manufacturing parameter

b = Level of importance of the specific manufacturing parameter

c = Influencing level of the specific AMT to the specific manufacturing parameter

n = Total number of manufacturing parameters

If the value of M.S was equal to 3 or higher, then the company was considered to have managed to achieve Manufacturing success in the specific AMT.

The term Business Success is defined as the realization of the full benefits attainable by AMT. The following methodology was developed and was used to determine whether a company managed to achieve Business Success for a specific AMT. Business Success was considered to be a function of the influence level of the specific technology, the actual impact on the specific competitive priority and its level of importance. The following formulae was used to determine the level of Business Success of each AMT.

$$B.S = \Sigma (a \times b / c) / n$$

where:

B.S = Level of Business Success

a = Level of impact of the specific AMT on the specific competitive priority

b = Level of importance of the specific competitive priority

c = Influencing level of the specific AMT to the specific competitive priority

n = Total number of competitive priorities

If the value of B.S was equal to 3 or higher, then the company was considered to have managed to achieve Business success in the specific AMT.

Based on the above methodology table 8.1 was prepared. The breakdown of the results is presented in Appendix "E".

Table 8.1 Successes and failures of AMT

AMT	Technical status	Manufacturing status	Business status
CAD	S	F	S
	S	S	F
	S	F	F
	S	F	F
	S	S	S
	S	F	F
	S	F	F
	S	F	F
	S	F	S
	S	F	S
CNC	S	F	S
	S	F	F
	S	F	F
	S	F	S
	F	F	S
	S	S	S
	S	S	S
	S	S	S
	F	S	F
	S	F	F
	S	F	F
	S	S	F
	S	S	F
	S	F	F
	S	F	F
	S	F	F
	S	F	F
CAD/CAM	S	S	S
	S	S	S
	S	F	S
	S	S	F
	S	S	F
	S	S	S
	S	S	S
	S	No information	No information
ROBOTICS	F	F	F
	S	S	S
	S	F	F
	S	S	S

S = Success
F = Failure

The results reveal that:

- Technical success was achieved in almost all the AMT applications (92.3%)
- Manufacturing success was achieved in 41% of the applications
- Business Success was achieved in 43.5% of the applications.
- All CAD applications achieved Technical Success but only two of these were found to achieve manufacturing success. Four applications were found to have achieved business success.
- In terms of CNC machines in two cases there was a Technical failure, while in only six cases manufacturing success was realised. Business success was achieved in six out of seventeen applications.
- In the case of CAD/CAM technologies all applications were found to have been Technically successful. Six out of eight applications were found to have achieved manufacturing success, whereas five of these were found also to have achieved Business success.
- With respect to Robotic technologies three out of four cases have achieved Technical Success. Two of these applications also achieved Manufacturing and Business success.

For comparison purposes it is worth mentioning the results of a survey by Voss (1988) which shows that all the companies which have introduced AMT achieved Technical success, while 57% achieved Business success. These results are drawn from an 18 month study into success and failure of AMT carried in 14 companies. In a study conducted by Beaty C (1993) is mentioned that only five of the ten companies studied had "successful" AMT projects. Beaty carried out an intensive three-year study on the implementation of AMT systems in ten manufacturing facilities ranging in size from a small start up plant of 80 employees to a division of a large multinational firm employing over 4000.

8.3 Factors Leading to Technical Success, Manufacturing Success and Business Success

The process of Implementation of Advanced Manufacturing Technologies is considered to be carried out in three phases as follows:

(a) The planning phase which deals with the process of Justification of the technology in accordance to business and manufacturing needs, and the planning of the various processes,

(b) The selection, transfer , pre-installation and installation of the technology in the manufacturing environment phase and

(c) The post-installation phase

Based on the above methodology the major elements and factors in each phase were identified based on the impact of these variables to each level of success (Technical Success, Manufacturing Success and Business Success). With an aim to facilitate the process a factor analysis was performed on the original variables investigated in chapters six and seven. in order to condense them into a smaller set of new composite dimensions (factors) with a minimum loss of information. After an orthogonal rotation of the factors the following new set of variables for each phase were identified:

(a) Planning phase

Thirty eight (38) planning factors undergone the process of factor analysis and were reduced to the following ten (10) factors:

(i) Factor 1-1 (fac 1-1) : Planning for Human resource development . On going adjustments to support AMT installation

(ii) Factor 2-1 (fac 2-1) : Level of process analysis. Planning of acquisition of information about types of technology, alternative sources of supply .

(iii) Factor 3-1 (fac 3-1) : Planning for infrastructure preparation

(iv) Factor 4-1 (fac 4-1) : Fitness level of AMT into the process

(v) Factor 5-1(fac 5-1): Lack of staff and knowledge in the workforce. Level of hindering the technology transfer process .

(vi) Factor 6-1(fac 6-1): Planning for overcoming lack of local technical support and technical and workforce infrastructure constraints.

(vii) Factor 7-1 (fac 7-1): Problems faced by managers and accountants

(viii) Factor 8-1 (fac 8-1): Limited managerial resources. Difficulties in the evaluation of cost and benefits of AMT investments

(ix) Factor 9-1 (fac 9-1): Group Buying and financing from the suppliers

(x) Factor 10-1 (fac10-1): Foreclosing options at the design and selection stage.

(b) Selection, Transfer and pre- implementation factors

Seventeen (17) selection, transfer and pre-implementation factors undergone the process of factor analysis and were reduced to the following five (5) factors:

(i) Factor 1-2 (fac1-2) : On going adjustments during AMT implementation . Measurement and control

(ii) Factor 2-2 (fac 2-2): Management support. Assignment of a project champion to promote the project.

(iii) Factor 3-2 (fac 3-2): Attention to supportive human resource practises

(iv) Factor 4-2 (fac 4-2): Fear of the workforce of being unable to cope with the new system.

(v) Factor 5-2 (fac 5-2): Provision of adequate training and support by AMT manufacturer.

(c) Post- implementation factors

Forty two (42) post-implementation factors undergone the process of factor analysis and were reduced to the following twelve (12) factors:

(i) Factor 1-3 (fac 1-3): Improvements in existing activities, policies / procedures modifications

(ii) Factor 2-3 (fac 2-3): Level of training given. Achievement of technical knowledge. Management / operators support

(iii) Factor 3-3 (fac 3-3): Workforce fear and reservations

(iv) Factor 4-3 (fac 4-3): Changes in management decision taking structure

(v) Factor 5-3 (fac 5-3): Employee involvement and knowledge about the anticipated impact of AMT to the working conditions

(vi) Factor 6-3 (fac 6-3): Policies procedures modification

(vii) Factor 7-3 (fac 7-3): Dependence on the supplier for AMT operation, software system modifications or upgrading

(viii) Factor 8-3 (fac 8-3): Training abroad

(ix) Factor 9-3 (fac 9-3): Closer working relationship between departments. Converged individual roles.

(x) Factor 10-3 (fac 10-3): Interim targets setting on which the process of implementation shall be evaluated

(xi) Factor 11-3 (fac 11-3): Changes in Wages and salary system

(xii) Factor 12-3 (fac 12-3): Changes in design procedures

8.3.1 Planning Phase

At this stage we shall try to present some relationship (models) relating planning factors with the various levels of success of the technologies. Table 8.2 shows a regression model integrating the planning factors and the level of technical success. More information on the regression model is given in appendix "E"

Table 8.2 Regression estimates : Technical Success (c 42)

Variable	B
fac1_1	.426287
fac3_1	.372348
fac4_1	.748229
fac5_1	-.765129
fac6_1	.387748
fac7_1	.091830
fac8_1	-.309910
fac9_1	-.194144
fac10_1	-.288004
(Constant)	8.125000

The results show that prediction of the level of technical success could be achieved through the following estimated linear regression relationship:

Technical Success (T.S) = 8.12 + 0.43 (fac1-1) + 0.37 (fac 3-1) + 0.75 (fac 4-1) - 0.76 (fac 5-1) + 0.39 (fac 6-1) + 0.09 (fac 7-1) - 0.31 (fac 8-1) - 0.19 (fac 9-1) - 0.29 (fac 10-1)

The interpretation of this equation is that some of the independent variables have a positive effect upon the level of technical success, while some others have a negative effect. The variables with the higher positive effect are the fitness level of AMT into the process and the level of planning for human resource development, while the values with the highest negative effect are the lack of staff and the lack of knowledge in the workforce as well as the limited managerial resources in the companies. Group buying and financing from the suppliers also exert a negative influence on the level of technical success.

Table 8.3 shows the results of a regression model correlating planning factors and level of Manufacturing Success. More information on the regression model is given in Appendix "E"

Table 8.3 Regression estimates: Manufacturing Success (MAN)

Variable	B
fac1_1	.123814
fac2_1	.157226
fac3_1	.139426
fac4_1	.398063
fac10_1	-.034897
(Constant)	3.203028

The results show that prediction of the level of Manufacturing success could be achieved through the following estimated linear regression relationship:

Manufacturing Success (M.S) = 3.203 + 0.12 (fac1-1) + 0.16 (fac2-1) + 0.14 (fac3-1) +0.4 (fac4-1) - 0.034 (fac10-1)

The strongest determinant of manufacturing success among the planning factors is the level of planning for infrastructure preparation. Obviously the more detailed the planning for changes the better and the most appropriate changes are performed to support the integration of the technologies in the manufacturing environment. Other positively influencing factors include the level of process analysis done and the level of planning for human resource development and infrastructure preparation.

Table 8.4 shows the results of a regression model correlating planning factors and level of Business success. More information on the regression model is given in appendix "E"

Table 8.4 Regression estimates : Business Success (Bus)

Variable	B
fac1_1	.381435
fac3_1	.337750
fac4_1	.319056
fac5_1	-.427593
fac10_1	-.529696
(Constant)	3.946660

The results show that prediction of the level of Business success could be achieved through the following estimated linear regression relationship:

Business Success (B.S) = 3.95 + 0.38(FAC1-1) + 0.34(FAC3-1) + 0.32(FAC4-1) - 0.43 (FAC5-1) - 0.53(FAC10-1)

I t is obvious from the above regression equation that the most important positive factor determining Business success is the level of planning for human resource development and on going adjustments during AMT implementation, together with the level of process analysis performed and the planning for infrastructure preparation. Negative factors include the foreclosure of alternative technology options at an early stage, and the lack of trained staff.

8.3.2 Selection Transfer and Pre- Implementation Phase

This section presents some relationships (models) relating the selection, transfer and pre- implementation factors with the various levels of success of the technologies. Table 8.5 shows the results of a regression model correlating selection, planning and pre-implementation factors with the level of Technical Success. More information on the regression model is given in appendix "E"

Table 8.5 Regression Estimates : Technical Success (c 42)

Variable	B
fac1_2	1.241000
fac2_2	.147715
fac3_2	.158209
fac4_2	.089366
fac5_2	.366180
(Constant)	8.125000

The results show that prediction of the level of technical success could be achieved through the following estimated linear regression relationship:

Technical success (T.S) = 8.12 + 1.24 (fac1-2) + 0.15 (fac2-2) + 0.16(fac3-2) + 0.09 (fac4-2) + 0.37 (fac5-2)

Interpretation of the above equation reveals that strongest determinants of technical success are the level of performing on going adjustments during AMT implementation.

The second most important positive factor appears to be the provision of adequate training by the equipment manufacturer before the installation of the AMT in the manufacturing environment.

Table 8.6 shows a regression model correlating selection, planning and pre-implementation factors with the level of Manufacturing success. More information on the regression model is given in appendix "E"

Table 8.6 Regression estimates : Manufacturing Success (MAN)

Variable	B
fac1_2	.750789
fac3_2	.321010
fac4_2	-.370103
fac5_2	.561443
(Constant)	3.203028

The results show that prediction of the level of Manufacturing Success could be achieved through the following linear regression relationship:

Manufacturing success (M.S) = 3.20 + 0.75 (fac1-2) + 0.32 (fac3-2) - 0.37(fac4-2) +0.56 (fac5-2)

The results reveal that companies which give special attention to the provision of training before the implementation of the technologies as well as companies which take considerable support by the AMT manufacturers are more likely to experience manufacturing success. Fear of personnel of being unable to cope with the new technology exerts a negative influence on the level of manufacturing success.

Table 8.7 shows a regression model correlating the selection, planning and pre-implementation factors with the level of Business Success achieved . More information on the regression model is given in appendix "E"

Table 8.7 Regression Estimates : Business Success (BUS)

Variable	B
fac1_2	.972975
fac2_2	.489928
fac3_2	.297675
fac4_2	-.592729
fac5_2	.257615
(Constant)	3.946660

The results show that prediction of the level of Business Success could be achieved through the following linear regression relationship:

Business Success (B.S) = 3.95 + 0.97 (fac1-2) + 0.49 (fac2-2) + 0.30 (fac3-2) - 0.59(fac4-2) +0.28 (fac5-2)

The regression equation reveals that companies which proceed with on-going adjustments as well as measurement and control during the AMT implementation process are more likely to achieve Business success. The level of Management support the attention to supportive human resource practices as well as the provision of adequate training before the implementation of AMT can also make valuable positive contributions to the level of Business Success. Negative effect on the level of Business success exerts the fear of the employees of being unable to cope with the new system (before AMT installation).

8.3.3 Post-Implementation Phase

In this section, (models) relating post implementation factors with the various levels of success of the technologies are presented. Table 8.8 shows the results of a regression model correlating post implementation factors with the level of Technical Success. More information on the regression model is given in appendix "E".

Table 8.8 Regression Estimates :Technical Success (c42)

Variable	B
fac1_3	.121862
fac2_3	1.218226
fac3_3	.114433
fac5_3	-.015872
fac7_3	.042187
fac10_3	.291556
(Constant)	8.125000

The results show that prediction of the level of Technical success could be achieved through the following estimated linear regression relationship:

Technical Success (T.S) = 8.12 + 0.12 (fac1-3) + 1.22 (fac2-3) + 0.11 (fac3-3) -0.01 (fac6-3) +0.04 (fac7-3) + 0.29 (fac10-3)

From the above model it is revealed that the Management and Operators support, the level of training given and the technical knowledge acquired are the main contributors to AMT Technical Success.

Table 8.9 shows the results of a regression model correlating post implementation factors with the level of Manufacturing success. More information on the regression model is given in appendix "E".

Table 8.9 Regression Estimates :Manufacturing Success (MAN)

Variable	B
FAC1_3	.664642
FAC2_3	.215081
FAC4_3	.121727
FAC6_3	.127745
FAC10_3	.819283
(Constant)	3.203028

The results indicate that prediction of the level of Manufacturing success could be achieved through the following estimated linear regression equation:

Manufacturing Success (M.S) = 3.2 + 0.66 (fac1-3) + 0.21 (fac2-3) + 0.12 (fac4-3) + 0.13 (fac6-3) +0.82 (fac10-3)

Interpreting the above regression equation is obvious that companies giving special attention to the setting of interim targets on which the process of implementation is evaluated are more likely to achieve Manufacturing success. The second strongest influence on the level of Manufacturing Success is the level of improvements performed on the existing activities as well as the modifications on the policies and companies procedures . A lower but positive impact exerts the support of the management and the operators as well as the level of training given and the achievement of technical knowledge in the workforce.

Table 8.10 shows the results of a regression model correlating post implementation factors with the level of Business success. More information on the regression model is given in appendix "E".

Table 8.10 Regression estimates : Business Success (BUS)

Variable	B
fac1_3	.536243
fac2_3	.492278
fac6_3	.615004
fac10_3	.318330
(Constant)	3.946660

The results show that prediction of the level of Manufacturing success could be achieved through the following linear regression equation:

Business success = 3.95 + 0.54 (fac1-3) + 0.49 (fac2-3) + 0.61 (fac6-3) + 0.32 (fac10-3)

The above results indicate that companies proceeding with improvements in policies and modifications in procedures after the introduction of AMTs in the manufacturing environment in order to support the technologies, are more likely to achieve Business success. Strong influence on Business success also exerts the continuous management and operators support as well as the level of achievement of technical knowledge. Finally a positive relationship exists between the level of Business success and the setting of interim targets on which the process of implementation is evaluated.

8.4 Summary

Almost all AMT applications managed to achieve Technical success, 41% of the applications achieved manufacturing success and 43.5% achieved Business success.

The higher positive effect on the level of **Technical success** exerts the fitness level of AMT into the process, the level of planning for human resource development, the continuing Management and Operators support, and the level of training given. Negative effect to Technical success exerts the lack of staff, the lack of knowledge in the workforce and the limited managerial resources in the companies .

The strongest determinant of **manufacturing** success exerts the fitness level of AMT into the process, the level of performing on-going adjustments during AMT implementation, the provision of adequate training and support by AMT manufacturer, the provision of improvements on existing policies and the modification on existing procedures as well as the setting of interim targets on which the process of implementation shall be evaluated. Negative effect on the level of manufacturing success experiences the fear of the personnel of being unable to cope with new technology.

On the other hand a high and positive impact on the achievement of **Business success** implies the level of planning for human resource development and infrastructure preparation, the level of proceeding with on- going adjustments during the AMT implementation process, the level of management support as well as the improvements/modifications to policies and procedures . Negative effect on the level of Business success experiences the fear of the employees of being unable to cope with the new system (before AMT installation) and the level of foreclosing options at the design and selection stage of the technology .

CHAPTER 9

STRATEGIC PLANNING, TRANSFER AND IMPLEMENTATION OF AMT. DEVELOPMENT OF AN INTEGRATED PROCESS PLAN

9.1 Introduction

This chapter concentrates on the planning requirements for the adoption of Advanced Manufacturing Technologies in order to safeguard their successful implementation. The research results are used in the development of a planning model for the acquisition of AMT. This model provides the framework for the correct justification and implementation of AMT to ensure Technical , Manufacturing and Business Success.

9.2 Strategic Justification, Transfer and Implementation of Advanced Manufacturing Technologies.

The processes used to justify the introduction, transfer and implementation of AMT into the organization have proved to be the greatest impediments to success [Tippet (1989)]. Based on the review of the planning and implementation requirements and the results of the research, an integrated model is proposed, to help management in the correct justification and implementation of AMT to ensure Technical, Manufacturing and Business Success.

The model incorporates all the planning procedures and implementation parameters to be followed in order to ensure successful AMT adoption and implementation . The planning model is divided into three phases as follows:

(a) The planning phase

(b) The Selection, Transfer and pre- implementation phase, and

(c) The post implementation phase.

This planning framework shown in a diagrammatic form in figure 9.1, establishes the methodology that can be adopted by the manufacturers. The way that this framework is operated is summarized as follows:

After estimating the Business opportunities, the manufacturer shall proceed to identify the product/market characteristics taking into consideration the existing strategies, products or markets. The next step is to establish the level of competitive priorities required to support the set product/market characteristics. These characteristics help establish the level of the required design and manufacturing parameters. Table 9.1 which indicates the relationship between the competitive priorities and the manufacturing parameters is used as a guide in order to determine the needed level of the manufacturing parameters. A process analysis should then be carried out in order to determine the existing level of manufacturing parameters. A comparison of the required and existing parameters gives the gap that must be filled by the proper operation of the appropriate AMT. Table 9.2 gives the impact each AMT exerts on the manufacturing parameters. This table can be used as a guide in order to determine the possible type of AMT to be selected. Prior to the AMT adoption decision the manufacturer should examine the fitness of AMT into the process and must consider some other defensive, selection and buying factors. Finally the whole decision should undergo a proper financial justification process.

After the decision to introduce AMT into the manufacturing environment has been taken, the planning of the transfer, installation and operation of the technology should be performed.

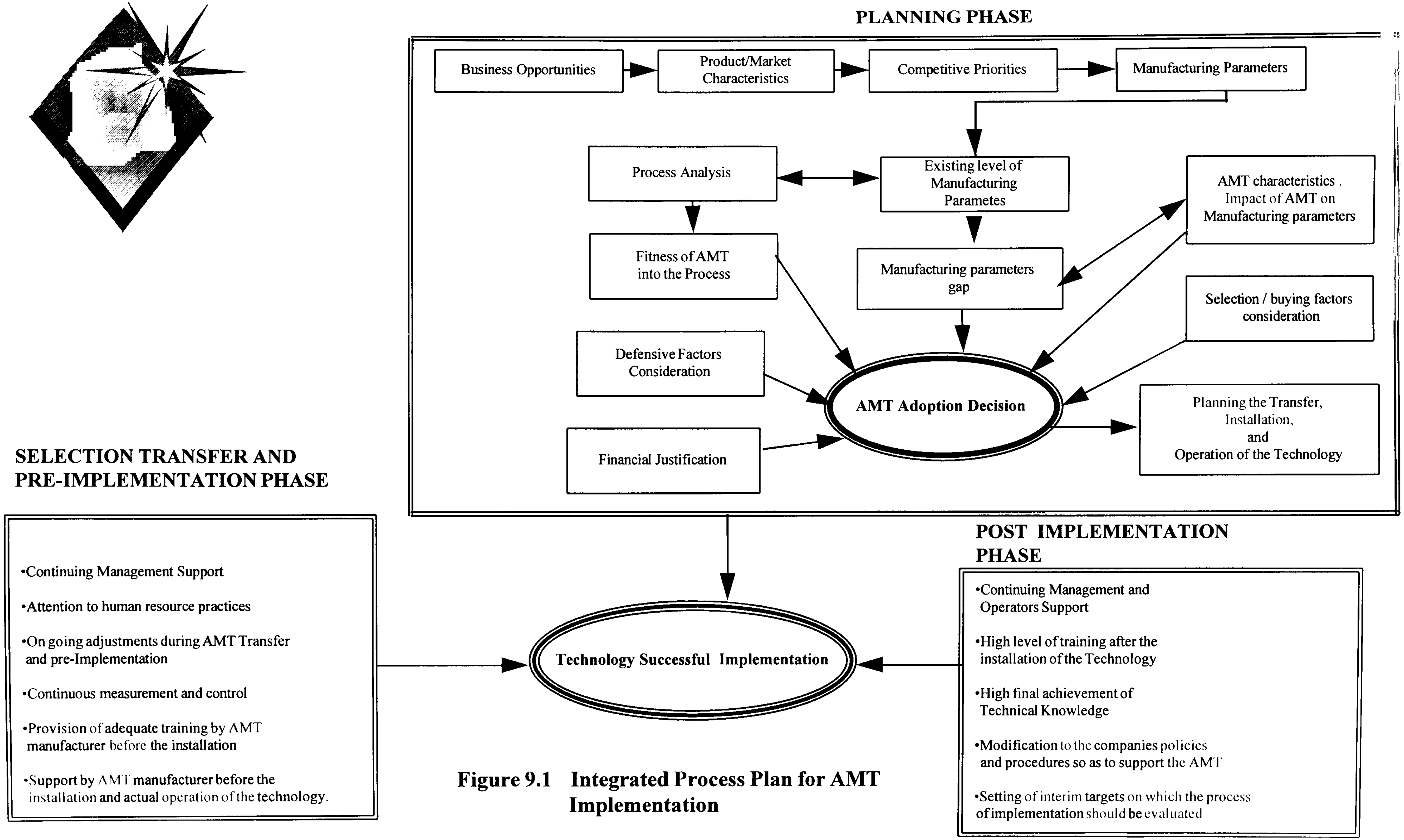

Figure 9.1 Integrated Process Plan for AMT Implementation

Each of the phases of the model are discussed below:

9.2.1 The Planning Phase

It is proposed that the following steps should be followed during the planning of Advanced Manufacturing Technologies

a) Estimating the business opportunities (Corporate and business strategies)

The need for technological innovations in the production processes is often initiated as a result of a changing strategic or business objectives. This requires an evaluation of the company's product/market characteristics and its competitive priorities.

(b) Identifying the product / market characteristics as a result of the business strategy, taking into consideration existing strategies, products or markets.

Such identification might include the following strategic considerations:

(i) Increasing / maintaining market share

(ii) Entering new markets with existing products

(iii) Introducing new products to existing markets and

(iv) Entering new markets with new products

(c) Establishing the level of the company's competitive priorities in order to support the required product/market characteristics.

It is proposed that the following competitive priorities should be included:

(i) Price

(ii) Consistent quality

(iii) Performance design

(iv) Delivery lead time

(v) Delivery performance

(vi) Product / Design flexibility

(vii) Volume flexibility

(d) Determining the level of the company's design and manufacturing parameters to support the established competitive priorities level.

It is proposed that the following manufacturing parameters should be included :

(i) Quotation and design lead times

(ii) Design to manufacture lead times

(iii) Ability to design and manufacture new products

(iv) Materials optimization from the design

(v) Improved product quality from the design

(vi) Tooling standardization / reduction

(vii) Manufacturing throuput time

(viii) Scrap rate and rework

(ix) Change over time

(x) Manufacturing lead times

(xi) Batch size

(xii) Space and assets

(xiii) Plant down time

(xiv) Direct labour cost

(xv) Finished goods stocks

(xvi) Raw materials stocks

(xvii) Supervision utilization

(xviii) Work In Progress (WIP)

(xix) Average Order Quality Level (A.O.Q.L)

(xx) Response to quality control traisability queries

(xxi) Management time utilization

If the existing level of manufacturing parameters are not adequate for achieving the set competitive priorities then the manufacturer should proceed to establish their required level. Table 9.1 shows the relationship between the competitive priorities and the manufacturing parameters. This table which summarizes the research results discussed in chapters 5 shows only the manufacturing parameters which exert a **considerable** impact on the competitive priorities and is proposed to be used as a guide only.

Table 9.1 Relationship between manufacturing parameters and competitive priorities

	CC1141	CC1142	CC1143	CC1144	CC1145	CC1146	CC1147
CC11521			+			+	
CC11522		+	+	+	+	+	+
CC11523			+	+	+	+	+
CC11524				+			
CC11525			+	+	+	+	
CC11526	+	+	+	+	+		
CC11527	+	+		+	+		+
CC11528	+						
CC11529				+	+	+	+
CC115210	+						+
CC115211	+	+		+	+		+
CC115212				+	+		+
CC115213							
CC115214	+	+			+		+
CC115215	+						
CC115216				-			
CC115217							
CC115218							+
CC115219	+	+	+	+	+	+	+
CC115220							
CC115221							

CC1141 Price
CC1142 Consistent quality
CC1143 Performance design
CC1144 Delivery Lead time
CC1145 Delivery performance
CC1146 Product / Design flexibility
CC1147 Volume flexibility
CC11521 Quotation and design lead times
CC11522 Design to manufacture lead times
CC11523 Ability to design and manufacture new products
CC11524 Materials optimization due to design)
CC11525 Improved product quality due to design
CC11526 Component and tooling standardization
CC11527 Manufacturing throuput time
CC11528 Scrap rate and rework
CC11529 Change over time
CC115210 Manufacturing lead times
CC115211 Batch size
CC115212 Space and assets
CC115213 Plant down time
CC115214 Direct labour cost
CC115215 Finished goods stocks
CC115216 Raw materials stocks
CC115217 Supervision Utilization (less routine administration
CC115218 WIP (Work In Progress)
CC115219 A.O.Q.L (Average Order Quality Level)
CC115220 Response to quality control traisability queries
CC115221 Management time utilization

Note: Positive sign represents positive relationship
Negative sign represents negative relationship

(e) Proceeding with the process analysis. Establishing the gap between the existing and the desired level of the manufacturing parameters.

After the calculation of the required level of manufacturing parameters the manufacturer should proceed to establish the gap between the existing and the desired level.

(f) Obtaining adequate knowledge of the AMT characteristics and their impact on the companies manufacturing parameters.

After establishing the gap between the existing and the desired level of manufacturing parameters the manufacturer should proceed with the selection of the appropriate technology to achieve the required impact on the manufacturing parameters.

Table 9.2 shows the level of impact of each AMT on the manufacturing parameters. This table contains the research results which could be used as a guide in the selection of the appropriate Advanced Manufacturing Technology. For example, table 9.2 shows that the most appropriate AMTs to optimise quotation and design lead times, design to manufacture lead times and the ability to design and manufacture new products are the CAD/CAM technologies followed by the CAD technologies. The change-over times, the manufacturing throughput times and the Average Order Quality level of the product are highly affected by the introduction of stand alone CNC machines. Of course the decision to adopt the specific technology should take into consideration all the other factors as described in the model.

Table 9.2 Impact of AMT on Manufacturing parameters

Variable	Mean	CAD	CNC	CAD/CAM	ROBOTICS
CC11521	1.03	1.83	.13	1.83	.00
CC11522	1.71	1.25	.94	4.14	.33
CC11523	2.41	2.00	1.88	4.43	1.00
CC11524	1.03	1.00	.12	2.57	1.25
CC11525	.97	1.25	.41	1.86	.00
CC11526	1.69	1.33	1.65	2.86	1.00
CC11527	2.36	1.08	2.59	3.86	2.50
CC11528	1.64	.67	1.88	2.86	1.25
CC11529	2.47	1.55	2.94	3.14	2.00
CC115210	1.97	1.25	2.12	3.00	2.00
CC115211	2.18	1.27	2.71	2.43	2.00
CC115212	.49	.00	.71	1.00	.50
CC115213	.37	.55	.41	.43	1.00
CC115214	1.97	1.33	2.35	2.14	2.75
CC115215	.49	.58	.53	1.00	.25
CC115216	.28	.50	.29	-.29	1.50
CC115217	1.31	1.08	1.41	1.86	1.75
CC115218	1.15	1.17	1.12	1.14	2.00
CC115219	2.26	1.17	2.71	3.14	2.00
CC115220	1.38	1.42	1.47	1.14	1.25
CC115221	1.21	1.33	1.12	1.71	1.25

CC11521 Quotation and design lead times
CC11522 Design to manufacture lead times
CC11523 Ability to design and manufacture new products
CC11534 Materials optimization due to design
CC11525 Improved product quality due to design
CC11526 Component and tooling standardisation
CC11527 Manufacturing throuput time
CC11528 Scrap rate and rework
CC11529 Change over time
CC115210 Manufacturing lead times
CC115211 Batch size
CC115212 Space and assets
CC115213 Plant down time
CC115214 Direct labour cost
CC115215 Finished goods stocks
CC115216 Raw materials stocks
CC115217 Supervision utilization (less routine administration)
CC115218 WIP (Work In Progress)
CC115219 A.O.Q.L (Average Order Quality Level)
CC115220 Response to quality control traisability queries
CC115221 Management time utilization

(g) Establishing any defensive factors which might be taken into consideration

It is very important during the justification of the technologies that the manufacturer should take into consideration some other defensive factors which could be decisive in the selection of the appropriate technology. Such factors include:

(i) Main contractors requirements

(ii) Solution to skilled labour problems

(iii) Solution to safety problems

(iv) Replacement of existing (old) equipment

(v) Vertical integration (Sub - contractor replacement e.t.c.)

(h) Determining the fitness level of AMT into the process.

Having examined the above factors the manufacturer should proceed with the determination of the fitness level of the AMT into the existing process. This process will help the company to establish the necessary modifications which are needed to support the introduction of the new technology. In addition to this, the compatibility of the new technology with the manufacturing plant's existing systems should be ensured. The results of the survey reveal that the level of process analysis performed prior to the selection and justification of the AMT is one of the important contributing factors to Manufacturing and Business success.

(i) Proceeding with the AMT adoption decision

Having followed the above guidelines and examined all the above factors the decision to proceed or not with the adoption of the needed technology should be taken.

(j) Considering the technology selection and buying related factors

Following the adoption decision the manufacturer should proceed with the selection of the specific technology. The results of the survey reveal that technology selection is an important part of the technology implementation process and should consist of the following:

(a) Gathering information about alternative sources

(b) Knowing the various constituents of the technology

(c) Knowing the different production units and different manufacturing practises.

Manufacturers in the survey that had emphasized these elements had achieved significantly higher levels of manufacturing performance than their counterparts

(k) Proceeding with financial Justification of the selected AMT.

The financial evaluation of the expenditure in AMT helps managers measure the exact effect of AMT on the company profitability, cash flow and the degree of risk involved. Furthermore, it gives a proper evaluation and thus allows cost monitoring to ensure that the estimated benefits actually materialize. The results of the survey suggest that the main problem faced in the financial justification of AMT appears to be the difficulties in the evaluation of the intangible benefits which are likely to be achieved by the AMT introduction.

(l) AMT specific equipment manufacturer adoption decision

After the strategic and financial justification of the specific technology the specific AMT equipment manufacturer should be selected

(m) Planning for the transfer, installation and operation of the technology

The specific AMT adoption decision is followed by the planning of the transfer, installation and operation of the technology. Manufacturers in the survey that emphasized the planning for human resource development and infrastructure preparation had experienced high levels of Technical, Manufacturing and Business success.

9.2.2 The Selection, Transfer and Pre- Implementation Phase

This phase consists of all the necessary activities which should be followed for the Selection, Transfer and Installation of the technology in the manufacturing environment. In terms of these activities successful manufacturers in the survey had expended significantly higher levels of effort than not so successful ones in the following areas:

(i) Performing on going adjustments during AMT transfer and pre-implementation together with continuous measurement and control during this process

(ii) Providing adequate training by the equipment manufacturer before AMT installation

(iii) Taking considerable support by the equipment manufacturer before the installation and actual operation of the technology.

(iv) Continuing management support and attention to supportive human resource practises.

9.2.3 The Post Implementation Phase.

This phase addresses all the activities which should be performed after the installation and productive operation of the technology within the manufacturing environment. The results of the survey reveal that companies which pay attention to the areas listed below during the post installation phase are more likely to experience success than their counterparts

(i) Continuing management and operators support

(ii) Level of training given and high final achievement of Technical knowledge

(iii) Modification to the company's policies and procedures so as to support the AMT implementation

(iv) Setting of interim targets on which the process of implementation should be evaluated.

9.3 Illustrative examples

In order to illustrate the above integrated process plan two examples are given below:

A Case 1

A medium sized steel structures manufacturing and erection company is operating in a relatively low volume market environment. This market is characterized by small erection works which account for 70% of the total market. The remaining 30% are heavy duty works . The company is operating in the small erection works market where it started facing high competition mainly from small local workshops. These small workshops are family owned and in most of cases are "one man businesses". This family character of these small workshops enables them to achieve flexibility together with low prices.

The company's management team faces the dilemma whether to withdraw from this market, or to remain by trying to retain competitive advantage over its competitors. The strategic decision and plans of the company are:

(a) To increase/maintain the existing market share on the small erection works and

(b) To enter the market for heavy erection works.

Following the process described earlier in this chapter the company should proceed to establish its competitive priorities in order to support its strategic decision. The following competitive priorities have been identified as being the ultimate ones

1 Product price reduction

2 Delivery performance improvement

3 Delivery lead times improvement

4 Product design flexibility and

5 Volume flexibility

In order to achieve these criteria, many changes in the manufacturing environment should be performed. A process analysis should be followed in order to establish the existing level of the manufacturing parameters within the manufacturing environment. Based on the results of the process analysis and the information given in table 9.1, the following manufacturing parameters should be altered in order to influence positively the required competitive priorities:

1. Component tooling standardization should be increased
2. Manufacturing throughput time should be reduced
3. Scrap rate and rework should be reduced
4. Average Order Quality level should be improved
5. Batch size should be increased

Having identified the manufacturing parameters which should be altered, table 9.2 is used to establish the most appropriate type of AMT to be adopted.

Based on table 9.2 the following AMTs are recommended:

Table 9.3 Possible AMTs for Case Study 1

Manufacturing parameter	**Recommended AMT**
Component tooling standardization	CAD/CAM and CNC
Manufacturing throughput time	CAD/CAM and CNC
Scrap rate and rework	CAD/CAM
Average Order Quality level	CAD/CAM and CNC
Batch size	CNC

Since one of the company's major activity is design work, the CAD/CAM technology is found to be the most appropriate AMT to be adopted. Successful implementation of the correct CAD/CAM technology should influence positively the manufacturing parameters and ultimately establish the desired competitive priorities of the company in order to safeguard its position in the market place.

In considering the type of technology to be adopted, the company shall take into account some defensive factors which could be decisive in the selection of the type of technology. In this case the only defensive factor which exists is the shortage of skilled labour which can be addressed effectively by the introduction of the CAD/CAM technology.

Before deciding the type of technology to be adopted the company should establish the fitness level of the AMT into the existing process and determine the necessary modifications which are needed to support it. The company should then proceed with the selection of the specific CAD/CAM technology considering the selection and buying factors outlined in the model. The CAD/CAM adoption decision shall undergo a financial justification process by taking into consideration both the tangible (direct) and intangible (indirect) benefits. If the specific technology is not financially justifiable the company should seek alternative technologies (probably stand alone CNC machines etc.)

B Case 2

A medium sized pump manufacturing company is operating in a relatively medium volume market environment with the bulk of its production being exported to the Arab Market. This market over recent years, has been penetrated by other overseas firms possessing distinct competitive advantage in product quality and price.

The company`s management team faces the dilemma of whether to withdraw from this market , or to remain by trying to regain the lost competitive advantage. If the strategic decision of the company is to increase/maintain the existing market share (exporting to the Arab Market), it should proceed to establish its competitive priorities in order to support its strategic decision. The following competitive priorities have been identified to be the most appropriate:

1 Product price reduction

2 Quality consistency

3 Improved performance design

In order to achieve these criteria some changes in the manufacturing environment should be performed. A process analysis should be followed in order to establish the existing level of the manufacturing parameters within the manufacturing environment. Based on the results of process analysis and the information given in table 9.1 the following manufacturing parameters need to be altered in order to influence positively the required competitive priorities:

1. Design to manufacture lead times should be reduced
2. Component tooling standardization should be increased
3. Manufacturing throughput time should be reduced
4. Average Order Quality level should be improved
5. Batch size should be increased
6. Direct labour cost should be reduced

Having identified the manufacturing parameters which should be altered, table 9.2 is used to establish the most appropriate type of AMT to be adopted.

Based on table 9.2 the following AMTs are advisable:

Table 9.4 Possible AMTs for Case Study 2

Manufacturing parameter	Recommended AMT
Design to manufacture lead times	CAD/CAM
Component tooling standardization	CAD/CAM and CNC
Manufacturing throughput time	CAD/CAM and CNC
Average Order Quality level	CAD/CAM and CNC
Batch size	CNC
Direct labour cost	CAD/CAM and CNC

As indicated in table 9.4 and taking into consideration that the company is not involved substantially in product design (it manufactures a relatively standard product range) the CNC technology is found as being the most appropriate AMT to be adopted. Successful implementation of the correct CNC technology should influence possitively the manufacturing parameters and ultimately achieve the desired competitive priorities of the company in order to safeguard its position in the market place.

In considering the type of technology to be adopted the company should also take into account some defensive factors which could be decisive in the selection of the type of technology. In this case no defensive factors exists since the company do not faces any skill shortage or other related problem and do not operate as a subcontractor.

Before taking the final decision on the type of technology to be adopted, the company should establish the fitness level of the CNC technology into the existing process and determine the necessary modifications which are needed to support it. The company should also consider the selection and buying factors outlined in the model and undertake a financial justification of the technology by taking into consideration both the tangible (direct) and intangible (indirect)benefits.

9.4 Summary

The research results regarding the planning and implementation requirements for the successful adoption of AMT in the Manufacturing environment were critically examined and integrated into a process plan (model). This integrated process plan is analytically presented and analysed in this chapter. This presentation is reinforced with two illustrative examples.

This process plan should enable Cypriot manufacturers select the most appropriate AMT to satisfy their strategic plans and competitive priorities.

CHAPTER 10

CONCLUSIONS

AND

RECOMMENDATIONS FOR FURTHER WORK

10.1 Conclusions

The primary focus of this thesis was to examine the process of Justification, Transfer and Implementation of AMT in the Cypriot Manufacturing Industry, investigate and quantify its impact on the Business and manufacturing environment and analyze the contributing factors to the Success or Failure of the technologies. The final aim of the thesis was to prepare an Integrated Plan for the strategic planning and implementation of AMT in the key manufacturing industries based on the research results. It is worth emphasizing that this research does not purport to present findings from a random sample of firms within the manufacturing Industry. The sample was selected in order to represent to the maximum possible extent all the companies using AMT.

The survey was conducted on a sample of 40 companies using personal interviews based on a purpose designed comprehensive questionnaire. The surveyed population consisted of small to medium size firms in the Machine Tools, Pumps, Metal and Wooden Furniture, Refrigerator, Printing and Ice Cream manufacturing industries. Unlike other studies, the survey was carried out by personal interviews rather than a mailed questionnaire and the sample covers nearly all the companies in the Cypriot Manufacturing Industry which have introduced AMT.

The questionnaire addresses the following areas :

(a) The operating environment in which the Cyprus manufacturing industry operates, with emphasis on the product and market characteristics and the product winner criteria which are needed to be competitive.

(b) The characteristics of the Advanced Manufacturing Technologies which were introduced and the impact they had on the competitiveness of each individual company.

(c) The successes and failures of the implementation of the technologies and the examination of the success and failure factors.

The survey responses were analysed and the following results were deduced:

- The Cypriot industry faces competitive pressures which have been sharpened by a custom union agreement between Cyprus and the European Union (1988) and the implementation of the GATT agreement in January 1996. The removal of the trade barriers as well as the reduction of the import duties exposed the previously protected Cypriot economy to the international competition.

- The Cypriot manufacturing industry should give emphasis on the production of quality products and should seek ways of improving the delivery times and the reliability with which quoted delivery times are met.

- In general, the competitiveness of the manufacturing companies which proceeded with the implementation of AMT was found to be relatively improved. The adoption of AMTs managed to improve the quality level and quality consistency of the products as well as the reliability of the product delivery times.

- It is of interest to mention that nearly all the companies managed to operate the technology at satisfactory levels (Technical Success), whilst 43.5% realized the full benefits attainable from the technology (Business Success).

- The more successful companies in the implementation of AMT are those who gave special attention to the people aspect. The provision of adequate training to the operators before and after the installation of the technologies, as well as their willingness to support the technology were among the most important factors for its successful implementation. Among the strongest determinants of success is the level of fitness which exists between the existing manufacturing philosophy and the new AMT. Companies that paid attention to this and performed on-going adjustments to the manufacturing processes, changed their policies and introduced modifications to their procedures to support the new technology were found to be most likely to achieve success.

- A strong determinant of failures in the implementation of AMT was found to be the fear of the employees that they would not manage to operate the new technology, especially before its installation.

- Many manufacturers tried to make a compromise between the type of technology actually needed and their budgetary constraints. As a result they started foreclosing options during the selection stage which led to the selection of a technology that did not satisfy actual needs. The result was a Business failure of the technology.

- A critical examination of the success and failure factors and the influence level of AMTs on the competitiveness of the companies was carried out and the results were critically examined, analysed and integrated into a process plan (model). This model provides the framework and all the necessary information for the Cypriot manufacturers to identify their needs, justify and select the most appropriate Advanced Manufacturing Technology to satisfy their strategic plans and competitive priorities.

The planning model is divided into three phases as follows:

(a) The planning phase

(b) The Selection, transfer and pre- implementation phase, and

(c) The post implementation phase.

Each face addresses separate issues which should be considered during the process of AMT implementation in the manufacturing environment.

The planning phase follows a rather deterministic approach in the justification of the technology taking into consideration the business opportunities and the product/market characteristics. The decision to adopt the specific AMT must precede an estimation of the parameters within the manufacturing environment which should be altered by the introduction of the AMT, a knowledge of the AMT characteristics and the examination of the fitness level of AMT in the existing processes. Following this, the whole decision should undergo a financial justification process. This planning process is facilitated by the provision of a table which is used as a guide in order to determine the needed level of the manufacturing parameters, and a table which is used to establish the most suitable technology to be adopted in order to alter the established manufacturing parameters. These tables were constructed from the analysis of the research results.

In the selection, planning and pre-implementation phase, as well as in the post implementation phase, is described the way these processes should be managed in order to safeguard the successful implementation of the technology.

The widest application of AMT in the Cypriot Manufacturing Industry managed to influence positively the flexibility of the companies, increase the quality of their products and reduce the production costs. Consequently, in most of the cases there was an increase and or maintenance of the existing market share where in many instances companies managed to introduce new products in existing markets. In addition, the implementation of AMTs provided a solution to the skilled labour shortage problem that the manufacturing industry is facing. The wide application of AMTs is expected to change the structure of the industry from labour intensive to knowledge intensive.

Based on the results of the study, a recommendation would be for the Cypriot manufacturers to seek ways of introducing Advanced Manufacturing Technologies in their manufacturing environment and include AMT in their strategic thinking and considerations. The proposed integrated planning model could be a very useful guide for the successful planning and implementation of such technologies.

10.2 Recommendations for further work

In the light of the findings presented, the following aspects need to be investigated further:

- There is a need for more research work to examine the relationship between the managerial profiles and the extent of application of AMT in the Cypriot manufacturing industry with emphasis on the process of planning the AMT introduction in the manufacturing environment.
- Based on the above analysis of the existing managerial profiles a training need analysis should be performed aimed at bringing the level of internal management capability with regard to AMT, up to the required standard.
- A need for testing the proposed integrated planning model in the Cypriot manufacturing industry and internationally.

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A P P E N D I X "A"

ADVANCED MANUFACTURING TECHNOLOGIES

-HARDWARE AND SOFTWARE-

AND THEIR CHARACTERISTICS

A.1 Introduction

Advanced Manufacturing Technologies (AMT) are split into (a) Pure Technical tools and (b) Management tools (manufacturing practices - software). Under the heading of Advanced Technical tools are included (a) Computer Aided Design (CAD), (b) Computer Aided Manufacturing (CAM, NC/CNC), (c) Computer Aided Design / Computer Aided Manufacturing (CAD/CAM), (d) Robotics, (e) Flexible Manufacturing Systems (FMS's), (f) Automatic Guided Vehicles (AGV's) etc. Under the heading of production management tools (software) are included (a) Just In Time (JIT), (b) Group Technology (GT), (c) Materials Requirements Planning (MRP) and Manufacturing Resources Planning (MRPII).

This Appendix explains briefly the above technologies. These technologies are extensively discussed in the literature [Harisson (1990), Krajewski et all (1990), Nisanci (1985)].

A.2 Specific Advanced Manufacturing Technologies

A.2.1 Advanced Technical Tools

Computer Aided Design - CAD-

The term Computer Aided Design -CAD- refers to the replacement of paper and pencil with computers and terminals in the design process. The designer creates drawings on a display monitor and instructs the computer to show several views of the subject according to specified dimensions. The most important benefits from the introduction of a CAD system are the following [Harisson (1990)]:

(a) Savings in the drawing office i.e. reduction of the number of draughtsmen. avoidance of sub-contracting of design, etc ,

(b) Reduction in delivery times through reduction of design and documentation time, drawing quality improvement and therefore reduction of delays in production,

(c) Sales increase because of faster and better presented quotations, reliable delivery dates, faster product introduction, better company image,

(d) Reduction of stock levels by reduction of production lead times and standardization of components used,

(e) Design of products which are too complex to be designed manually,

(f) Reduction of production costs, etc .

Numerically Controlled Machines (NC-CNC)

Numerical Control (NC) is defined as the automatic control of a process performed by a device that makes use of numerical data usually introduced as the operation is in progress. Thus NC machines are large machine tools programmed to produce small to medium size batches of intricate parts. By following a preprogrammed sequence of instructions, NC machines can drill, turn, bore, or mill many different parts in various sizes and shapes. These machines were first developed in the early 1950s at the Massachusetts Institute of Technology through research sponsored by the U.S.A Air Force. The objective was to find more efficient methods of manufacturing jet aircraft.

Numerically controlled machines are currently the most commonly used form of flexible automation. The newer models receive their instructions from a computer, not from a punched tape or card as in the past (CNC machines). CNC machines are usually stand-alone pieces of equipment, each controlled by its own microcomputer. These cover almost all engineering machining processes (drilling, milling, turning. grinding and so forth) and have obvious applications to operations in other areas of manufacturing (control of plastic injection moulding machines, printing presses etc.).

The advantages of CNC systems are seen mainly in situations requiring change, that is when small batches are required (set-up time at the beginning of a batch is significant) or when items within different batches are slightly different (such changes being made, and checked for validity through modifications to the program rather than during manufacture). Such systems also come into their own in the manufacture and testing of complex items requiring many machining operations and high levels of consistent quality [Harisson (1990)].

Computer Aided Design/Computer Aided Manufacturing -CAD/CAM-

Computer Aided Manufacturing (CAM) refers to the use of computers in the management and control of manufacturing.

A CAD/CAM system integrates the design and manufacturing function through a computer. The system translates final design specifications directly into detailed machine instructions for manufacturing the part.

Industrial Robots

Industrial Robots are programmable machines designed to move objects around and perform certain tasks which would ordinarily be done by humans. Robots can operate independently of human control. Most are stationary and mounted on the floor, with an arm that can reach into difficult locations. They are of particular value in dangerous work environments or as part of a repetitive work cycle. Typical Robot applications are materials handling, processing (such as welding and painting) assembly, inspection and testing. Second generation Robots equipped with sensors that simulate touch and sight can be used to wash windows, pick fruits from trees, mix chemicals in laboratories, handle radioactive materials, etc.

The initial cost of a Robot depends on its size and function. Other costs include modifications to both product and process to accommodate the Robot, preparation of the worksite, installing and debugging the robot, and retraining and relocating workers. Robots are necessarily parts of more complex engineering systems and their support equipment may cost many times more than the robot itself. Benefits from robot installation include [Harisson (1990)]: (a) less waste material, (b) more consistent quality, (c) savings in labour, and (d) flexibility in production.

Flexible Manufacturing Systems (FMS)

A Flexible Manufacturing system (FMS) is defined as an automated manufacturing system which is capable, with a minimum of manual intervention, of manufacturing any of a family of components [Erickson et all(1991)]. Nisanci (1985) characterizes FMSs as the stepping stones to automated, unmanned machining systems. Flexible manufacturing systems incorporate many individual technologies of flexible automation such as Automated handling, NC, CNC, Group technology, Robots, Automatic testing, etc [Harisson (1990), Krajeewski et all (1990)]. An FMS consists of a number of machine tools and handling and testing equipment, integrated by computer control. In detail an FMS incorporates the following [Harisson (1990)]:

(a) Several computer-controlled work stations, such as CNC machines or robots,

(b) A computer controlled transport system, and

(c) Loading and Unloading stations.

Many benefits can arise from the introduction of FMS, the most important of which are [Harisson (1990)] :

(a) Reduction in inventory through improvements in the Production Control system,

(b) Increased Productivity through better planning and control of the flow of work and therefore reduction of set-up times,

(c) Unmanned operation (e.g. in third-shift working), and

(d) Improved flexibility.

Automated Guided Vehicles (AGVs)

AGV is a small, driverless, battery-driven truck that moves materials between operations. Most models follow a cable installed below the floor, but optical paths and other methods have extended their capabilities. They can go anywhere so long as there is a space and a relatively smooth floor. Instructions are issued from either an on-board computer or a centralized computer. The AGVs ability to route around problems such as production bottlenecks and transportation blockages helps production and can avoid expensive, unpredictable shutdowns. Further more AGVs give just-in-time delivery of parts, thus reducing stock piles of expensive inventories throughout the plant [Harisson (1990)].

A.2.2 Production Management Systems

Group Technologies

This manufacturing technique, groups parts or products with similar characteristics into families and sets aside groups of machines for their production. The families can be based on shape, size, manufacturing requirements, etc. The aim is to minimize machine change over or set up time by finding a set of products with similar processing requirements. Group Technology can provide the following benefits [Harisson (1990)]:

(a) Less set up time,

(b) Lower work - in - progress inventory,

(c) Less materials handling,

(d) Reduced cycle time, and

(e) Increased opportunities for automation .

Materials Requirements Planning (MRP) and Manufacturing Resource Planning (MRP II)

MRP can be defined as being a system aiming to provide planning and control for manufacturing. The acronym MRP has two related meanings. The first meaning is Materials Requirements Planning(MRP). MRP aims to maintain a valid schedule of customer delivery dates through the use of a computer based planning and control system. In more detail MRP is a set of techniques which uses bills of material, inventory data, and the master production schedule to calculate requirements for materials, to make recommendations to release replenishment orders for material and further on to make recommendations to reschedule open orders when due dates and need dates are not in phase. The above outline refers to the MRP, often called open loop or type I. The closed loop MRP or the type II implies that there is a continuous feed back from the system so that the planning is kept valid all times. More recently MRP systems have been expanded to become complete planning and control mechanisms giving rise to the new term manufacturing resource planning (MRP II) or a type III system. MRP II is a method of effective planning of all the resources of a manufacturing company. This is done by integrating all the related business and transaction aspects of manufacturing including MRP, capacity planning, inventory control, product costing, shop floor control, finance, marketing, engineering and human resource management [Harisson (1990)].

Just In Time (JIT) Approach

The philosophy of JIT manufacturing is to operate a simple and efficient manufacturing system capable of optimizing the use of manufacturing resources such as capital, equipment and labour. JIT is a disciplined program for improving overall productivity and elimination of waste or non-value added activities. It provides for the cost-effective production and delivery of only the necessary quality parts in the right quantity, at the right time and place, while using the minimum amount of facilities, equipment, materials and human resources. The basic elements of JIT are waste elimination, total quality control and attention to the development of human resources. The manufacturing systems most likely to be associated with JIT are [Harisson (1990)]:

(a) Kanban,

(b) Zero Inventory,

(c) Material Requirements Planning (MRP),

(d) Manufacturing Resource Planning (MRP II),

(e) Group Technology.

APPENDIX "B"

THE QUESTIONNAIRE

CONFIDENTIAL QUESTIONNAIRE

This survey is entirely confidential

and no individual company will be identified in the report

EVALUATION OF THE OF ADVANCED MANUFACTURING TECHNOLOGY (AMT) IMPLEMENTATION IN THE CYPRIOT MANUFACTURING INDUSTRY

The purpose of this questionnaire is to assess the Implementation of AMT in the Cypriot Manufacturing Industry, investigate and quantify its impact on the Business and Manufacturing environment and analyze the contributing factors to the Success or Failure of the technologies.

This questionnaire is divided into five sections:

Section "A": Company General Characteristics

Section "B": Manufacturing Technologies: Present and Future Applications

Section "C": Impact of AMT on Company Competitiveness - Successes and Failures of AMT

Section "D": Planning factors - AMT Strategic Planning Factors

Section "E": AMT operational Factors (Before and After the Actual Productive Operation of AMT)

Company name :...

Address:..

Interviewee name:..

Position:..

Give details of the specific products manufactured by your company:

....
....
....
......

SECTION A COMPANY GENERAL CHARACTERISTICS

A1. Company's classification

		% of total production
A1.1	Metal Industries	%
A1.2	Chemical Industries	%
A1.3	Clothing Industries	%
A1.4	Shoes Industries	%
A1.5	Printing Industries	%
A1.6	Food Industries	%
A1.7	Furniture industries	%
A1.8	Other (identify)	%

A2. Location: ....

A3. No. of years at present location: ....

A4. Year of Firm was originally founded: ....

A5. Year firm was acquired: ....

A6. Workforce structure

A6.1	No of full time employees		
A6.2	Total no. of managers		
A6.3	Total no. of engineers		
A6.4	No. of employees in the administration dept.		
A6.5	No. of employees in the finance dept.		
A6.6	No. of employees in the marketing/sales dept.		
A6.7	No. of employees in the manufacturing dept.		
A6.7.1	No. of employees in the engineering dept.		
A6.7.1.1	No. of engineers		%
A6.7.1.2	No. of draftsmen		
A6.7.2	No. of employees in the production dept.		
A6.7.2.1	Production managers		%
A6.7.2.2	Supervisors		
A6.7.2.3	Skilled workers		
A6.7.2.4	Unskilled workers		

A6.8 Training officer or a person who is in charge of that duty Yes No

A7. Gross output : £

A8. Value added as a percentage of gross output : %

A9. Exports as % of gross output : [%]

A10. R & D expenses : [£]

A11 Ratio of productive assets to total assets [%]

A12. Value of stocks at 31.12.1995 : [£]

A13. Stock turn-over: [months]

A14. Do you work on shifts. [YES] [NO]

Give the number of shifts per 24 hours. [ ]

A15. Is the company unionized? [YES] [NO]

A16. Do you have sub-contractors? [YES] [NO]

A17. Give the percentage of sub-contracting to the total manufacturing output ....%

A18 Do you operate as a subcontractor; [YES] [NO]

A19 Give the percentage to the total manufacturing output ....%

A20. Are you operating close to your maximum capacity? [Yes] [No]

A21 State the capacity cushion of your plant: [%]

A22 Reasons for under capacity utilization

State the level of influence of the following reasons for under capacity operation :

		No influence									Full influence
		1	2	3	4	5	6	7	8	9	10
A22.1	Labour shortage										
A22.2	Market problems										
A22.3	To absorb flactuations in the demand										
A22.4	Any other (identify)										

A23 Production/plant characteristics

State the level of existence of the following in your company

		Low 1	2	3	4	5	6	7	8	9	High 10
A23.1	Capacity cushion										
A23.2	Plant flexibility										
A23.3	Technology intensity										
A23.4	Degree of vertical integration										
A23.5	Degree of subcontracting										
A23.6	Degree of operating as a subcontractor										

A24 Company cultures

State the level of existence of the following in your company:

		Low 1	2	3	4	5	6	7	8	9	High 10
A24.1	Receptivity to new ideas										
A24.2	Faster approval										
A24.3	Collaboration between departments										
A24.4	Abundant praise and recognition										
A24.5	Advance warning of changes, open circulation of information										
A24.6	Extra resources available										
A24.7	Attitude that we are always learning										

SECTION B MANUFACTURING TECHNOLOGIES: PRESENT AND FUTURE APPLICATIONS

B1. General

B1.1 Total no. of machine tools : ☐

B1.2 No of computer controlled machine tools : ☐

B2. Advanced manufacturing technologies used (hardware)

B2.1 CAD System: Dept. .... (state the Dept.)

	19...	19...	19...	19...	19...	PLANNED
No of systems						
Amount spent £						

B2.2 NC machines: Dept. ....

	19...	19...	19...	19...	19...	PLANNED
No of systems						
Amount spent £						

B2.3 CAM systems: (CNC) Dept. ....

B2.3.1 EX-NOVO

	19...	19...	19...	19...	19...	PLANNED
No of systems						
Amount spent £						

B2.3.2 - RETROFITTED

	19...	19...	19...	19...	19...	PLANNED
No of systems						
Amount spent £						

B2.4 CAD/CAM systems: Dept...

B2.4.1 - EX-NOVO

	19...	19...	19...	19...	19...	PLANNED
No of systems						
Amount spent £						

B 2.4.2 - RETROFITTED

	19...	19...	19...	19...	19...	PLANNED
No of systems						
Amount spent £						

B2.5 Robotics: Dept. ....

	19...	19...	19...	19...	19...	PLANNED
No of systems						
Amount spent £						

B2.6 Flexible systems: Dept. ....

	19...	19...	19...	19...	19...	PLANNED
No of systems						
Amount spent £						

B2.7 AGVs: Dept. ....

	19...	19...	19...	19...	19...	PLANNED
No of systems						
Amount spent £						

B2.8 Other (specify): Dept. ....

	19...	19...	19...	19...	19...	PLANNED
No of systems						
Amount spent £						

B3. Advanced manufacturing technologies used (software)

State the year of introduction of the following practices:

B3.4 MRP

B3.4.1 Open loop

19...	19...	19...	19...	19...	PLANNED

B3.4.2 Closed loop

19...	19...	19...	19...	19...	PLANNED

B3.5 MRPII

19...	19...	19...	19...	19...	PLANNED

B3.6 Other (specify)

19...	19...	19...	19...	19...	PLANNED

SECTION C IMPACT OF AMT ON COMPANY COMPETITIVENESS-SUCESSES AND FAILURES OF AMT

C1 IMPACT OF AMT ON COMPANY COMPETITIVENESS

C1.1 Successes and failures from AMT implementation

C1.1.1 Systematic assessment of the effects of AMT implementation

How systematic have the effects of the implementation of AMT been assessed?

Not assessed 1	2	3	4	5	6	7	8	9	Very systematically 10

C1.1.2 Product / market characteristics (Before the introduction of AMT)

State the main product / market characteristics before and after the introduction and operation of AMT

Product Market	Local		Europe		Arab		Other	
	Before	After	Before	After	Before	After	Before	After
	%	%	%	%	%	%	%	%
	%	%	%	%	%	%	%	%
	%	%	%	%	%	%	%	%
	%	%	%	%	%	%	%	%

C1.1.3 Level of impact of AMT introduction

State the level of impact of AMT introduction on the following

		Low 1	2	3	4	5	6	7	8	9	High 10
C1.1.3.1	Increasing/maintaining market share										
C1.1.3.2	Entering new markets with existing products										
C1.1.3.3	Introducing new products to existing markets										
C1.1.3.4	Entering new markets with new products										

C1.1.4 Competitive priorities

State the level of existence of the following competitive priorities before and after the introduction and operation of AMT.

		Before										After									
		Poor									Ideal	Poor									Ideal
		1	2	3	4	5	6	7	8	9	10	1	2	3	4	5	6	7	8	9	10
C1.1.4.1	Price																				
C1.1.4.2	Consistent Quality																				
C1.1.4.3	Performance design																				
C1.1.4.4	Delivery Lead time																				
C1.1.4.5	Delivery performance																				
C1.1.4.6	Product/Design flexibility																				
C1.1.4.7	Volume flexibility																				

C1.1.5 Process design and manufacturing parameters

State the value of the following in your company before and after the introduction and operation of AMT:

C1.1.5.1Tangible parameters

			Before	After
C1.1.5.1.1	No. of machines	No		
C1.1.5.1.2	No. of employees	No		
C1.1.5.1.3	Floor space	M.		
C1.1.5.1.4	Manufacturing cost as a % of sales			

		Before	After
C1.1.5.1.4.1	Raw materials		
C1.1.5.1.4.2	Direct labour		
C1.1.5.1.4.3	Energy		
C1.1.5.1.4.4	Manufacturing overhead		

C1.1.5.2 **Intangible parameters**

State the level of existence of the following manufacturing parameters before and after the introduction and operation of AMT.

		Before										After									
		Poor									Ideal	Poor									Ideal
		1	2	3	4	5	6	7	8	9	10	1	2	3	4	5	6	7	8	9	10
C1.1.5.2.1	Quotation and design lead times																				
C1.1.5.2.2	Lead times (design to manufacture)																				
C1.1.5.2.3	Ability to design and manufacture new products																				
C1.1.5.2.4	Materials optimization due to design																				
C1.1.5.2.5	Improved product quality due to design																				
C1.1.5.2.5	Component and tooling standardization/reduction																				
C1.1.5.2.7	Throughput time (manufacturing)																				
C1.1.5.2.8	Scrap rate and rework																				
C1.1.5.2.9	Change over time																				
C1.1.5.2.10	Manufacturing Lead times																				
C1.1.5.2.11	Batch size improvement																				
C1.1.5.2.12	Space and assets (as a result of stocks, WIP, etc.)																				
C1.1.5.2.13	Plant down time (as a result of planned maintenance)																				
C1.1.5.2.14	Direct labour cost																				
C1.1.5.2.15	Finished goods stocks																				
C1.1.5.2.16	Raw materials stocks																				
C1.1.5.2.17	Supervision utilization (Less routine administration)																				
C1.1.5.2.18	WIP (Work in progress)																				
C1.1.5.2.19	A.O.Q.L																				
C1.1.5.2.20	Response to quality control traisability queries																				
C1.1.5.2.21	Management time utilization																				

C2 ESTIMATED FUTURE SITUATION - EXPECTED AFTER THE INTRODUCTION OF AMT

C2.1. Product - Market characteristics

State the estimated optimum product - market characteristics

Product Market	Local	Europe	Arab	Other
	%	%	%	%
	%	%	%	%
	%	%	%	%
	%	%	%	%

C2.2 Competitive priorities

Give the optimum level of the following competitive priorities in accordance to the estimated priority you expected prior to the introduction of AMT.

		Poor 1	2	3	4	5	6	7	8	9	Ideal 10
C2.2.1	Price										
C2.2.2	Consistent Quality										
C2.2.3	Performance design										
C2.2.4	Delivery Lead time										
C2.2.5	Delivery performance										
C2.2.6	Product/Design flexibility										
C2.2.7	Volume flexibility										

C3 REALITY AS A RESULT OF ENVIRONMENTAL AND OTHER CHANGES

C3.1 Product - Market characteristics

State the actual optimum product - market characteristics

Product Market	Local	Europe	Arab	Other
	%	%	%	%
	%	%	%	%
	%	%	%	%
	%	%	%	%

C3.2 Competitive priorities

Give the optimum level of the following competitive priorities in accordance to existed priority after the introduction of AMT.

		Poor 1	2	3	4	5	6	7	8	9	Ideal 10
C3.2.1	Price										
C3.2.2	Consistent Quality										
C3.2.3	Performance design										
C3.2.4	Delivery Lead time										
C3.2.5	Delivery performance										
C3.2.6	Product / Design flexibility										
C3.2.7	Volume flexibility										

C4 Level of success

State the level of success of AMT implementation in your company with regard to the following:

		Low 1	2	3	4	5	6	7	8	9	High 10
C4.1	Level of down time										

		Low 1	2	3	4	5	6	7	8	9	High 10
C4.2	Technical success										
C4.3	Manufacturing success										
C4.4	Business success										

C5 Time required to achieve success

State the number of years required to achieve Technical, Manufacturing and Business success. Assess its level.

		Excessive 1	2	3	4	5	6	7	8	9	Required 10	Years
C5.1	Technical success											
C5.2	Manufacturing success											
C5.3	Business success											

SECTION D PLANNING FACTORS, AMT STRATEGIC PLANNING FACTORS,

D1 Level of importance

Give the level of importance of the following in your company before the implementation of AMT

D1.1 Competitive priorities

		Poor 1	2	3	4	5	6	7	8	9	Ideal 10
D1.1.1	Price										
D1.1.2	Consistent Quality										
D1.1.3	Performance design										
D1.1.4	Delivery Lead time										
D1.1.5	Delivery performance										
D1.1.6	Product / Design flexibility										
D1.1.7	Volume flexibility										

D1.2 Manufacturing parameters

		Poor 1	2	3	4	5	6	7	8	9	Ideal 10
D1.2.1	Quotation and design lead times										
D1.2.2	Lead times (design to manufacture)										
D1.2.3	Ability to design and manufacture new products										
D1.2.4	Materials optimization due to design										
D1.2.5	Improved product quality due to design										
D1.2.6	Component and tooling standardization/ reduction										
D1.2.7	Throughput time (manufacturing)										
D1.2.8	Scrap rate and rework										
D1.2.9	Change over time										
D1.2.10	Manufacturing lead times										
D1.2.11	Batch size										
D1.2.12	Space and assets (as a result of stocks, WIP, etc.)										
D1.2.13	Plant down time (as a result of plned maintenance)										
D1.2.14	Direct labour cost										
D1.2.15	Finished goods stocks										
D1.2.16	Raw materials stocks										
D1.2.17	Supervision utilization (Less routine administration)										
D1.2.18	WIP (Work in progress)										
D1.2.19	A.O.Q.L										
D1.2.20	Response to quality control traisability queries										
D1.2.21	Management time utilization										

D2 Factors influencing the decision to introduce AMT

State whether the following factors have been considered and the level of influence in the decision to introduce AMT

D2.1 Market related

		No influence 1	2	3	4	5	6	7	8	9	Substantial influence 10		
D2.1.1	Increasing/maintaining market share											YES	NO
D2.1.2	Entering new markets with existing products											YES	NO
D2.1.3	Introducing new products to existing markets											YES	NO
D2.1.4	Entering new markets with new products											YES	NO

D2.2 Defensive factors

		No influence 1	2	3	4	5	6	7	8	9	Substantial influence 10		
D2.2. 1	Main contractor's requirement											YES	NO
D2.2.2	Solution to skilled labour shortage problem											YES	NO
D2.2. 3	Solution to a safety problem											YES	NO
D2.2. 4	"Me too approach"											YES	NO
D2.2. 5	Replacement of existing (old) equipment											YES	NO
D2.2.6	Vertical integration (sub-contractor replacement etc.)											YES	NO

D2.3Competitive priorities

		No influence 1	2	3	4	5	6	7	Substantial influence 8	9	10		
D2.3.1	Price											YES	NO
D2.3.2	Consistent Quality											YES	NO
D2.3.3	Performance design											YES	NO
D2.3.4	Delivery Lead time											YES	NO
D2.3.5	Delivery performance											YES	NO
D2.3.6	Product / Design flexibility											YES	NO
D2.3.7	Volume flexibility											YES	NO

D2.4 Manufacturing parameters

		No influence 1	2	3	4	5	6	7	8	9	10 Substantial influence		
D2.4.1	Quotation and design lead times											YES	NO
D2.4.2	Lead times (design to manufacture)											YES	NO
D2.4.3	Ability to design and manufacture new products											YES	NO
D2.4.4	Materials optimization due to design											YES	NO
D2.4.5	Improved product quality due to design											YES	NO
D2.4.6	Component and tooling standardization/ reduction											YES	NO
D2.4.7	Throughput time (manufacturing)											YES	NO
D2.4.8	Scrap rate and rework											YES	NO
D2.4.9	Change over time											YES	NO
D2.4.10	Manufacturing lead times											YES	NO
D2.4.11	Batch size improvement											YES	NO
D2.4.12	Space and assets (as a result of stocks, WIP, etc.)											YES	NO
D2.4.13	Plant down time (as a result of plned maintenance)											YES	NO
D2.4.14	Direct labour cost											YES	NO
D2.4.15	Finished goods stocks											YES	NO
D2.4.16	Raw materials stocks											YES	NO
D2.4.17	Supervision utilization (Less routine administration)											YES	NO
D2.4.18	WIP (Work in progress)											YES	NO
D2.4.19	A.O.Q.L											YES	NO
D2.4.20	Response to quality control traisability queries											YES	NO
D2.4.21	Management time utilization											YES	NO

D3 Level of satisfaction

Give the level of satisfaction of the following in your company before the introduction of AMT

D3.1 Competitive priorities

		Low 1	2	3	4	5	6	7	8	9	10 High
D3.1.1	Price										
D3.1.2	Consistent Quality										
D3.1.3	Performance design										
D3.1.4	Delivery Lead time										
D3.1.5	Delivery performance										
D3.1.6	Product / Design flexibility										
D3.1.7	Volume flexibility										

D3.2 Manufacturing parameters

		Low 1	2	3	4	5	6	7	8	9	High 10
D3.2.1	Quotation and design lead times										
D3.2.2	Lead times (design to manufacture)										
D3.2.3	Ability to design and manufacture new products										
D3.2.4	Materials optimization due to design										
D3.2.5	Improved product quality due to design										
D3.2.6	Component and tooling standardization/ reduction										
D3.2.7	Throughput time (manufacturing)										
D3.2.8	Scrap rate and rework										
D3.2.9	Change over time										
D3.2.10	Manufacturing lead times										
D3.2.11	Batch size										
D3.2.12	Space and assets (as a result of stocks, WIP, etc.)										
D3.2.13	Plant down time (as a result of plned maintenance)										
D3.2.14	Direct labour cost										
D3.2.15	Finished goods stocks										
D3.2.16	Raw materials stocks										
D3.2.17	Supervision utilization (Less routine administration)										
D3.2.18	WIP (Work in progress)										
D3.2.19	A.O.Q.L										
D3.2.20	Response to quality control traisability queries										
D3.2.21	Management time utilization										

D4 Process analysis - Fitness of AMT into the process

State the level of performing the following during AMT justification

		Low 1	2	3	4	5	6	7	8	9	High 10
D4.1	Process analysis										
D4.2	Knowledge of AMT characteristics and its impact on manufacturing parameters										
D4.3	Determination of the fitness of AMT into the process(In relation to its impact on manufacturing parameters)										
D4.4	Fitness level of AMT into the process										

D5 Financial Justification of AMT

State the level of the following Problems faced in Financial Justification of AMT

		Low 1	2	3	4	5	6	7	8	9	HIgh 10
D5.1	Accountants										
D5.2	Managers										
D5.3	Difficulties in the evaluation of cost and benefits of such investments (difficulties in the evaluation of intangible benefits)										

D6 Technology Selection and Buying related factors
State the level of planning for utilization of the following buying factors:

		Low 1	2	3	4	5	6	7	8	9	High 10
D6.1	Information about alternative sources (other suppliers)										
D6.2	Knowledge of the various constituents of the technology										
D6.3	Knowledge the different production units or different manufacturing practices (knowledge of the state of the art technology)										
D6.4	Group buying										
D6.5	Break the technological package										
D6.6	Finance from the suppliers										

D7 Constrains
State the level of planning for over coming the following constrains

		Low 1	2	3	4	5	6	7	8	9	High 10
D7.1	Budgetary constrains										
D7.2	Technical and workforce infrastructure constrains										
D7.3	Lack of local technical support										

D8 Planning the technology Transfer/ Implementation
State the degree/level of performing the following during AMT planning:
D8.1 Planning of the technology transfer process

		Low 1	2	3	4	5	6	7	8	9	High 10
D8.1.1	Long term planning (How AMT will integrate into the System)										
D8.1.2	Short term planning (time planning of the phases of technology implementation)										

plan the aim of which is to perform activities so as to be compatible and supportive of AMT)										
8.2.2 Improvements on existing activities (operation, transport, inspection and storage).										
8.2.3 Simplification and planning to achieve a smooth flow through the Manufacturing process										
8.2.4 Policies/procedures modifications										
8.2.5 Pattern work organization changes										

ning for HRD

	Low									High
	1	2	3	4	5	6	7	8	9	10
3.3..1 OvercomingWorkforce reservations										
3.3.2 Overcoming Operators perception as being more skilled or deskilled										

kforce preparation and training

	Low									High
	1	2	3	4	5	6	7	8	9	10
3.4.1 Personnel utilization										
3.4.2 Timing of training to be given										
3.4.3 Level of training to be given										
3.4.4 Type of training to be given										
3.4.5 Learning process										

going adjustments during AMT implementation

	Low									High
	1	2	3	4	5	6	7	8	9	10
8.5.1 Planning and budgeting to realize the benefits (allocation of the necessary resources,money, people and time)										
8.5.2 Measurement and control										

Direct investment ☐

Joint Ventures ☐

State import mode ☐

e of contract signed

e whether the following has been applied and the level of application

		Low 1	2	3	4	5	6	7	8	9	High 10	Yes	No
2.1	Supply of technical personnel to start up production or to provide technical assistance												
2.2	Turnkey contract												
2.3	Product in hand contract												
2.4	An indicative technical service to operate the technology												

oming Factors hindering Technology Transfer process

evel of hindering the technology tranfer process the following factors:

upplier related factors

		Low 1	2	3	4	5	6	7	8	9	High 10
3.1.1	Bureaucratic delays with foreign countries instituted by individuals or groups unknowledgeable about technology transfer										
3.1.2	Cultural and social differences from supplier of technology										
3.1.3	Distance from the supplier of technology										
3.1.4	Lack of communication with the supplier of technology										
3.1.5	Lack of trust and goodwill with the supplier of technology										
3.1.6	Lack of support (technical) from the supplier of technology										

overnment related factors

		Low 1	2	3	4	5	6	7	8	9	High 10
3.2.1	Government intervention and regulations										
3.2.2	Taxation effect										
3.2.3	The transmission channels										
3.2.4	Lack of appropriate legislation										
3.2.5	Frequent changes in current policies and commercial laws										

		1	2	3	4	5	6	7	8	9	10
3.3.3	Management have little experience outside their own particular company										
3.3.4	Lack of knowledge in the workforce										

ying related factors

·ing the selection and transfer of AMT to your company state the level of utilization of the ɔwing buying factors:

		Low 1	2	3	4	5	6	7	8	9	High 10
4 .1	Group buying										
4.2	Break the technological package										

:hnology selection related factors

ring the selection and transfer of AMT to your company state the level of utilization of the ɔwing technology selection related factors:

		Low 1	2	3	4	5	6	7	8	9	High 10
5.1	Foreclosing options at the design and selection stage due to budgetary constrains etc										
5.2	Proper information about the supplier and the product										

level of analysis / preparation / improvements on the following before and after the actual ɘ operation of AMT

rastructure preparation

provements on existing activities (operation, transport, inspection and storage).

nplification and planning to achieve a smooth flow through the Manufacturing ɔcess

		Before Low 1	2	3	4	5	6	7	8	9	High 10	After Low 1	2	3	4	5	6	7	8	9	High 10
:6.1.1	Operation activities																				
:6.1.2	Transport activities																				
:6.1.3	Inspection activities																				
:6.1.4	Storage activities																				

6.2.1	Procedures covering materials handling																				
6.2.2	Procedures covering purchasing																				
6.2.3	Procedures covering testing																				
6.2.4	Procedures covering quality control																				
6.2.5	Procedures covering inventory control																				
6.2.6	Procedures covering design																				
6.2.7	Procedures covering scheduling																				
6.2.8	Procedures covering training																				
6.2.9	Wages and salary systems																				
6.2.10	Any other (identify)																				

tern work organization (changes)

te the degree of changes in the pattern of work organization (design and ıufacturing) as follows:

		Before										After									
		Low									High	Low									High
		1	2	3	4	5	6	7	8	9	10	1	2	3	4	5	6	7	8	9	10
6.3.1	Changes in management decision taking structure (shorten management hierarchies, delicate autonomy to shop floor, increase of the effectiveness of communications by reducing the time necessary to take and convey a decision etc)																				
6.3.2	Formulation of small autonomous working groups with a greater degree of flexibility and internal control																				
6.3.3	Closer working relationship between departments (merging of the design and manufacturing activities, closer co-operation between the marketing and manufacturing dept etc) ie all departments working as fingers on the same hand																				
6.3.4	Interim targets setting on which the process of implementation shall be evaluated																				
6.3.5	Changes in the manufacturing philosophy																				
6.3.6	Changes in plant layout (relocation of the equipment etc), production scheduling and organizational design																				
6.3.7	Converged individual roles																				

.2 Operations manager support																				
.3 Users support																				

'kforce preparation

e the level of formulation/existence of the following during the process of AMT ementation

	Before										After									
	Low									High	Low									High
	1	2	3	4	5	6	7	8	9	10	1	2	3	4	5	6	7	8	9	10
}.1 Representative cross functional implementation teams																				
}.2 Project champion for promoting the project																				
}.3 Employee involvement from the beginning by keeping workers informed up- today about plans for AMT and the reasons why they are needed (sense of ownership)																				
}.4 Employees knowledge about the anticipated impact the new technology will have with regard to job security, working conditions, promotion opportunities, retraining requirements, job classifications, work team structure etc																				
}.5 Workers involvement to the maximum possible extend in the selection and implementation of AMT																				
}.6 Attention/changes to supportive human resource practices (organizational structure, payment systems, motivation level etc)																				
}.7 Awareness of other executives of the company as to the characteristics of AMT and their implication to the product output, and be in-line so that the benefits of AMT introduction are visible to the end user																				

).1.1	Fear of redundancy or job loss																				
).1.2	Fear of being unable to cope with the new system																				
).1.3	They try to minimize the threads to their skills and employment levels																				
).1.4	Specialists feel threatened by newcomers trained in later developments																				
).1.5	Preference for continuing familiar operations and responsibilities																				
).1.6	Union reservation towards AMT introduction																				

)erators attitudes

te the level of existence of the following:

		Before: Deskilled						More skilled				After: Deskilled							More skilled		
		1	2	3	4	5	6	7	8	9	10	1	2	3	4	5	6	7	8	9	10
).2.1	Operators perception as being more skilled or deskilled																				

ersonnel utilization

ate the level of personnel utilization during AMT operation

		Before: Low									High	After: Low									High
		1	2	3	4	5	6	7	8	9	10	1	2	3	4	5	6	7	8	9	10
).3.1	Utilization of existing personnel by providing adequate training																				
).3.2	Recruitment of newly appointed trained personnel																				

orkforce training

vel of technical knowledge of the personnel

ate the level of existence/achievement of the following:

		Before: Low									High	After: Low									High
		1	2	3	4	5	6	7	8	9	10	1	2	3	4	5	6	7	8	9	10
0.1.1	Existing technical knowledge of your employees to implement AMT																				
0.1.2	Achievement of technical knowledge of your employees by giving them training before the introduction of AMT																				

		full extend										full extend									
		1	2	3	4	5	6	7	8	9	10	1	2	3	4	5	6	7	8	9	10
).3.1	Training abroad																				
).3.2	In house training with experts from abroad																				
).3.3	In house training with experts from Cyprus																				
).3.4	You have sent them to private institutions in Cyprus																				
).3.5	You have sent them to Government institutions in Cyprus																				
).3.6	Other (specify)																				

›ss training of the employees

		Before										After									
		Low									High	Low									HIgh
0.4.1	Cross training of the employees on various machines as a result of AMT introduction	1	2	3	4	5	6	7	8	9	10	1	2	3	4	5	6	7	8	9	10

ppliers support

ıte the level of Technical support given by the equipment manufacturer

		Before										After									
		Low									High	Low									High
		1	2	3	4	5	6	7	8	9	10	1	2	3	4	5	6	7	8	9	10
1.1	Support given by the equipment manufacturer																				
1.2	Dependency on the supplier for AMT operation, software system modifications or upgrading.																				

arning process

ıte the type and the level of learning process followed during AMT ›lementation as follows:

		Low									High
		1	2	3	4	5	6	7	8	9	10
2.1	Make it work approach										
2.2	Minimize output approach										
2.3	Leave well enough approach										
2.4	Learn and improve approach										

ı realize the benefits(lead time reduction, responsiveness, quality, flexibility, etc.)

3.1 Planning and budgeting to realize the benefits (allocation of the necessary resources, money, people and time)

Low 1	2	3	4	5	6	7	8	9	High 10

ıasurement and control

	Low 1	2	3	4	5	6	7	8	9	High 10
3.2.1 Periodic evaluation of achievements relative to interim targets										
3.2.2 Identification of the nature and extend of shortfalls and the reasons for them as the basis for considering proposed remedial efforts										
3.2.3 Analysis to cover shortcomings not only in the performance of AMT but also in the effectiveness of supporting procurement, marketing and other managerial efforts										

APPENDIX "C"

DESCRIPTIVE STATISTICS RELATING TO THE PLANNING OF AMT

.00	9	22.5	22.5	22.5
4.00	1	2.5	2.5	25.0
6.00	1	2.5	2.5	27.5
8.00	5	12.5	12.5	40.0
9.00	7	17.5	17.5	57.5
10.00	17	42.5	42.5	100.0
	-------	-------	-------	
Total	40	100.0	100.0	

[ean 7.075 Std dev 4.041 Variance 16.328
ange 10.000 Minimum .000 Maximum 10.000

alid cases 40 Missing cases 0

able C.2 Descriptive statistics pertaining to the influencing level of "entering new markets with existing products" to the AMT introduction (D212)

alue Label	Value	Frequency	Percent	Valid Percent	Cum Percent
	.00	25	62.5	62.5	62.5
	4.00	1	2.5	2.5	65.0
	5.00	1	2.5	2.5	67.5
	7.00	2	5.0	5.0	72.5
	8.00	3	7.5	7.5	80.0
	9.00	3	7.5	7.5	87.5
	10.00	5	12.5	12.5	100.0
		-------	-------	-------	
	Total	40	100.0	100.0	

[ean 3.100 Std dev 4.205 Variance 17.682
ange 10.000 Minimum .000 Maximum 10.000

alid cases 40 Missing cases 0

.00	17	42.5	42.5	42.5
4.00	2	5.0	5.0	47.5
5.00	2	5.0	5.0	52.5
8.00	5	12.5	12.5	65.0
9.00	6	15.0	15.0	80.0
10.00	8	20.0	20.0	100.0
	-------	-------	-------	
Total	40	100.0	100.0	

lean 4.800 Std dev 4.433 Variance 19.651
ange 10.000 Minimum .000 Maximum 10.000

alid cases 40 Missing cases 0

able C.4 Descriptive statistics pertaining to the influencing level of "entering new markets with new products" to the AMT introduction (D214)

alue Label	Value	Frequency	Valid Percent	Cum Percent	Percent
	.00	30	75.0	75.0	75.0
	4.00	2	5.0	5.0	80.0
	5.00	2	5.0	5.0	85.0
	7.00	2	5.0	5.0	90.0
	8.00	2	5.0	5.0	95.0
	10.00	2	5.0	5.0	100.0
		-------	-------	-------	
	Total	40	100.0	100.0	

lean 1.700 Std dev 3.172 Variance 10.062
ange 10.000 Minimum .000 Maximum 10.000

alid cases 40 Missing cases 0

	.00	40	100.0	100.0	100.0
		-------	-------	-------	
	Total	40	100.0	100.0	

ſean .000 Std dev .000 Variance .000
.ange .000 Minimum .000 Maximum .000

'alid cases 40 Missing cases 0

'able C.6 Descriptive statistics pertaining to the influencing level of "solution to skilled labour shortage problem" to the AMT introduction (D222)

'alue Label	Value	Frequency	Valid Percent	Cum Percent	Percent
	.00	15	37.5	37.5	37.5
	4.00	2	5.0	5.0	42.5
	7.00	5	12.5	12.5	55.0
	8.00	7	17.5	17.5	72.5
	9.00	3	7.5	7.5	80.0
	10.00	8	20.0	20.0	100.0
		-------	-------	-------	
	Total	40	100.0	100.0	

ſean 5.150 Std dev 4.258 Variance 18.131
ƚange 10.000 Minimum .000 Maximum 10.000

'alid cases 40 Missing cases 0

'able C.7 Descriptive statistics pertaining to the influencing level of "solution to a safety problem" to the AMT introduction (D223)

'alue Label	Value	Frequency	Valid Percent	Cum Percent	Percent
	.00	37	92.5	92.5	92.5
	3.00	1	2.5	2.5	95.0
	7.00	1	2.5	2.5	97.5
	8.00	1	2.5	2.5	100.0
		-------	-------	-------	
	Total	40	100.0	100.0	

ſean .450 Std dev 1.709 Variance 2.921
ƚange 8.000 Minimum .000 Maximum 8.000

'alid cases 40 Missing cases 0

Value Label	Value	Frequency	Percent	Valid Percent	Cum Percent
	.00	40	100.0	100.0	100.0
		-------	-------	-------	
	Total	40	100.0	100.0	

Mean .000 Std dev .000 Variance .000
Range .000 Minimum .000 Maximum .000

Valid cases 40 Missing cases 0

Table C.9 Descriptive statistics pertaining to the influencing level of "replacement of existing (old) equipment" to the AMT introduction (D225)

Value Label	Value	Frequency	Percent	Valid Percent	Cum Percent
	.00	38	95.0	95.0	95.0
	5.00	2	5.0	5.0	100.0
		-------	-------	-------	
	Total	40	100.0	100.0	

Mean .250 Std dev 1.104 Variance 1.218
Range 5.000 Minimum .000 Maximum 5.000

Valid cases 40 Missing cases 0

TableC.10 Descriptive statistics pertaining to the influencing level of "vertical integration (Sub-contractor replacement" to the AMT introduction (D226)

Value Label	Value	Frequency	Percent	Valid Percent	Cum Percent
	.00	37	92.5	92.5	92.5
	7.00	1	2.5	2.5	95.0
	8.00	2	5.0	5.0	100.0
		-------	-------	-------	
	Total	40	100.0	100.0	

Mean .575 Std dev 2.049 Variance 4.199
Range 8.000 Minimum .000 Maximum 8.000

Valid cases 40 Missing cases 0

Value	Frequency	Valid Percent	Cum Percent	Percent
.00	20	50.0	50.0	50.0
1.00	20	50.0	50.0	100.0
	-------	-------	-------	
Total	40	100.0	100.0	

Valid cases 40 Missing cases 0

Table C.12 Level of problems faced by the accountants in the financial justification of AMT (D51)

Value Label	Value	Frequency	Valid Percent	Cum Percent	Percent
	1.00	36	90.0	90.0	90.0
	7.00	2	5.0	5.0	95.0
	8.00	1	2.5	2.5	97.5
	9.00	1	2.5	2.5	100.0
		-------	-------	-------	
	Total	40	100.0	100.0	

Mean	1.675	Std dev	2.068	Variance	4.276
Range	8.000	Minimum	1.000	Maximum	9.000

Valid cases 40 Missing cases 0

Table C.13 Level of "managers resistance" in the justification of AMT (D52)

Value Label	Value	Frequency	Valid Percent	Cum Percent	Percent
	1.00	36	90.0	90.0	90.0
	5.00	3	7.5	7.5	97.5
	8.00	1	2.5	2.5	100.0
		-------	-------	-------	
	Total	40	100.0	100.0	

Mean	1.475	Std dev	1.502	Variance	2.256
Range	7.000	Minimum	1.000	Maximum	8.000

Valid cases 40 Missing cases 0

.00	2	5.0	5.1	5.1
2.00	3	7.5	7.7	12.8
3.00	5	12.5	12.8	25.6
4.00	2	5.0	5.1	30.8
5.00	5	12.5	12.8	43.6
6.00	1	2.5	2.6	46.2
7.00	6	15.0	15.4	61.5
8.00	10	25.0	25.6	87.2
9.00	5	12.5	12.8	100.0
.	1	2.5	Missing	
	-------	-------	-------	
Total	40	100.0	100.0	

Mean	5.821	Std dev	2.654	Variance	7.046
Range	9.000	Minimum	.000	Maximum	9.000

Valid cases 39 Missing cases 1

APPENDIX "D"

DESCRIPTIVE STATISTICS PERTAINING

AMT TRANSFER PROCESS

Value Label	Value	Frequency	Valid Percent	Cum Percent	Percent
	1.00	40	100.0	100.0	100.0
		-------	-------	-------	
	Total	40	100.0	100.0	

Valid cases 40 Missing cases 0

Table D.2 Level of contract signed for the "supply of technical personnel to start up production or to provide technical assistance" (E21)

Value Label	Value	Frequency	Valid Percent	Cum Percent	Percent
	.00	38	95.0	95.0	95.0
	6.00	1	2.5	2.5	97.5
	10.00	1	2.5	2.5	100.0
		-------	-------	-------	
	Total	40	100.0	100.0	

Mean	.400	Std dev	1.823	Variance	3.323
Range	10.000	Minimum	.000	Maximum	10.000

Valid cases 40 Missing cases 0

Table D.3 Level of "turnkey contract signed" (E22)

Value Label	Value	Frequency	Valid Percent	Cum Percent	Percent
	1.00	5	12.5	12.5	12.5
	5.00	1	2.5	2.5	15.0
	7.00	1	2.5	2.5	17.5
	8.00	3	7.5	7.5	25.0
	9.00	9	22.5	22.5	47.5
	10.00	21	52.5	52.5	100.0
		-------	-------	-------	
	Total	40	100.0	100.0	

Mean	8.300	Std dev	2.972	Variance	8.831
Range	9.000	Minimum	1.000	Maximum	10.000

Valid cases 40 Missing cases 0

	.00	40	100.0	100.0	100.0
		-------	-------	-------	
	Total	40	100.0	100.0	

Mean	.000	Std dev	.000	Variance	.000
Range	.000	Minimum	.000	Maximum	.000

Valid cases 40 Missing cases 0

Table D.5 Level of provision of an "indicative service to operate the technology" (E24)

Value Label	Value	Frequency	Percent	Valid Percent	Cum Percent
	.00	36	90.0	90.0	90.0
	2.00	1	2.5	2.5	92.5
	9.00	2	5.0	5.0	97.5
	10.00	1	2.5	2.5	100.0
		-------	-------	-------	
	Total	40	100.0	100.0	

Mean	.750	Std dev	2.499	Variance	6.244
Range	10.000	Minimum	.000	Maximum	10.000

Valid cases 40 Missing cases 0

APPENDIX "E"

DESCRIPTIVE STATISTICS RELATING TO SUCCESSES AND FAILURES OF AMT

	9.00	0.59	0.55
	7.00	0.49	1.36
	10.00	3.16	4.10
	6.00	-0.36	0.61
	7.00	1.27	1.83
	8.00	1.75	1.82
	8.00	2.86	5.90
	9.00	2.36	3.82
CNC	8.00	1.50	3.74
	9.00	2.67	2.40
	8.00	2.15	2.18
	8.00	2.83	4.11
	2.00	0.86	4.24
	8.00	4.18	7.70
	8.00	3.58	3.81
	7.00	8.81	3.54
	3.00	4.04	1.24
	9.00	1.53	1.84
	9.00	1.89	2.89
	8.00	3.37	2.00
	9.00	4.30	2.06
	8.00	2.67	1.17
	9.00	1.45	1.18
	9.00	2.07	2.65
	9.00	2.36	2.88
CAD/CAM	9.00	7.75	4.20
	6.00	5.79	9.62
	9.00	2.53	5.41
	10.00	3.52	2.89
	8.00	4.42	2.23
	10.00	7.17	5.64
	10.00	3.96	3.49
	10.00	.	
ROBOTICS	3.00	2.50	2.67
	10.00	5.02	8.70
	10.00	1.41	1.32
	8.00	3.38	4.70

Table E.2 Regression estimates : Technical Success (c42)

Variable	B	SE B	95% Confdnce Intrvl B		Beta
FAC1_1	.426287	.238536	-.060868	.913442	.226311
FAC3_1	.372348	.238536	-.114807	.859503	.197675
FAC4_1	.748229	.238536	.261074	1.235384	.397226
FAC5_1	-.765129	.238536	-1.252284	-.277974	-.406198
FAC6_1	.387748	.238536	-.099407	.874903	.205851
FAC7_1	.091830	.238536	-.395325	.578985	.048751
FAC8_1	-.309910	.238536	-.797066	.177245	-.164528
FAC9_1	-.194144	.238536	-.681299	.293011	-.103069
FAC10_1	-.288004	.238536	-.775160	.199151	-.152898
(Constant)	8.125000	.235535	7.643973	8.606027	

Table E.3 Regression estimates: Manufacturing Success (MAN)

Variable	B	SE B	95% Confdnce Intrvl B		Beta
FAC1_1	.123814	.346524	-.580407	.828036	.059696
FAC2_1	.157226	.346524	-.546996	.861447	.075805
FAC3_1	.139426	.346524	-.564795	.843648	.067223
FAC4_1	.398063	.346524	-.306159	1.102285	.191922
FAC10_1	-.034897	.346524	-.739119	.669324	-.016825
(Constant)	3.203028	.342165	2.507665	3.898391	

Table E.4 Regression estimates : Business Success (Bus)

Variable	B	SE B	95% Confdnce Intrvl B		Beta
FAC1_1	.381435	.501153	-.637030	1.399899	.124649
FAC3_1	.337750	.501153	-.680714	1.356215	.110374
FAC4_1	.319056	.501153	-.699408	1.337521	.104264
FAC5_1	-.427593	.501153	-1.446058	.590871	-.139733
FAC10_1	-.529696	.501153	-1.548161	.488769	-.173099
(Constant)	3.946660	.494849	2.941006	4.952313	

Table E.5 Regression estimates : Technical Success (c42)

Variable	B	SE B	95% Confdnce Intrvl B		Beta
FAC1_2	1.241000	.231305	.770931	1.711069	.658833
FAC2_2	.147715	.231305	-.322354	.617784	.078420
FAC3_2	.158209	.231305	-.311860	.628278	.083991
FAC4_2	.089366	.231305	-.380703	.559435	.047443
FAC5_2	.366180	.231305	-.103889	.836249	.194401
(Constant)	8.125000	.228396	7.660844	8.589156	

Table E.6 Regression estimates : Manufacturing Success (MAN)

Variable	B	SE B	95% Confdnce Intrvl B		Beta
FAC1_2	.750789	.301563	.138583	1.362995	.361985
FAC3_2	.321010	.301563	-.291196	.933217	.154772
FAC4_2	-.370103	.301563	-.982309	.242103	-.178441
FAC5_2	.561443	.301563	-.050763	1.173650	.270694
(Constant)	3.203028	.297770	2.598523	3.807534	

Table E.7 Regression estimates : Business Success (BUS)

Variable	B	SE B	95% Confdnce Intrvl B		Beta
FAC1_2	.972975	.474992	.007674	1.938275	.317959
FAC2_2	.489928	.474992	-.475372	1.455229	.160104
FAC3_2	.297675	.474992	-.667625	1.262975	.097277
FAC4_2	-.592729	.474992	-1.558029	.372571	-.193698
FAC5_2	.257615	.474992	-.707685	1.222915	.084186
(Constant)	3.946660	.469017	2.993502	4.899817	

Table E.8 Regression estimates :Technical Success (c42)

Variable	B	SE B	95% Confdnce Intrvl B		Beta
FAC1_3	.121862	.243025	-.372577	.616300	.064695
FAC2_3	1.218226	.243025	.723787	1.712664	.646742
FAC3_3	.114433	.243025	-.380005	.608872	.060751
FAC5_3	-.015872	.243025	-.510310	.478567	-.008426
FAC7_3	.042187	.243025	-.452251	.536625	.022397
FAC10_3	.291556	.243025	-.202882	.785995	.154784
(Constant)	8.125000	.239968	7.636781	8.613219	

Table E.9 Regression estimates : Manufacturing Success (MAN)

Variable	B	SE B	95% Confdnce Intrvl B		Beta
FAC1_3	.664642	.302513	.049862	1.279422	.320450
FAC2_3	.215081	.302513	-.399699	.829861	.103699
FAC4_3	.121727	.302513	-.493053	.736507	.058689
FAC6_3	.127745	.302513	-.487035	.742525	.061591
FAC10_3	.819283	.302513	.204503	1.434063	.395008
(Constant)	3.203028	.298707	2.595982	3.810075	

Table E.10 Regression estimates : Business Success (BUS)

Variable	B	SE B	95% Confdnce Intrvl B		Beta
FAC1_3	.536243	.488571	-.455609	1.528095	.175239
FAC2_3	.492278	.488571	-.499573	1.484130	.160872
FAC6_3	.615004	.488571	-.376847	1.606856	.200977
FAC10_3	.318330	.488571	-.673521	1.310182	.104027
(Constant)	3.946660	.482425	2.967285	4.926035	