ADAMA SCIENCE AND TECHNOLOGY UNIVERSITY

School of Mechanical Chemical and Material Engineering

Trends, Challenges and Prospects of Advanced Manufacturing Technology Transfer and Implementation: A case of Ethiopian Basic Metal and Engineering Industries (BMEIs)

A Thesis submitted in partial fulfilment of the requirements for the award of the degree of
Masters of Science

in

Manufacturing Engineering

By

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Program of Mechanical Design and Manufacturing Engineering
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Approved by Board of Examines

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Candidate Declarations

I hereby declare that the work which is being presented in this thesis entitled **"Trends, Challenges and prospects of Advanced Manufacturing Technology (AMTs) Transfer and Implementations: The Case of Ethiopian Basic Metal and Engineering industries (BMEIs)** "in partial fulfilment of the requirements for the award of the degree of masters of science in Manufacturing Engineering is an authentic record of my own work carried out **September to May 2017** under the supervision of **Dr.J.Bhaskran** , Program of Mechanical Design and Manufacturing Engineering, Adama science and Technology University, Ethiopia.

The matter embodied in this thesis has not been submitted by me for the award of any other degree or diploma. All relevant resources of information used in this thesis have been duly acknowledged.

Solomon Dufera Tolcha	________________	______________
Candidate	Signature	Date

This is to certify that the above declaration made by the candidate is correct to the best of my knowledge and belief. This thesis has been submitted for examination with our approval.

Dr.J.Baskaran	________________	______________
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Mr. Tariku Desta	________________	______________
Co-Advisor	Signature	Date

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Abstract

The purpose of this study is to empirically assess current status, trend and challenges of the Advanced Manufacturing Technology transfer and implementation in Ethiopian Manufacturing companies particularly in Metal and Metal engineering sector and finally aimed to develop an integrated framework/model to facilitate successful implementations of advanced manufacturing technologies.

To achieve the above purpose, qualitative and Quantitative research methods were used. A survey was conducted on sample of 29 industries under Basic metal and engineering sector. An instrument used to collect data were personal interview based purpose designed questionnaires. The data collected from the surveyed industries where analysed using descriptive statistics using SPSS software.

The study reveal that the level of implementation of Advanced manufacturing technologies (AMTs) in Ethiopian Basic metal and Engineering sector was very low with the investment levels at mean of 1.58 in five point scale of 1 to 5. Among surveyed AMTs, CAD are the most popular AMT in all industry, almost 96.6% of BMEIs use CAD. The important reason found to introduce the AMT in BME industry were to increase/maintain market share and desire to introduce a new product to existing markets. In addition to this the study also reveal that quality, delivery performance and performance of design are found the most important competitive priority to introduce AMTs among the surveyed competitive priority. On other hand the identified manufacturing parameter considered as important reason to introduce AMTs were found to be to improve average order quality Level (A.O.Q.L) of product, ability to design and manufacture new product, standardization of component tooling, reduction of change over-time, etc. The study also found that distance from supplier of technologies, lack of workforce, management little experience about AMT is the main challenges that hindered the technology transfer in Ethiopian BMEIs. From the study, it was also found that continuous management commitment, need to revise policies and procedure, degree of financial support, clear vision and objective, identifying the technology which the strategy requires, need to recognize the organizational structure, selection of vendor based on planned strategy, employee motivation, employee relation and cooperation, existence of an employee education & training program prior to implementation, safety of performing job, and need for team members to be familiar with the new technology, degree of availability of skill manpower, understanding the potential contribution of AMT to current operation is the key factor for successful implementations of AMT. Based on the above results from the survey the integrated planning framework was developed to facilitate the successful implementations of advanced manufacturing technologies.

Based on the aforementioned findings of the research, it is recommended by the researcher that the shortcomings identified should be taken into consideration in order to achieve a benefits obtained from advanced manufacturing technologies by successfully transferring and implementing AMT to manufacturing industries.

Keywords: *Advanced Manufacturing Technology (AMT), Basic Metal and engineering, key success factor, statistical package for social science (SPSS), Technology implementation, Technology transfer*

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ABBREVIATIONS AND ACRONYMS

AGV Automated guided vehicles
AMH Automated Material Handling
AMT Advanced Manufacturing Technology
AMTI Advanced Manufacturing Technology index
AMTs Advanced Manufacturing Technologies
APDETs Advanced Product Design and Engineering Technologies
APPTs Advanced Production Planning Technologies
AsMTs Assembly and Machining Technologies
ASRS Automated Storage and Retrieval Systems
BC bar coding
BMEIs Basic Metal and Engineering Industries
CAD Computer-Aided Design
CAE Computer-Aided Engineering
CAM Computer-Aided Manufacturing
CAQCS Computer-Aided Quality Control System
CIM Computer Integrated Manufacturing
CNC Computer Numerical Controlled
DNC Direct Numerical Controlled
ERP Enterprise Resource Planning
FDI Foreign Direct Investment
FMC Flexible Manufacturing Cells
FMS Flexible Manufacturing System
GDP Gross Domestic Product
GT Group Technology
JIT Just-in-Time
MHTs Material Handling Technologies
MNCs Multinational Corporations
MRP Material Requirement Planning
MRP II Manufacturing Resources Planning
MSME Micro, Small and Medium Enterprises
NC Numerical Controlled
NCM *Numerically Controlled M*achine
RP rapid prototyping
SPC statistical process control
GTP Growth and Development Plan
MIDI Metal industry and Development
A.O.Q.L average order quality Levl

CHAPTER 1: INTRODUCTION

1. 1 Introduction

Today, Technology is the backbone of business of all size and is by enabler to attain the competitive edge in the market. Advanced manufacturing technologies and techniques (AMTs) have the potential to significantly improve production output, attain quality and stabilize profitability, thereby ultimately serving to meet our manufacturing objectives and goals. AMTs improve manufacturing process and products through the use of innovative technologies and finds applications in all areas of manufacturing, including design, control, fabrication, and assembly. This family of technologies includes Computer-Aided Design, Manufacturing, Engineering & Process Planning (CAD, CAM, CAE, CAPP, CIM etc), Resource Planning, Automated materials handling systems, Control systems, Process Technologies, Flexible manufacturing systems, Custom manufacturing, High precision technologies, Sustainability technologies, High performance computing and advanced robotics, intelligent manufacturing, group technology etc.

According to Sign et al, (2013), Manufacturing processes and systems used in design and production are undergoing dramatic changes in response to new customer needs and emerging technologies. Complexity, dynamism and uncertainty have become dominant characteristics of recent competition patterns which have resulted in a demand-diversified market with more multifaceted products (Sigh et al, 2013). AMT appears to represent a perfect interaction between technological potential and the manufacturing challenges. The major benefits of Advanced Manufacturing Technologies (AMTs) include faster machine cycle, greater reliability, and reduced inventory, saving on labor, greater flexibility and improved quality. The use of AMTs permits the integration of the full spectrum of production functions and manufacturing processes with computer technologies (Kotha, M.S. and Swamidass, P.M., 2000). With the use of computer technology, AMTs make the data storing and manipulation possible. Data held electronically can be changed and distributed easily and cheaply between these technologies. Companies therefore adopt these technologies for a wide range of activities, ranging from scheduling to quality inspection.

In the global business environment, technology is one of the salient elements for remaining competitive Jabar et al, (2010). With globalization and free trade agreements, manufacturing companies in Ethiopia are under increasing pressure to adopt AMTs to simply survive the global competition.

Exposure to global competition reveals that manufacturing companies in Ethiopia can no longer rely on simple conversion of raw material into goods, but a process of conversion constantly reinventing itself. Globally products are now made better, faster and cheaper and manufacturing companies in Ethiopia cannot afford to do otherwise, else they will produce goods that are not globally competitive. To survive and compute in global market the Ethiopian Manufacturing industry need to use latest advanced manufacturing technologies. Therefore the purpose of this study was to assess the status and challenges facing of advanced manufacturing technologies transfer and implementation in Ethiopian Basic metal and Engineering Industries and proposing the framework for successful transfer and implementations of AMT in Ethiopian manufacturing industries.

1.2 Advanced manufacturing technologies

The definition of advanced manufacturing technology, which has been adopted by different researchers are wider. Yousef (1992) defined AMTs as a group of integrated hardware and software based technologies. Boyer et al, (1997) used the term AMT to describe a variety of technologies that utilize computers to control, track, or monitor Manufacturing activities, either directly or indirectly. Small and Yasin (1997), AMT can be described as a group of computer-based technologies, including computer-aided Design (CAD), Robotics, Flexible Manufacturing System (FMS), Automated Material Handling systems (AMHS), and Computer Numerically Control (CNC) or Automated techniques. Y. Park (2000), AMT is "a comprehensive collection of technologies for enhancing the efficiency and flexibility of manufacturing systems". As by Honggeng Zhou, G. Keong Leong (2009), AMTs provide a variety of operational benefits, which includes better coordination between different departments; greater control of the processes; reduced product design time; shorter lead time and stable, high- quality outputs.

More specifically, AMT can be described as a group of computer-based technologies, including computer-aided design (CAD), computer numerical control (CNC) machines, direct numerical control (DNC) machines, robotics (RO), flexible manufacturing systems (FMS), automated material handling systems, automated storage and retrieval systems (AS/RS), automated guided vehicle (AGV), bar coding (BC), rapid prototyping (RP), material requirement planning (MRP), statistical process control (SPC), manufacturing resource planning (MRP II), enterprise requirement planning (ERP), activity based costing (ABC), and office automation.

Likewise related literature depicts different classification of AMTs based on different characteristics i.e level of integration or functionality. However, AMTs investigated in this study can be grouped into seven domains based on the functionality. The seven domains are:

- Advanced Product design and Engineering Technologies (APDETs): concerned with design and engineering such as CAD, CAM, CAE, GT, CAPP etc
- Advanced Production Planning Technologies (APPT): concerned with logistic planning and control of such as MRP, MRPII, ERP, etc
- Advanced Material Handling Technologies (AMHTs): concerned with handling of materials such AGV, AMHS, AS/RS.
- Advanced Assembly and Machining Technologies (AMcT): concerned with NC, CNC, DNC, FMS, robots, etc
- Integrated Manufacturing technologies: concerned with production management tools such as TQM, JIT, etc
- Networking communications: LAN, WAN, GAN, etc
- Quality control and Inspections: Computer aided quality control and Inspections Statistical quality control

1.3 Technology Transfer in Ethiopia

The idea of modern science and technology in most African countries was introduced in the beginning of the 20th century. In the case of Ethiopia, it is believed that the first half of the 20th century was considered as the beginning of application of modern science and technology, along with the establishment of higher learning institution although its role to bring sustainable socioeconomic development of the country has not been to the desirable level (Gulelat Getaw, 2011).

In this sense, Ethiopia has attempted the transfer of various modern and noticeable technologies, since the era of Emperor Menilik II (1886-1930). Some of the major technologies have been acquired in the form of turn key projects, international technology co-operation, and recently through Foreign Direct Investment (FDI), Joint Ventures (JV), and via the local businessmen. However, technology transfer is not far from a one-step shopping of technological hardware. Hence, most of the technologies imported to Ethiopia with limited resources have failed to be adopted, improved, re-engineered, and disseminated to other similar industries at the desired level, which should be considered as the ultimate goals of technology transfer. This result in, the lack of self-capability to undertake major infrastructure development activities like, road construction, bridges, hydro-power dams, sugar industries, cement industries etc. by the citizens of the country. This clearly indicates weakness in absorbing foreign technology from similar projects and industries which took place several decades ago. Ethiopian government adopted and implemented the Agricultural Development-Led Industrialization (ADLI), as the leading national development plan that primarily aspired to increase agricultural productivity and then through the income effect. It is expected to augment demand for manufactured goods, thereby motivating industrialists to expand their production capacity utilization and also to increase investment in industry. However, the contribution of the manufacturing sector among others to the growth of the GDP of the country is still minimal, and the efforts being made to add value through manufacturing of the agricultural products are very little. This shows that the manufacturing sector's development is at its grass root level (Gulelat Getaw, 2011).

One of the reasons why ADLI failed to solve the root causes of low development of the industrial sectors is, it lacks national technology transfer coordination and implementation strategy to build the capacity of the industrial sectors through technology transfer from both foreign and domestic sources.

However, the Ethiopian government has developed the Growth and Transformation Plan (GTPI) which is a medium term strategic framework which span for five-year period (2010/11-2014/15). The plan could be considered as a major milestone towards building a modern and productive agricultural sector with enhanced technology and an industrial sector that plays a leading role in the economic development. The recent developed growth and transformation plan (GTP II) which will span for five year from 2015-2019 .The strategic pillars of the GTP II (Growth and Transformation Plan) related to manufacturing include (1) developing light and small manufacturing enterprises that are globally competent and leading in Africa (2) establishing a foundation for further growth of the strategic heavy industries which ultimately enable Ethiopia to become an industrialized country by 2025 (source: MoFED, 2015)

1.4 Overview of BMEs

Metal and engineering industries are identified as one of the five priorities for existing industry investment to build capacity and upgrade performance in terms of utilization of capacity. The

Ethiopian metal industry sector is classified into two categories: basic metal and engineering industries. Basic metal industries deal with production of metal from ore, scrap and conversion of billet, slabs etc. into primary metal products such as hot rolled ribbed and plain reinforcement bars, wire rod, angles, cold rolled tubes of various profiles, cold rolled sheets, galvanized sheets and tubes whereas engineering industries convert primary metal products into secondary products such as metallic structures, tanks, pressure vessels, machine parts, components, machineries, transport equipment, electrical and electronic equipment, measuring and control instruments and others. The primary metal products produced by basic metal industries are subsequently raw materials (inputs) for the downstream engineering industries (Gulelat Getaw, 2011).

The basic metal and engineering industry is crucial to the development of any modern economy and is considered to be the backbone of human civilization. It is for this reason that the level of per capita consumption of steel is treated as an important index of the level of socioeconomic development in any country. It is a product of a large and technologically complex industry having strong forward and backward linkages in terms of material flows and income generation. All major industrial economies are characterized by the existence of a strong steel industry and the growth of many of these economies has been largely shaped by the strength of their steel industries in their initial stages of development. The Ethiopian condition on basic metal sectors reveals that basic metal industries lack the crucial component of producing basic metals from iron ore or other process route. Although, the engineering industries are still in the infancy stage over the years even if expansion of this industry is making a very substantial increment and is not likely to make a very potential contribution to the National Economy. The manufacturing sector as a whole and the basic metal and engineering industrial sub-sector performance is very low in Ethiopia.

This is illustrated by the low valued added and the low share of metal and engineering industries account in 2014-15 for around 0.8 percent of GDP in Ethiopia, equivalent to $US0.5 billion of value added. Accelerated growth of over 25 percent/year, on average, in these industries is expected over the decade ahead as its share increases to more than 2.5 percent of GDP by 2025. More competitive metal and engineering industries are expected to grow, in part, through import substitution, exports, increased value addition, improved integration between the upstream and downstream activities and more innovation in products and markets. (MoFED,2016)

Different survey and researches indicate that most of the metal and engineering industries operate under their capacity. The reason for this is Scarcity of finance, Scarcity of raw materials and obsolete manufacturing technology in operation. Ethiopia, which is total importer of various machinery and equipment, has to devise strategies to develop the Manufacturing industry in order to improve its foreign trade deficit in the long range. Overall, it can be inferred that the contribution of the basic metal industries to the overall economy is minimal which indicates that there is much to be desired from this industries if it have to position themself to a level where it can be a real contributor to the economy (MIDI, 2016).

However, the overall trend of the industry is some encouraging if it will continues to grow, especially in a better enabling environment. Therefore, improvement in this sector can help to cut import figures by increasing locally produced primary products and equipment.

1.5 Statement of Problem

The government of Ethiopia through its second Growth and Transformation plan (GTP II) has given high priority to manufacturing sector particularly to the Basic Metal and engineering sector. The objective and targets have been set to enhance the productivity and competitiveness of the sector. To meet this strategic objective and targets Advanced-manufacturing technologies could potentially help the sector to boost productivities and their competitiveness both locally and internationally. The impact of advanced manufacturing technology on economic development is very high in certain developed countries. Especially USA, China, Japan, Korea, Russia, German, etc. are benefited from AMTs. The benefits obtained from AMTs are Increasing the global competitiveness and enhancing productivities but not limited to this. The developing countries are also now transferring and implementing of advanced manufacturing technology to increase productivity and competitiveness of the sector.

In case of Ethiopian, manufacturing industries have try to transfer and implement some of advanced manufacturing technologies. However, advanced manufacturing technologies are not successfully transferred and implemented in Ethiopia BMEIs. Because they did not study the critical success factor to transfer and implement AMTs. In general, there are only limited study done on advanced manufacturing technologies transfer and implementation in Ethiopian manufacturing industries.

Therefore, the purpose of this study is to empirically assess current status and critical success factor of AMTs transfer and implementation in Ethiopia manufacturing companies particularly in Metal and engineering sector and to develop a frame work to facilitate their successful implementations. To this end, the study address the following research directions.

- ☞ What is status of AMTs transfer and implementation of firms?
- ☞ What factors are affecting AMTs adoption and implementation?
- ☞ What are the success factors and barriers influencing AMTs transfer and implementation process in BMEIs?

1.6 Objectives of study

In line with the above justification, the study address the following general and specific objectives.

1.6.1 General objectives of study

The general objective of this study is to empirically assess current status of advanced manufacturing technologies transfer and implementation in Ethiopia manufacturing companies particularly in Metal and Metal engineering sector and to develop frame work to facilitate their successful implementations.

1.6.2 Specific objectives

In line with above major objectives, the study aims at achieving the following specific objectives:

- ☞ assess the status of companies AMTs transfer and implementations;
- ☞ Identify and examine the factors hindering AMT transfer; and
- ☞ Investigate the key success factors and the barriers in technology implementations process
- ☞ Develop framework to facilitate a successful transfer and implementation of AMTs in BMEIs

1.7. Scope of study

The survey covered only purposively selected industries under BMEIs. The study were try to incorporate only some of advanced Manufacturing technologies, but it was not address each problem related to AMTs implementation and transfer.

1.8. Expected output

The immediate output of this study was a complete document which holds up to date empirical data about advanced manufacturing technologies transfer and implementation in Ethiopian

BMEIs industries. It also provide the framework and all the necessary information for the manufacturers to identify their needs, justify and select the most appropriate AMT to satisfy their strategic plans and competitive priorities

1.9. Significance of study

The outcome of this study may have the following significance for different bodies. Primarily this study contribute to the broadening of our understanding of Advanced Manufacturing technologies transfer and implementation in Ethiopian BMEIs perspective. It provide manufacturing sector with up-to-date information regarding advanced manufacturing technologies transfer and implementation in Ethiopian BMEIs industries. The information in turn can serve the government, manufacturing industries, policy maker, as input in formulating and implementation strategies and policies for future new technology transfer. This study will provide the basis for Advanced Manufacturing Technology transfer and serves other sectors as a supplement to their knowledge. It could also help in identifying current status of AMTs adoption and implementations and suggest future directions. It could been used as a general frame work for advanced technology adoption and transfer in the different Ethiopian Manufacturing industries. It also provide the frame work and all the necessary information for the manufacturers to identify their needs, justify and select the most appropriate AMT to satisfy their strategic plans and competitive priorities.

1.10 Organization of the Study

This research report is composed of six chapters. The first chapter deals with the Introductions, statement of the problems, objectives of the study, outcomes and significance of the study have been clearly discussed. In the second chapter, related literature review in the area of Advanced manufacturing Technology, technology transfer and implementation , Definition of used this research and overview BMEIs been clearly discussed. The third chapter deal with Methodology. Data collection, analysis, discussion and interpretation have been discussed in the fourth chapter. In the fifth chapter, the researcher proposes the framework for successful implementations of Advanced Manufacturing Technology. Finally, conclusion, recommendation and future works have been discussed in thesis sixth chapter.

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CHAPTER 2: LITERATURE REVIEW

2.1 Advanced Manufacturing Technologies

Different studies have adopted wider definitions of AMTs. Yousef (1992) defined AMTs as a group of integrated hardware and software based technologies. These technologies are often referred to as intelligent or smart manufacturing systems and often integrate computational predictability within the production process (liker et al, 1992). Boyer et al, (1997) used the term AMT to describe a variety of technologies that utilize computers to control, track, or monitor Manufacturing activities, either directly or indirectly. As cited in Bruce D.et al While the international Manufacturing strategy survey was explicit in identifying AMTs to respondents, there has been some debate about whether AMT represent only the cutting edge technology or it is an adopted terminology that classifies a segment of manufacturing? The answer is the latter. AMT involves new manufacturing techniques and machines combined with information technology, microelectronics, and new organizational practices in manufacturing process. AMT is a key enabler to help manufacturers meet the productivity, quality, and cost reduction demands of competitive global markets (industry Canada, 2002. Sun et al, (2007) regards AMTs as a wide variety of modern computer based technologies in the manufacturing environment. From these studies, it can be summarized that, AMT suggests both soft and hard technologies which are being employed to enhance manufacturing competencies. This study adopts the narrower form of AMT as the use of innovative technology to improve production process and it is this concept that is further explored within this study.

2.2 AMTs definitions

From the related literature history of Advanced Manufacturing Technology is of advancement from the automation of individual machine tools (NC, CNC), through incorporation between such machines, towards much higher levels of amalgamation involving large-scale monitoring and controlling systems (FMS, CIM) (Canada and Sullivan, 2000). As the complication and extent of the inventories and orders involved in the production environment increases the development and adoption of MRP or MRP II and ERP are determined. Manufacturing industries use CAD and CAM to help the design activities and the control of machinery. AS/RS and AGVs are used to progress incoming materials and part, work in progress and final manufactured goods. Robots are used to do repetitive tasks to achieve stability, assurance, rapidity and potency. These computer based technologies provide manufacturing industries with a new capability for manufacturing – made potential owing to the development of a inclusive, robust, and competitive core information technology. The list of AMT investigated in this study, together with its definition is presented in Table 1-1 as follows:

Table 1-1: list of AMTs and their definition

AMTS	Descriptions
Computer aided design (CAD)	CAD is used to design and develop products, these can be goods used by end consumers or intermediate goods used in other products. CAD is also extensively used in the design of tools and machinery used in the manufacture of components. CAD is used throughout the engineering process from conceptual design and layout, through detailed engineering and analysis of components to definition of manufacturing methods (Kotha and Swamidass, 2000). It consists of the following component parts: CAD computer, computer peripherals, operations software, and user software. When CAD is integrated with CAE: it assists in the design and drawing process –new products or modifies existing products. It includes the direct graphic-interactive generation of two- or three-dimensional data models with subsequent graphic output, supporting activities such as calculations (e.g. the finite-element method) or simulations (Rosnah *et al*., 2003).
Computer aided manufacturing (CAM)	(CAM) refers to the use of specialized computer programs to direct and control manufacturing equipment. When CAD information is translated into instructions for CAM, the result of these two technologies is called CAD/CAM (Hunt, 1987). Computer aided engineering (CAE) software assists the engineer while examining and testing design from a structural or engineering point of view. When CAD is integrated with CAE, it assists in the design and drawing process for new products or modifies existing products. It includes the direct graphic-interactive generation of two- or three-dimensional data models with subsequent graphic output, supporting activities such as calculations or simulations (sun et al, 2007).
Computer-aided engineering (CAE)	CAE software supports the engineer while examining and testing design form of structural or engineering point of view. (Skinner, 1984).
Group technology (GT)	GT supports in designing and testing a product, from a structural or engineering point, controlling of manufacturing machinery, and also part classifications and coding system (slack et al, 1995)
Material requirement	Material Requirement Planning (MRP) – employs to determine and manage material needs, dates, and capacities by using bills of materials,

planning (MRP)	operations scheduling, materials, and time as well as the recording of operating data. A helpful tool for the planning of production and/or the management of customer orders (Harrison, 1990; Slack et al., 1995).
Manufacturing Resources Planning(MRPII)	The extension of MRP, which is referred to as Manufacturing Resource Planning (MRP II), allows inventory data to be augmented by other resource variables, such as labor hours, material cost (rather than material quantity), or capital cost
Enterprise Resource Planning (ERP)	ERP is an extension of MRP II. ERP incorporates business processes by using a centralized database. It includes modules to allow efficient exposure and assessment making throughout the company, process data interactively and to be accessible in real time, and it also allows easier global incorporation (Slack et al, 1995).
Automated materials handling (AMH) Automated storage and retrieval systems (ASRS)	AMH Systems improve the efficiency of transportation, storage, and retrieval of materials in and from warehouses. . Automated storage and retrieval systems (ASRS) provide for the automatic placement and withdrawal of parts and products into and from designated places Automated materials handling system which use computers to direct automatic loaders to pick and place items. Storage automation is mostly effected by means of (elevated) shelf storages which are operated by automatic high-lift trucks. It can also include automatic identification of items and interfacing with automatic guided vehicles
Automated Guided vehicles (AGV)	Transport automation is in most cases undertaken by driverless transportation systems, such as automated guided vehicles (AGVs) or rail-guided vehicles, also by suspended conveyors and roller conveyors of conveyor belts. AGV are small autonomously powered vehicles which move materials to and from.
Computer Numerically Controlled machines (CNC) or numerical controlled machines (NC)	Machining tool which is directly connected to a computer that controls it. The information can either be stored on disk/computer (CNC), or in a form of a pouched paper tape (NC). This information manages the movements of its tools and the speed of the machine throughout the processing operation. The set of coded instructions and the computer connected to the machine have taken the place of the operator who would earlier have controlled the machine by hand. Today, CNC manages are mostly applied for turning machines, boring and milling machines, horizontal boring machines, and machining centers. Other machining work grasps a share of over 20% in NC/CNC machines, the main share being held by grinding and erosion machines; but CNC manages exist for almost types of machining (Slack et al, 1995).

Flexible manufacturing cells (FMC) or Flexible manufacturing systems (FMS)	A flexible manufacturing cell consists of two or more NC/CNC machines which are communicated by handling devices (such as robots) and transport system. A FMS can effort on more than one different work piece simultaneously. It allows varying machining operations on diverse work pieces to be executed within given vicinity (Lindburg, 1992). The NC computer units execute the machining operations, robots which move parts to and from the work stations, transport/material handling facilities which move the parts between work stations, and managed under the guidance of central computer system. FMC- capable of single path recognition of raw materials and single conduit delivery of a finished product, FMS- capable of multiple conduits. It may also be included of two or more FMCs associated in series or parallel.
Computer Integrated Manufacturing (CIM)	It integrates all elements in the manufacturing process from product design to allocation (CAD/CAM, CNC, robots, AGV, production planning, logistics). It connects beyond company departments by integrating computer systems. (Lay, 1990; Udo and Ehie, 1996). A diversity of single element is designed in a specific approach to connect already installed systems. With CIM, a continual digital information flow is created between all computer supported technical and administrative departments of a plant; avoiding multiprogramming and multi-keeping of the same data in the recollections of the computer systems in different department.
Robotics: simple pick and place robots or more complex robots	Robotics was first introduced for industrial applications in the early 1960s. It often has the appearance of one or several arms ending in a wrist. Its control unit uses a memorizing device and sometimes it can use sensing and adaptation appliances that take account of the environment and circumstances (Kotha and Swamidass, 2000). These multi-purpose machines are generally designed to carry out repetitive functions and can be adapted to other functions without permanent alteration of the equipment. The movement of robots is controlled in a similar manner to NC machine tools but most robots have many degrees of freedom. Robots can be classified based on their application as handling robots, process robots and assembly robots.
Computer-aided quality control (CAQCS)	Computer-aided quality control systems -Automatic inspecting and testing performed on incoming materials and/or final product which carry out quality inspections performed by automation or robotics (Kotha and Swamidass, 2000)).

2.3 Classification of AMTs

Different scholars have classified AMTs based on multidimensional criteria and different characteristics such as functionalities, level of integrations as shown on table 1-2. AMTs investigated in this study can be grouped into seven domains based functionalities of technologies. The seven domains are:

- Advanced Product design and Engineering Technologies (APDETs): concerned with design and engineering such as CAD, CAM, CAE, GT, etc
- Advanced Production Planning Technologies (APPT): concerned with logistic planning and control of such as MRP, MRPII, ERP, etc
- Advanced Material Handling Technologies (AMHTs): concerned with handling of materials such AGV, AMHS, AS/RS.
- Advanced Assembly and Machining Technologies (AMcT): concerned with NC, CNC, DNC, FMS, robots, etc
- Integrated Manufacturing technologies: concerned with production management tools such as TQM, JIT, etc
- Networking communications: LAN, WAN, GAN, etc
- Quality control and Inspections: Computer aided quality control and Inspections Statistical quality control

2.3 Evolution of Advanced Manufacturing Technology

Over the past few decades, manufacturing has gone from a highly labour-intensive set of mechanical processes to an increasingly sophisticated set of intensive information technology process. This trend will continue to accelerate as advances in manufacturing are made **(Stephanie S. Shipp et.al. 2012)**. From inception with the use of traditional means to the period of mechanization, there has been a growing need to satisfy consumer demand for improved product at short delivery time. This led to the development of programmable automation whose prime objective was to quicken production process and to ensure quality products [(11)]. With this development came the application of computer in manufacturing and emergence of new manufacturing technologies like the computer aided design (CAD), computer aided manufacturing (CAM), robots, flexible manufacturing system (FMS), just in- time (JIT) and other technologies that help in building advanced manufacturing . Computer applications also facilitated the development ERP (Enterprise Resource Planning) systems which monitored and integrated key activities such as marketing & sales, planning, manufacturing, inventory control

Table 1-2:Classification of AMTs

	Researcher and year of publication	**Classification /dimensions**
1	Rosenthal (1984)	1. Computer-aided design group 2. CAD/CAM group 3. Computer-aided manufacturing group 4. Factory management and control group
2	Warner (1987)	1. Shop floor technologies with intelligence 2. Product oriented technologies 3. Information and control technologies
3	Adler (1988)	**(i)** Design automation **(ii)** Manufacturing automation **(iii)** Administrative /control technologies
4	Swamidass and Kotha (1998)	**(i)** Information exchange and planning technologies (MRPII, computer for production planning etc), combined the logistic and planning technologies (LPT) from Kotha (1991) (ii) Product design technology (CAD/CAE, automated drafting technologies), (iii) High volume automation technology (robotics, manufacturing automation, computer-aided quality control etc) (split the process technology (PT), Kotha (1991**). (iv)** Low-volume automation technology (CNC, CAD/CAM, FMS).
5	Kotha (1991)	**(i)** *Product design technologies (PDT*); CAD, CAE and automated drafting technologies **(ii)** *Process technologies (PT):* FMS, NC and programmable controllers; **(iii)** *Logistics/ Planning technologies (LPT*); Includes production scheduling systems, shop floor control systems and MRP systems; (**iv**) *Information exchange technologies (IET);* such as general databases, structure translators, data transfer procedures and intrafactory networks.
6	Small and Chen (1997) Small and Yasin (1997)	i) Stand-alone systems (a) Design and engineering technologies; CAD, CAE (b) Machining, and fabricating and assembly technologies: NC/CNC/ DNC, robotics, lasers. ii) Intermediate system (c) Automatic material handling technologies: AS/RS. (d) automated inspection and testing equipment: Computer-aided quality control iii) Integrated systems (e) FMS (f) CIM (g) logistic-related technologies/or Management/ information technologies: JIT, MRP, MRPII.
7	Small (1999)	**(i)** Integrated process and information/logistic technologies: CAD, NC/CNC/DNC, MRP, MRPII, JIT,

		FMS, CIM, robots **(ii)** Integrated information/logistic technologies: CAD, NC/CNC/DNC, MRP, MRPII, JIT; and **(iii)** Non-integrated technologies which comprises of CAD, NC/CNC/DNC
8	Boyer et al. (1996)	i) Design: included design and process technologies such as CAD, CAE, CAM, computer-aided process planning and the use of CNC equipment. ii) Manufacturing: FMS, real time process control systems and robotics, iii) Administrative: MRPII, ERP and knowledge and decision support systems
9	Heijltjes (2000)	1. Methods for design: CAD, and CAE. 2. Methods for flexible manufacturing: CAM, CNC 3. machines, Robotics and FMS; 4. Methods for computerized planning and control: MRP, ERP.
10	Udo and Ehie (1996)	a) Hardwar-based technologies b) Software-based technologies
11	Pong Emmy C.M. (2009)	i) Product design technologies ii) Product planning technologies iii) Material handling technologies iv) Assembly and machining technologies v) Integrated manufacturing technologies

and shipping. With ERP systems demanding robust manufacturing processes and Global competition highlighting labour costs, increased emphasis on productivity grew through the nineties. 6-sigma, lean, critical chain and other productivity/waste reduction programmes became increasingly popular(Okonkwo Valentine Tochukwu, David Kanume Koroma, 2015)

As manufacturing evolved globally, there was a strong need for integration with companies adopting holistic and systematic integration approach rather than individual automation in functional units with each unit acting as an island hindering communication and dissemination of information among themselves. In order to appreciate the historical developments that had taken place during the last four centuries, the evolutions in manufacturing technology towards integrated systems are summarised in Fig. 2-2. However, the precise time span for the evolutionary stages cannot be determined and are not given in figure shown (Nagalingam SV et.al, 2008).

2006 Resource scheduling for virtual CIM system

2005 colloborative CIM sytems concempt development

2000 frame work and architecture of virtual CIM

1997 Virtual CIM concept introduced

1986 Distributed CIM concept introduced

Advanced systems in CAM, CAPP, CAQC, AS/RS, FMS, etc

1980 Application of CIM systems

1970 Development in CAD and Development in NC such as CNC, DNC

1950 Early development in NC for Automation

1930 Very Large Mass production systems

1900 Mass Production system

1750 Mechanization and Early Factory system

1600 Craftman ship

Manual and animal Labour

Figure 2-1Evolution of Advanced Manufacturing Technology

2.4 Advanced Manufacturing technology strategies

Research on manufacturing focus on the transformation of present factories, towards reusable, flexible, modular, intelligent, digital, virtual, affordable, easy to adapt, easy to operate, easy to maintain and highly reliable one. European research has identified three types of factories at forefront of new models of manufacturing, each with different primary characteristics, namely: Smart Factories, Virtual Factories, and Digital Factories. In broad terms they are characterised as follows (Mr.R.R.Lande, 2016):

Smart Factories offer agile manufacturing (flexibility and short-time cycles) and customisation involving process automation control, planning, simulation and optimization technologies, robotics, and tools for sustainable manufacturing; smart factories are underpinned with lean and ICT systems, characterised as energy efficient , reliable, and cost-effective production operations.

Virtual Factories are global networked operations built on pervasive ICT systems. Seamless integration of intelligence from all aspects of the business (regardless of where located and including external partners and suppliers) facilitate and drive decision-making. In simple terms

Digital Factories-To visualize the product before it is realized. Mainly strategies going to be pursued in future are based on (1) high performance manufacturing to the highest level of accuracy to the order of micro/Nano level (2) exploiting special materials thro processing and handling

(1)**High Performance Manufacturing –strategies**

- Flexible, adaptive Production plants for rapid and optimal energy use
- High Precision and Micro manufacturing equipment
- Tools production planning and in situ simulation
- Zero defect manufacturing

(2)**Exploiting new materials through manufacturing**

- Net shape manufacturing for structural and functional materials
- New materials manufacturing through functionalities
- Manufacturing strategies for repair and re use
- Product design using sustainable materials processing technologies

Advanced manufacturing involves one or more of the following elements:

Advanced products—advanced products refer to technologically complex products, new materials, products with highly sophisticated designs, and other innovative products (Zhou et al. 2009; Rahman 2008).

Advanced processes and technologies: advanced manufacturing may incorporate a new way of realizing the products with the advanced processes and technologies. Smart manufacturing and enterprise concepts in recent years, paradigms of manufacturing as an ecosystem‖ have emerged. The term smart encompasses organizations that create and use data and information throughout the product life cycle with the goal of creating flexible manufacturing processes that respond rapidly to changes in demand at low cost minimum impact on the environment with the concept of efficient production and recyclability.

2.5 Global Trends in advanced Manufacturing and Implications

The increasing interest in manufacturing around the world is fundamentally linked to changes in technology that are reconfiguring all aspects of the production process and creating more value. Because of transformative technologies, the possibilities for manufacturing in high-cost locations like the US, Europe, Asia and elsewhere have expanded, while manufacturing capabilities around the world, particularly in developing countries, are also increasing. Advanced manufacturing technologies are not only changing the cost equation of manufacturing but, importantly, becoming integral to the innovation of new products, processes and services (Berger, 2013). These technologies are central to the development of new, more complex products and processes, often 'hybrid' products that combine hardware with software. Examples include wearable medical devices or small batch, customized biopharmaceutical production based on personalized medicine. As stated earlier, these new processes with their emphasis on software and programming require an upgrading of skills.

Advanced manufacturing may also require closer proximity to R&D capabilities to facilitate continuous iterations between research, development and manufacturing (R, D & M). For some companies engaged in new product introduction (NPI), locating manufacturing near R&D capabilities is an important part of their overall innovation strategy. Below I briefly review some of these new technologies and trends to understand how they might affect the built environment as it relates to manufacturing.

2.6 Advanced Manufacturing Technologies and Trends

Advanced manufacturing refers to manufacturing that is less susceptible to competition from low-cost locations because either it uses a high degree of information technology (IT) in its products or processes, and/or it employs workers with higher skills, often measured by the number of scientists or engineers (Helper *et al*., 2012). It is the use of new IT combined with advanced machinery that often defines advanced manufacturing and leads to increasing automation, intelligence, efficiency, and sustainability in manufacturing processes. There are five large-scale trends applicable to the manufacturing sector that has been instrumental in the shift from traditional labor-intensive processes to advanced-technology based processes. There are: (1) the ubiquitous role of information technologies, (2) the reliance on modelling and simulation in manufacturing process, (3) the acceleration innovation in global supply-chain management, (4) the moving towards rapid changeability of manufacturing in response to customer needs and external impediments, (5) the acceptance and support of sustainable manufacturing. This trends allow for tighter integration of R& D and production, mass customization, increased automation, focus on environmental concerns. A recent study at MIT identified seven key categories of emerging and potential advanced manufacturing technologies (De Weck, 2014). These include:

1. *Nano-engineering of Materials and Surfaces*. Synthesis and structuring of functional and multifunctional materials at the nano-scale and micro-scale from the ground up; materials do not exist in nature and thus have no direct counterparts in the natural world. Biomedical applications such as implantable stents are enabled by such technology.
2. *Additive and Precision Engineering*. New manufacturing processes that build up macroscopic parts in fibres or layer by layer and achieve complex three-dimensional shapes starting from ingredients in powder or wire form. Additive manufacturing (AM) is a latest technology that could improve manufacturing process by building up thin layers of materials from digitized three-dimensional (3D) designs virtually constructed using advanced CAD software (K. Srinivasulu and Solomon Dufera ,2016). This allows for 3-D printing and rapid prototyping at a small scale in a range of materials – plastic, metal, concrete. Dental and medical implants are now built using this method.
3. *Robotics and Adaptive Automation*. Innovative design, use, and adaptation of robots and automation equipment in manufacturing that can replace or augment human labour during manufacturing, especially when very high precision is needed, tasks are easily standardized and repeatable, and large forces and torques are required.
4. *Next-Generation Electronics*. Advanced circuits using non-silicon materials, mask-less processes and flexible, potentially organic substrates. This allows for the potential of ‘printed electronics’ on to clothes, paper or other flexible substrates for wearable devices or product packaging.
5. *Continuous Manufacturing of Pharmaceuticals and Biomanufacturing*. The process of continuous manufacturing of small molecules as well as turning cells and organisms into programmable factories leads to shrinking the size of chemical manufacturing plants by several orders of magnitude. It may also be applied to the case of biofuels.
6. *Design and Management of Supply Chains*. Planning and managing large and distributed networks of suppliers in multi-echelon supply chains that enable flexible,

resilient, and increasingly decentralized distribution of components and products. This involves web-based management of manufacturing.

7. *Green Sustainable Manufacturing*. New manufacturing and recovery processes that minimize the use of energy, recycle materials, and reduce waste and emissions. With the scarcity and potential monopolization of some materials (e.g. rare earth elements) as well as environmental concerns, this has become an important lens through which to design manufacturing processes.

Of these seven, additive manufacturing and robotics and adaptive automation have perhaps received the most attention because they are particularly valuable in reducing time to market and costs. Additive manufacturing makes industrial design and prototyping more accessible while robotics and automation can both reduce the labour costs within manufacturing processes and also extend human capabilities. The implications of the latter are prompting significant discussions about the future of work.

The effects of these emerging technologies on manufacturing can be seen in a depiction of traditional and advanced manufacturing. In the past, manufacturing had four primary stages that operated in a linear fashion (figure 2-2): sourcing raw materials from nature which were then fabricated into parts, assembled, and then delivered as final products.

Today, several new dimensions show how manufacturing is evolving. Raw materials can often be replaced by *material design*, new synthetic materials that are created from scratch. Fabrication and assembly are blurred through the introduction of highly efficient processes and automation in *continuous processing* that allows batch sizes of one. *Bundling* speaks to the ‘product-service-software’ bundle where the product is not just a physical artefact but an integrated solution that involves the bundling of physical products with services and software.

Finally, *recycling* is recognition of the problems, environmental and otherwise, with waste and the opportunities for reusing and recycling materials. Viewed as a whole, the manufacturing process becomes much more complex and nonlinear with many more options for reducing time and costs as well as improving quality.

The size of the operation can also be reduced to meet smaller scale production goals. Finally, through real and virtual supply chains, the manufacturing process is open to inputs in the form of material design, fabrication, parts and assembly from around the world as well as the cloud. New possibilities for the production of products and services are being created in established and new emerging industries alike.

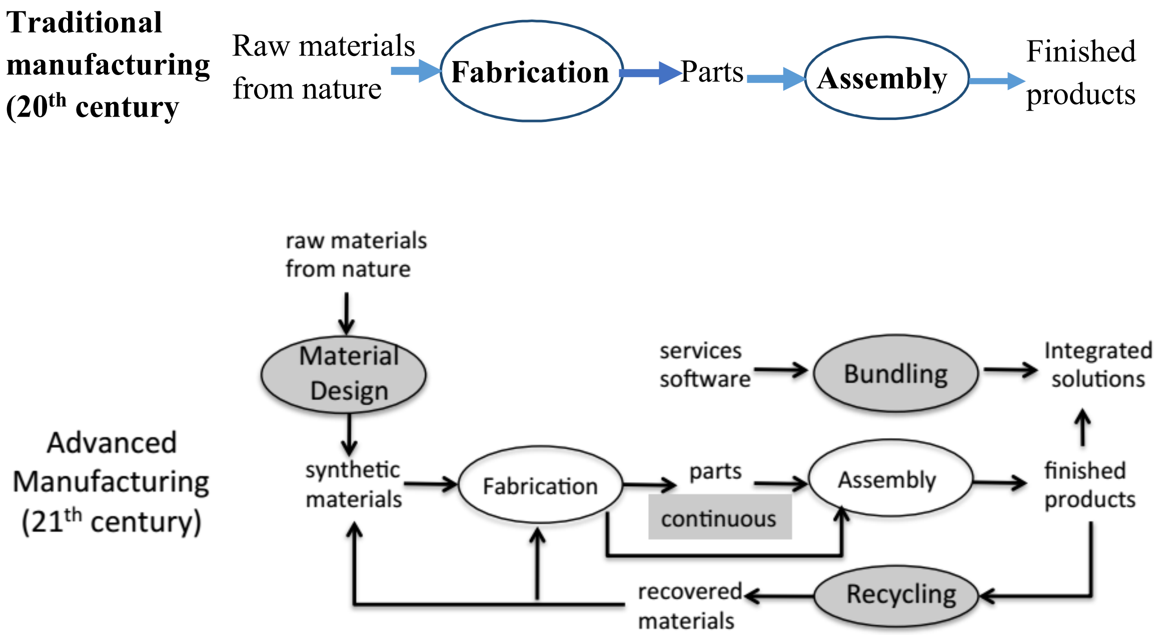

Figure 2.2Traditional and advanced manufacturinng (De Weck, 2014)

2.7 Technology Challenges

Rapid shrinking of the supplier base due to the out sourcing of manufacturing activities resulting negative impact on the technology development.(Mr. R. R. Lande , 2016)

- ❖ High level of investment needed in R&D and high risk factor makes technology developers to become a big barrier to technology-based innovation.
- ❖ Availability of strategic special Materials, understanding of its characteristics, evaluation technique and processing for designs.
- ❖ Simulation capability of electronic device fabrication lags to cope up with the technology development.
- ❖ Globally linked manufacturing and enterprise systems and migration to cloud sharing also highlight the increasing need for cyber security and robustness of IT infrastructures.

2. 8 Benefits of AMT

Technology is said to affect competitiveness in two ways. Firstly, the development of efficient and flexible process drives a leaner cost structure, and secondly, through enabling the development of products of greater quality, better design and shorter delivery periods (Vinas etal, 2001). Efstathiades et al., (2002) highlight how AMTs enable both economies of scale and of scope without the need to change hardware, while allowing the blending of small-batch and customer-order operations with the low-cost efficiency of standardized mass production. Although operational and organizational benefits are often associated with AMT, all AMTs are not the same and do not provide the same benefits. It is known that innovations are extensions to product offering or improved process (incremental), while radical innovations involves the application of new technologies into previously un-utilized applications. Innovations also involve changes in the core components without altering a product's overall architecture (Noori, 1997). These individual characteristics of the product changes or process upgrade affect the level and types of benefits derived.

The benefits of AMT have been widely reported and classified as tangible and intangible. The tangible benefits, which are easily quantifiable, include inventory savings, less floor space, improved return on investments (ROI), and reduced units of costs. The Intangible benefits, which is are difficult to quantify, include an enhanced competitive advantage, increased flexibility, improved product quality, and quick response to customer demand (Ariss et al, 2000). These benefits may still offer many improvements with respects to organizational improvements and management/ worker satisfaction. For example, the process of implementing AMT might lead to better communication, redesigned workflows, or better communication, redesigned workflows, or better integration of work across functional boundaries.

Some more common benefits sought through the implementation of AMT that used as justification criteria for the implementation presented as table 1-3 can include, increased productivity or throughput, better management control, overcoming lack of skills, reduced set-up times, improved accuracy in materials planning, cost reduction, increased product or process flexibility, decreased lead-times; reduced product development cycle times, better working relationships, improved utilization of equipment and improved product quality and productivity(Dangayach and Deshmukh (2005), Koc and Bozdag (2009), Percival (2009).

Table 2-3: Benefits for implementation of AMT

Benefits	Description	Reference
Increased productivity	Greater output per hour of labour input, higher production rates	Scheer, 1994, Mechling et al., 1995, Sohal, 1996
Improved product quality	Automated operations not only produce parts at faster rates than do their manual counterparts, but they produce parts with greater consistency and conformity to quality specifications.	Marii et al 2006, Koc and Bozdag(2009),, Percival (2009).
Reduced manufacturing lead time	Automation allows the manufacturer to reduce the time between customer order and product delivery, this gives the manufacturer a competitive advantage in promoting good customer service.	Marri et al., 2000. Marri et al.2006 Dangayach and Deshmukh (2005),
Reduction of in-process inventory	In-process inventory is of no value, it serves none of the purpose of raw materials stock for finished product inventory, automation tends to accomplish this goal by reducing the time a work part spends in the factory.	Rothwell and Dodgson, 1992, Marri et al., 2000.
High cost of not automating	A significant competitive advantage is gained by automating a manufacturing plant, the benefits of automation often show up in intangible and unexpected ways, such as improved quality, higher sales, better labour relations, and better company image, the companies that do not automate are likely to find themselves at a competitive disadvantage with their customers, employees, and the general public.	Morris and Morris, 1994, Chapelete, 1996.
High cost of labour	Increasing labour cost causes higher investment in automated equipment economically justifiable to replace manual operations, machines can produce at higher rates of output, automation results in a lower cost permit unit of production	Morris and Morris, 1994, Chapelete, 1996.
Market growth	Improved market growth and success, leader in new technology, improved market share, market leadership, enhanced competitive advantage	Marri et al., 2000, Irani and Love, 2001
Trends of labour toward the service sector	Certainly automation of production jobs has caused some of this shift, there are also social and institutional forces that are responsible for the trend, government employment has consumed a certain share of the labour market, there has been a tendency for people to view factory work as tedious, demeaning and dirty.	Ramamurthy, 1995, Kaiser, 2002.
Safety	Transferring the operator from an active participation to a supervisory role work is made safer, it has also provided an impetus for automation.	Gunasekaran and Thevarajah, 1999, Marri et al., 2003.
High cost of raw material	The high cost of raw materials in manufacturing results in the need for greater efficiency in using these materials, the reduction of scrap is one of the benefits of automations.	Koc and Bozdag (2009)

Improved shop floor operations	Improved flexibility, response to changes, teamwork, increased plant efficiency, capacity planning, improves data management, manufacturing control and accuracy of decisions	Percival (2009)., Weatherall, 1992, Morris and Morris, 1994
Employee motivation	Being trained to manipulate vendor software and training others, interest in computerized production planning and control increases as time passes, pay increases based on improved employee flexibility.	Irani and Love, 2001, Marri and Sohag, 2004.

2.9 Effect of AMTs on Organizational Performance, competitive priorities and Manufacturing parameters

The study of advanced manufacturing technology with emphasis on strategy and performance is receiving increased attention among scholars. Investment on advanced manufacturing technology has been growing steadily for the past decades; countries like the USA, Germany and Japan have shown remarkable advancements in the field. Research works like Waldeck (2007), Laosirihongtong et al (2004), Machuca et al (2004) came up with notions that balancing AMT investment will result in better performance in profit and growth of the enterprise. With the increasing pace of technological change and accelerated globalization of business, manufacturers are facing unprecedented level of pressure resulting from competition from products, new product introduction and shorter product life.

Competitive advantage among manufacturing companies has led to the enhancement and advancement of manufacturing technology globally (Karim, 2007). Globally, with market pressure, companies are forced to look beyond cost and emphasize on speed, quality, agility and flexibility of their manufacturing facilities (Nahim et. al, 2006), (Yusuf et al, 2004). Investments in AMTs provide resources that enable a firm to respond to rapid market change and adapt to shorter product life cycles by designing and producing high quality, custom designed products (Handfield and Pagell ,1995).

Dean and Snell (1996) found a positive relationship between AMT investment and financial performance in the immediate time span in their longitudinal analysis. Agreeing with these results Gordon and Sohal (2001) found that firms with greater investments in AMTs show higher performance in profitability. Vonderembse et al. (1997) emphasized the integration of stand-alone AMT to improve the manufacturing performance. Jonsson (2000) found in his research that high investors in AMT show greater performance in sales growth and profit. Diaz et al. (2003) emphasized that companies lacking AMT would have fewer strategic options and a narrower scope of action. This could lead them in failing to develop new capabilities and in turn they may lose competitive advantage. On the other hand, there is also some other research, which disagrees with the positive contribution of AMTs on firm performance. Boyer et al.(1997) found that there were no differences in performance in terms of growth, profitability and flexibility on the basis of each firm's investment pattern related to AMTs. Swammidas and Kotha (1998) observed no direct impact of AMT investments on firm's financial performance. Chung (1996) indicates that 50–75% of AMT adoptions fail regarding expected benefits like flexibility, quality, and reliability.

Efstathiades (1997) found that the competitiveness of companies which is preceded with implementations of Advanced Manufacturing Technologies is quite high. He also found that the adoption of AMTs have positive influence to competitive priorities and manufacturing parameter of companies. The researcher also argue that firms which adopt the AMTs into their Manufacturing environment achieve greater organizational performance than those not adopting AMTs.

Tufan Koc.Erhan Bozdag (2006) conducted an empirical research of CNC technologies implementations in SME manufacturing to determine the effect of CNC technology affects the firms performance and to determine the manufacturing parameter and competitive priorities that affected by the adoption of CNC technology. The author consider the following competitive priorities and manufacturing parameter his study:

Competitive priorities

Cost: Cost is one of the basic determinants of why customers choose one product over competing alternatives. Improved manufacturing technology plays an important role in affecting the cost structure of a product through more efficient manufacturing operations with less waste.

Quality: quality of a product is affected by manufacturing technology through the factors such as product design, tightness of tolerances, inspection performance, material choices, and so on.

Delivery performance: Product delivery on time and earlier than competitors is extremely important for competitive advantage. Early delivery makes firms benefit from technology leadership advantage, which will endure even after a competing alternative is available by converting its product to an even better or cheaper one through using improved manufacturing technology.

Flexibility: the industry progress market requirements change rapidly and firms apply strategies to satisfy specific customer needs. These needs are usually related to the change in both product variety and product quantity. Therefore firms should be flexible enough to respond to such changes in the market by improved manufacturing technology.

Manufacturing parameter

- Product design performance

- Production planning performance ,
- Machine set up performance,
- Part inspection performance,
- Material handling performance,
- In process waiting time,
- Manufacturing time utilization,
- Maintenance performance,
- Defective part production,
- Tool utilization,
- Fixture utilization,
- Manufacturing space utilization,
- Raw material inventory need,
- Work in process inventory need,
- Finished product inventory need,
- Capacity utility ratio,
- Batch size constrain

The Author investigated statically on purposely selects 100 SMS. He found that CNC technology has significant difference on organizational performance as well as on competitive and manufacturing parameters. The CNC user have gain a significant benefits than no user of CNC.

2.10Transfer and Implementation of Advanced Manufacturing Technology

2.10.1 Technology transfer

Technology transfer can be stated as an exchange of expertise and technology/knowledge from possessor to the recipient of technology. There are two ways of making a transfer: either purchase it or develop it. By definition, a transfer of technology means a definite change in process, in product, in power, in attitude, in want and desires, and also in situations that are political, social, economic, or environmental. Technology transfer occurs because of the existence of buyers (transferees) and the sellers (transferor). In today's world transfer is mostly from developed country to the developing country (Amri Ahmed, 1995).

The transfer of technology from advanced countries to emerging economies constitutes one of the fundamental ways to pursue progress towards convergence between the two economies in terms of standards of living. Nevertheless, the level of R&D expenditure that developed countries can afford gives them a clear advantage in the technological field. It therefore seems logical for emerging countries, which have a more limited investment capacity, to try to exploit technological advances with the least possible expenditure.

Undeniably, technology has emerged as a crucial factor in development of markets, which are ever evolving and subject to change at every instant. For any nation/firm to remain competitive in the market and achieve its goals, it is necessary to stay in constant touch with the latest technology and latest consumer needs and requirements. The development experiences of developed nation demonstrate that the technology contributes more to production and productivity than physical inputs like labor and capital. Thus the technology transfer has been of great significance in view of bridging technological gaps and enabling underdeveloped countries to accelerate the pace of development at par with developed nations.

Technology transfer is a system that encompasses the social and economic fabric of a country. Where technology has been effectively transferred, there is a visible change – from the person to the production system as well as compatibility with the needs, in the institutional framework, skills, training, financial capacity, promotion, and active support of endogenous capacity and appreciation of the natural environment of the recipient country (Liu, Sifeng, et al., 2010).

The process of technology selection/transfer is characteristic as being complicated process which requires skill and managerial know-how. The process is also highly delicate and costly and as a result there is a need to put much effort and time into the transfer phase of AMT introduction into the organisation. Very often, the buyer of technology is in a weak position, especially when facing a stronger and more experienced supplier from an industrialised country (Efstathiades et al, 2000). Transfers of technology from developed countries to the developing nations have multifold benefits to both parties. Some of the reasons that can be cited by the developed countries are: (Gulelat Gatew, 2011)

- The continuation of export;
- The development of defense of local markets;
- The lack of space for development in the home country;
- The increase of pollution in the developed countries;
- The assurance of supply of raw materials; and
- The search for low cost production site

On the other hand, the imported technologies directly affect the recipient countries through:

- The increase of production resources like technical services, imported machinery and equipment, foreign raw materials, components, and parts not available in the host country;
- The extent of exploiting existing resources by generating new job opportunities, using local resources by widening indigenous entrepreneurship and/or technical capabilities;
- The substantial growth in the productivity of utilization of labor, capital and natural resources including land

As cited in (Efstathiades et al, 2000), Djeflat (1988) suggests that the buyer or recipient countries 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.

According to Efstathiades et al, (2000), 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 the technology 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 and Walker, 1986) cited in (Efstathiades et al, 2000)

Advanced manufacturing technologies can be imported through the following channels:

1. Direct investments;
2. Joint ventures; and
3. State controlled import modes.

The most commonly used modes 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 (Efstathiadas et al, 2000, Gulelat Getaw, 2011). 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.

2.10.1.1 Influencing Factors of Technology Transfer

(A) Government Related Factors

Technology is a kind of knowledge product; it needs to be protected by the legal system, particularly in the field of intellectual property rights. The degree of protection for intellectual property rights varies in different countries in the cross-border business environment. In some countries, a large number of counterfeit products infringe the international technology transfer and reduce the profit of export. Many companies in these countries can rarely get rid of the infringement problem; the protection of intellectual property rights of technology transfer in the host country or region is an important factor.

The policy system plays a decisive role in the effectiveness of technology transfer. It is difficult for technology transfer to succeed in a country or region, where there are frequent government interventions and many restrictions on foreign-funded enterprises. Policies of technology-importing countries or regions will have a direct impact on technology transfer in scientific and technical content and quality (Liu, Sifeng, et al, 2010)

(B) Market Related Factors

Market factors are the fundamental factors of technology transfer. The effect of market competition and market size on technology transfer is particularly obvious. If the opening level of the home country or region is low, only a small number of transnational companies operating a monopoly in an industry will be able to maintain the technical advantage of their monopoly status to gain more profits. So the industry slows down the speed of technical progress and hampers the technical development.

The size of the market determines the scale of production. If the market capacity is large, economy grows steadily, and resident's purchasing power is strong in a country or a region, the growing space of technology importing countries or regions will be great. Accordingly, these areas' attraction of investment and technology transfer will be stronger. (Liu, Sifeng, et al, 2010)

(C) Technology Basis

A nation or regions technology basis is important for technology transfer. The availability of human resources, the knowledge level, the development of productive forces, and the technology level will have a real impact on the transfer. The countries and regions with a great technology base and high skill levels will be capable of exporting technology. The conditions of technology-importing countries or regions restrict their ability to accept new technologies. If other conditions remain constant, the country with high performance technology and good technical basis is more likely to promote the country's technology transfer. (Liu, Sifeng, et al, 2010

(D) Infrastructure Status

Infrastructure includes transportation, canals, ports, bridges, telecommunications, electricity, water and urban water supply and drainage, gas, and other facilities. These are substantial engineering facilities to provide public service for production and the residents. It is the common material base for production, management, work and life, and guarantees that the main facilities in a city operate normally. Moreover, it is not only an important condition for material production, but also an important condition for reproduction of labor. As the exporter or recipient of technology, the infrastructure construction must be taken into consideration in the implementation of technology transfer. (Liu, Sifeng, et al, 2010)

2.10.2 Effective factor on AMTs transfer and implementations performance

The rapid growth in both availability and range of AMT choice opens up major opportunities not only for improving substitution innovation but also for radical alternatives. These opportunities have never been done before and are doing in ways which were not possible hither to (saberi et al, (2010). Changes in communication and interaction related to AMT implementation have been shown to result in greater satisfaction with the technology (Stock and McDermott, 2001) and AMT adoptions appear to be a key condition for long term competitiveness. However, many AMT projects fail to meet the expectations of their adopters (Koc and Bozdag, 2009) and increasing signs of difficulty began to emerge which suggested that the translation of potential benefits into real competitive advantage was not always as simple as signing a cheque for a new piece of equipment (Bessant, 1994). In many cases not only AMT investments have been criticized for not yielding the desired results (Chung, 1996), but also some researchers found a negative contribution of AMTs to the firm performance (Boyer *et al*., 1997; Swamidass and Kotha, 1998). The researchers concluded that the relationship between AMTs and firm performance has a complex relationship (Koc and Bozdag, 2009) and the link is influenced by other factors, some controllable and some not controllable (Heine *et al*., 2003).

Thus , Applying and implementing new technologies indicated that there are broader issues that have to be considered. Management of firms that are considering the implementations of AMT need to recognize, understand and address these issues in order to overcome or circumvent the problems of previous installations. They require knowing what the organizational and strategic factors are which make a firm more competitive and adept at using AMT in improving its performance and whether AMT's impact on company performance more pronounced if associated with a compatible organizational design and human force and management practices. Because of high cost and moderate-to high risk involved in AMT investment, it is so important for any organization to know more about these the factors. Generally, the investigated factors can be classified as technological, organizational and internal/external. This classification is illustrated in Figure 2.3

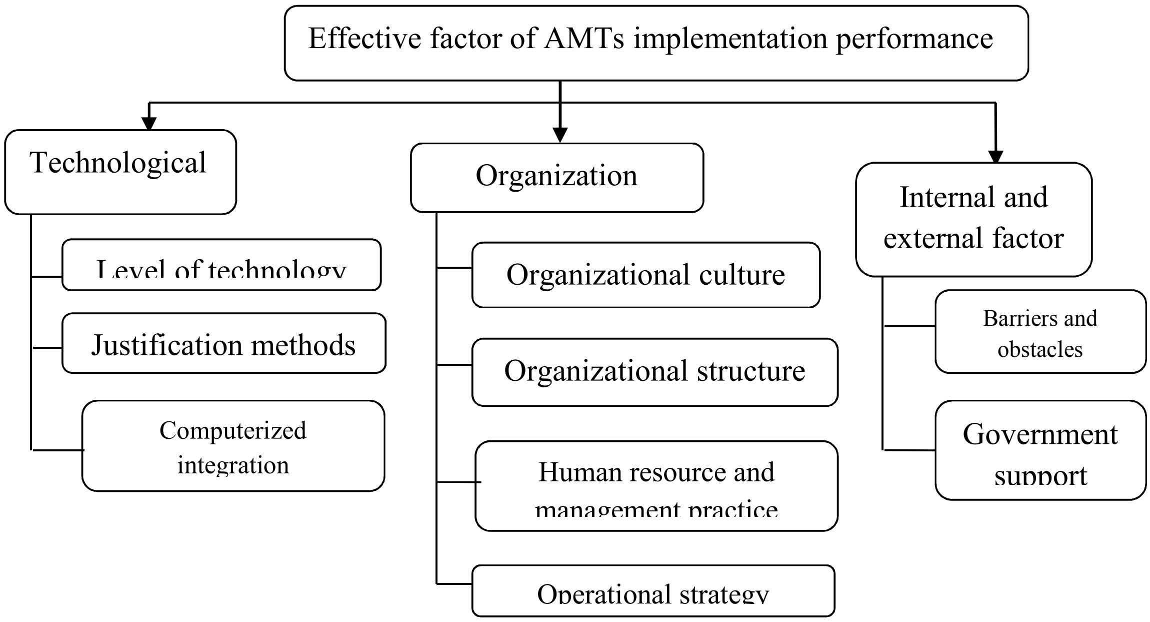

Figure 2.3: Factors effecting AMT implementation (Saberi et al, 2010)

2.11 Overview of Basic Metal and Engineering Industries

The Basic Metal and Engineering (BME) is a sub-sector within Manufacturing Sector. Basic Metals Industries are concerned with the refining and production of raw metal products from mineral ores, while Engineering Industries are industries which use these metal products as an input and fabricate them into various engineering products. Products of basic metals industries fall under two categories ferrous (Iron and Steel) and non-ferrous (all other metals but most importantly, aluminum, copper, tin, bronze and brass).

The sub-sector is further divided into:

Basic Metal Industries: are industries that deal with production of metal from ore, scrap and conversion of billet, slabs etc. into primary metal products such as metal sheet, tubes, bars, wires, cables and nails. This major group includes establishments engaged in processing ferrous and nonferrous metals from ore, pig, or scrap and those engaged in rolling, drawing, and alloy metals and castings of primary products.

Engineering Industries: convert primary metal products into secondary products such as metallic structures, windows and doorframes, tanks, pressure vessels, machine parts, machineries, transport equipment's, electrical and electronic equipment's, measuring and control instruments and etc.

The basic metal and engineering industry is crucial to the development of any modern economy and is considered to be the backbone of human civilization. It is for this reason that the level of per capita consumption of steel is treated as an important index of the level of socioeconomic development in any country. It is a product of a large and technologically complex industry having strong forward and backward linkages in terms of material flows and income generation. All major industrial economies are characterized by the existence of a strong steel industry and the growth of many of these economies has been largely shaped by the strength of their steel industries in their initial stages of development. The Ethiopian condition on basic metal sectors reveals that basic metal industries lack the crucial component of producing basic metals from iron ore or other process route.

Engineering industries in Ethiopia is still in its infancy over the years even if expansion of this industry is making a very substantial increment and is not likely to make a very potential contribution to the National Economy. However, it is evident that engineering industries can play an important role in serving other industries by providing experienced technical manpower at large and also a significant role by incubating small-scale industries.

2.11.1 Historical Development of BMEIs in Ethiopia

The BMEI is the material basis of national economy and main industrial body and engine for rapid growth of economy, and it is also considered as the backbone of human civilization. BMEI is crucial to the development of any modern economy and is considered to be the backbone of human civilization and industrial development. This is due to, it is a product of a large and technologically complex industry having strong forward and backward linkages in terms of material flows and income generation. Hence, it is evident that these industries can play an important role in serving other industries by providing experienced technical manpower at large and also a significant role by incubating small-scale industries.

All major industrial economies are characterized by the existence of a strong steel industry and the growth of many of these economies has been largely shaped by the strength of their steel industries in their initial stages of development. The Basic Metal and Engineering (BME) is a sub-sector within Manufacturing Sector. Basic Metals Industries are concerned with the refining and production of raw metal products from mineral ores. While Engineering Industries are industries which use these metal products as an input, and fabricate them into various engineering products. Products of basic metals industries fall under two categories ferrous are iron and steel, and nonferrous are all other metals but most importantly, aluminum, copper, tin, bronze and brass (Gulelat Getaw, 2011).

Basic metal industries, as the name implies are normally upstream technologies that cater to the requirements of downstream technologies by providing the required raw material in sufficient quantity and acceptable quality. In connection with this all engineering industries, engaged in the manufacture of components, parts, capital goods, etc, depend on the output of the basic metal industries for their raw material requirement. The construction sector also depends on the basic metal industries, when it comes to concrete reinforcement and pre-engineered buildings. The agricultural sector is also a consumer of the output of these industries, for some of its requirements such as structures for green house, pipes for irrigation, etc (Gulelat Getaw, 2011).

All over the world, engineering industry is regarded as the engine for industrial development. The progress of this industry is the key to social and economic progress. It is catalytic in achieving import substitution, export enhancement, high degree of value addition, optimal use of agriculture, mineral and other resources, and forward and backward integration with other economic sectors.

During the Axumite period, agricultural ploughing was started and skilled craftsmen produced ploughs. Works in silver and bronze of crosses and coins also flourished during this period.

Iron ore was found in many parts of the country, but the process of transforming it into a usable metal was not an easy task at all. By the 1830 and 1840s iron ploughshares each weighing two to five kilogram were fairly general, and could be bought nearly at all markets (Pankrust Alula,2005). Smelting was widely practiced by blacksmiths who operated one or more self-made sheepskin bellows over a charcoal fire. When the ore was brought to smelting point, the iron was taken out of the fire with large awkward pincers or tongs and held by one man upon a flat stone, while two or three others, with large round or rather oval stones struck it in turn. The operation was repeated until it was free from all earthly matters, and fit for use.

The ambitious plan of Emperor Tewedros to manufacture fire-arms, led to the establishment a foundry at Gafat by Protestant Missionaries in the 1850s, which is relatively modern. However, it has still employed the traditional hand operated bellows skin. One of the workers records that three feet high furnaces were used which can produce a temperature of 700 degree centigrade. The coal for these furnaces came from chilga, on the right bank of the Galila River, where there were six seams of very good quality coal that are three miles long and ten inches to a foot deep. The lime came from Debretabor and Dalanta. By using large unskilled manpower, the missionaries succeeded in producing bars of iron. Greek charcoal burners who began operation around 1912, producing a superior quality suitable for iron heating or smelting, which was sold for a dollar and a half per 50 kilos, while other local charcoal costed no more than half a dollar (Gulelat Getaw, 2011).

The iron produced in the previously maintained forms were hammered, carved and processed by handicraft's men into different shapes and sizes from simple household articles to complex agricultural implements using the traditional charcoal furnace. These include ploughshares, necessary iron parts for pickaxes, sickles, knives, razors, spearheads, swords and daggers, bullets and rifle spare parts, tent pegs, hammers, pincers, drills, nails, hatches, saws, files, flat pieces of iron on which to bake bread etc.

In the early 20th century, there were numerous blacksmiths in the Addis Ababa area, near Entoto, Gefersa, and as well as at the Palace. Considerable iron work was also reported in Jimma, Nekemte and Harar. In Gondar, the casting process involved silversmiths making models of the required objects in wax. The wax model was then embedded with clay, which was easily destructible on completion of the process, and let thoroughly dry in the sun, it was heated so as to melt the wax contained inside, which flowed out through a hole left for the purpose. Molten metal was then poured into the space originally occupied by the wax, this was then left to solidify. The ready-made object was then separated from the clay mould (Punkrast Richard, 1990).

During imperial era (1950-1974), the Ethiopian Iron and Steel Foundry, and Kaliti Steel Industry were established to process corrugated sheet and reinforcement bars. Kotebe Metal Tools Factory which is now under Nigat Mechanical Engineering Share Company and several sheet metal fabrication shops were also established towards the end of this period.

The industrial sector in Ethiopia was insignificant before 1974, and it was characterized by production for domestic market mainly to substitute imports, and large scale and medium sized manufacturing industries were owned by foreign nationals.

During Derg Era (1974-1991), the basic metal and engineering sub-sector was organized under National Metal Corporation. The corporation established the following new industries with objective of achieving self-sufficiency in industrial spare parts, tractors and pumps, and accelerating mechanization of agriculture. The industries include:

- Akaki Spare Parts and Hand Tools S.Co;
- Nazareth Tractor Factory;
- Pump Factory;
- Maru Metal P.L.C. (evolved from the private sector).

The National Metal Corporation in collaboration with foreign consultants conducted several studies among which are Basic Metal Sector Development Study, Kotebe Metal Tool Factory Improvement Study, Pre-feasibility of Steel Processing and others are too few to be mentioned. To support the sub-sector with product development, tool and die manufacturing, the Engineering Design and Tool Center (EDTC) was established with support of UNDP towards the end of the Derg era.

In the middles of 1990s, the Basic Metals and Engineering Industry Agency (BMEIA) was established to enable the sub-sector contribute to overall economic development in the country. The tasks of BMEIA include:

- Formulate, on the basis of the industrial policy of the country, policies for the development of the Basic Metals and Engineering Industry sub-sector, and follow up the implementation upon approval;
- Undertake market studies and promotional activities relating to the sub-sector;

- Provide services in the selection of technology and products, enhancing the development of the sub-sector;
- Restructure public enterprises engaged in the sub-sector, and direct and supervise their organization and management, other than their financial administration;
- Assess the production capacities and technological capabilities of enterprises engaged in the sub-sector with view of product identification, raw materials provision, capacity building and product development;
- Encourage the participation of private investors in sub-sector;
- Undertake studies regarding engineering and technical skills;
- Promote the expansion of modern engineering management and production techniques to raise the quality of products in the sub-sector;
- Render consultancy services in the identification and preparation of projects in the sub-sector;
- Undertake studies and research and dissemination in the sub-sector; and
- Manage scrap metal.

This measure helps to understand the government about BME sub-sector as the back bone for industrialization. BEMEIA has successfully carried supervision of public enterprise in the sub sector, registration and certification of professionals, consultants and contractors in the sub-sector, offered support in industrial energy conservation and die manufacturing. When the government prepared the industrial development strategy that encourages manufacture of goods for export market using agricultural products as raw materials, the BEME sub-sector was given less emphasis and during implementation BMEIA was reorganized as Metal Products Development Center with limited scope of activities. Nevertheless, the sub-sector's growth is being propelled by increased construction activities in the country (Gulelat Getaw, 2011).

Important achievements in the BME sub-sector during this era are establishment of the following industries.

- Sheet metal cutting and corrugation plants;
- Several truck, bus and trailer bodies manufacturing plants were established;
- Several mechanical workshops for sheet metal and structural fabrication;

- Aluminum window and door manufacturing shops;
- Mechanical workshop for reconditioning of engines and part manufacture;
- Tube and hollow section plant;
- Aluminum profile plant;
- Reinforcement bar rolling mills; and
- Cold sheet metal rolling mill.

2.11.4 Performance of the industry in Ethiopia

The manufacturing sector as a whole and the basic metal and engineering industrial sub-sector performance is very low in Ethiopia. This is illustrated by the low valued added and the low share of manufacturing industries in the country's GDP which is only about 8.5 %. On average, metal industries was about 12.6 % of the manufacturing sector. With regard to gross value of production the basic metal industries constitute 0.56% to 7% of the manufacturing sector in the period 2002-2004. If we consider the performance of the basic metal industries in the year 2015, its contribution to the GDP is to the magnitude of 8.1%. Fixed capital asset of the sub-sector had increased in the years 1991-1996. However the share of fixed capital investment compared to other section was low which about 7.47% (WDI).

Basic metal products that amount about Birr 2.76 billion and Engineering products amounting Birr 10.86 billion were imported in 2005 total import of basic metal products and engineering products has reached USD 1.48 billion. During this period, total import reached USD 4.38 million. The highest expenditure was on metal and engineering products (metal products, machinery and vehicles), which was 33.7 % of the total of import.

Currently, the major consumer of the outputs of the basic metal industries is the construction sector. With the current growth of the construction sector, however, it has not been possible to meet the demand with the existing basic metal industries because of which the country is forced to import the balance. The volume of import is immense and characterizes the dependence of our economy on this important material. The engineering industries mainly require mild steel for welding fabrication, and alloyed steels for engineering components and parts. However, because of the low level of development their material requirement is limited which doesn't go along with the production capacities of the basic metal industries in general and hot rolling facilities in particular. As a result, the material demand for the engineering industries is fully met through import and for some time to come the engineering industries can't be a market base for the basic metal industries.

There are few plants, which can be considered as engineering factory. The manufacture of machinery and equipment is almost non-existent with the exception of the former pump factory, truck, bus and tractor assembly plant and trailer manufacturing plant and the abandoned light aircraft assembly plant of Ethiopian Airlines.

Different survey and researches indicate that most of the metal and engineering industries operate under their capacity. The reason for under capacity utilization is named as lack of market, high product price and lack of raw materials. Furthermore, the reasons given for low productivity of the enterprise are: Scarcity of finance, Scarcity of raw materials and obsolete machinery in operation. It is surprising that engineering design skill, manufacturing skill, management skill and economy of scale were rated as minor contributors to productivity. Due to their low productivity and Competitiveness of the metal sector, only about 10 % of the enterprises have exported their products. Most companies believe that price, customer service and quality are instruments for gaining competitive advantage. However, 47 % of the enterprise believes that their product prices are cheaper than imported ones. Their reason behind is high raw material costs, low manufacturing quality and high manufacturing costs. Causes for high raw materials cost were given as purchase from retailers and low order quantity. As a result, they buy at higher unit price. Scarcity of working capital is also the major bottleneck for timely order of raw materials.

Ethiopia, which is total importer of various machinery and equipment, has to devise strategies to develop the engineering industry in order to improve its foreign trade deficit in the long range.

Overall, it can be inferred that the contribution of the basic metal industries to the overall economy is minimal which indicates that there is much to be desired from this industry if it has to position itself to a level where it can be a real contributor to the economy. However, the overall trend of the industry is very much encouraging if it continues to grow, especially in a better enabling environment. Therefore, improvement in this sector can help to cut import figures by increasing locally produced primary products and equipment.

2.11.5 High-technology Export in Ethiopia

The Ethiopian Basic metal industry is a locally oriented industry. According to data from United Nations (Comrade Database High-technology exports (% of manufactured exports) in Ethiopia was 8.10% as of 2014. Its highest value over the past 19 years was 16.32% in 2004, while its lowest value was 0.13% in 2002. Those Advanced manufacturing technologies (high-Technologies) are products with high R&D intensity, such as in aerospace, computer, pharmaceutics, scientific instruments, and electrical machinery.

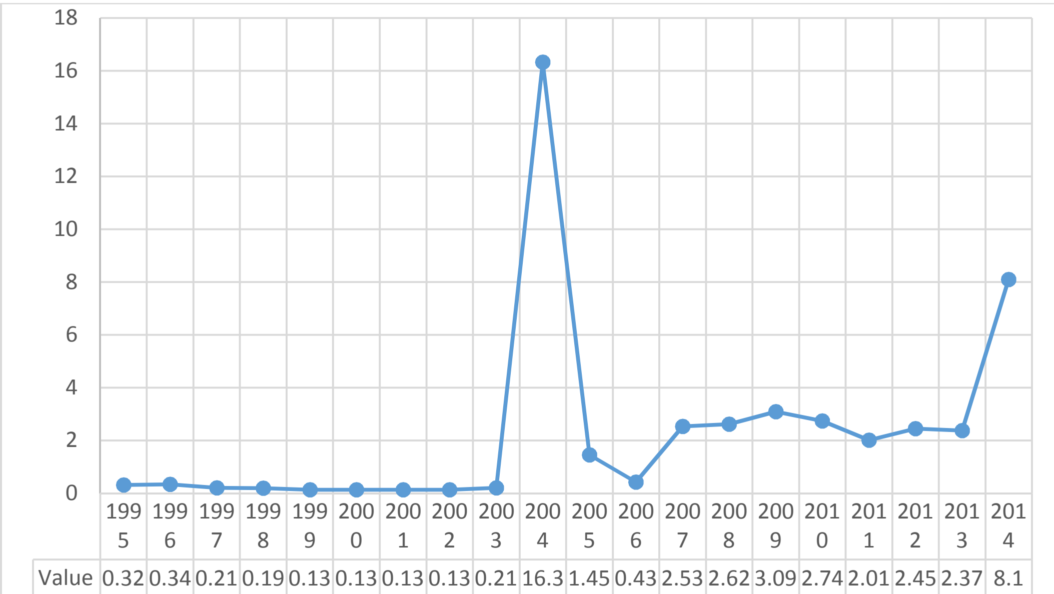

Figure 2.4: High technology export

Definition: High-technology exports are products with high R&D intensity, such as in aerospace, computers, pharmaceuticals, scientific instruments, and electrical machinery.

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CHAPTER 3: RESEARCH DESIGN AND METHODOLOGY

To achieve the general objective and specific objective of the research, the following the research Design and methodologies has been used.

3.1 Research Design

The overall research design of thesis were includes: Literature review, fact gathering, and discussion, and analysis, interpretation of data, conclusion and recommendations.

3.2 Source of Data Collection

There are two sources of data which includes primary and secondary data. The primary data gathering was conducted through use of questionnaires aforementioned with interview and visits which was administered to BMEIs and the secondary data was gathered from book, journals, articles, news-papers, magazines, conference papers, reports, electronic databases, and genuine internet sources.

3.2 Data Collections Instruments

In this study data collection instruments was mainly survey Questionnaires with aforementioned interview and Interview. See Appendix I and II.

3.2.1 Questionnaires administrations

A specifically designed comprehensive questionnaire was used as a basis of extracting information from the companies. The questionnaire was developed 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 adoption and Implementation of AMTs in the Ethiopian Manufacturing Industry particularly BMES was examined followed by an investigation and qualification of the impact of AMT on a comprehensive set of company performance indicator grouped as competitive priorities and manufacturing parameters.

- ☞ **Competitive priories** are the features and characteristics of the products that are visible to the customer and attract him to buy it. These include price quality consistency, product performance, delivery lead time, delivery performance product design flexibility and volume flexibility.
- ☞ **Manufacturing parameter** is that parameter in the production environments that affect directly the competitive priorities and are expected to be influenced by the

introduction of AMT in the manufacturing environment. These includes the quotation and design the lead times , the design to manufacture the lead times ,the ability to design and manufacture the products ,the manufacturing through put time , the changeover time , the manufacturing lead times , the batch size , the direct labor 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 5 point scale, the level of success of each technology was established.

Based on the level of success and the management activities identified in the process of 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 frame work and all the necessary information for the manufacturers to identify their needs, justify and select the most appropriate AMT to satisfy their strategic plans and competitive priorities.

As stated before the questionnaire was based on the recent developments in the subject and was designed after a thorough study of international literature. It's a structure includes Five sections (Efstathiades, 1997). Each one addressing separate issues.

- ❖ Section A and B deal with the general characteristic of the companies and the application of advanced manufacturing technologies.
- ❖ Section C determine the impact of AMT on the company products, competitive priorities and manufacturing parameters.
- ❖ While section D and E examine the management process followed during the introduction and the operation of AMT in the manufacturing environment.

Section A: *General Characteristic of the Companies*: This section include questions which aimed to extract information of a general nature, and related to the introduction and implementation of advanced manufacturing technologies. In detail it yields information on:

a. The employment characteristic of the companies.
b. The manufacturing characteristics
c. The operational characteristics
d. The production plant characteristics

Section B: Advanced *manufacturing technologies: Present and Future Applications*: This section examine the level of application of AMT in the survey companies. These technologies can be classified according to their functionalities.

- Advanced Product design and Engineering Technologies (APDETs): CAD, CAM, CAE,GT,
- Advanced Production Planning Technologies (APPT): MRP, MRPII, ERP,
- Advanced Material Handling Technologies (AMHTs): AGV, AMHS, AS/RS,
- Advanced Assembly and Machining Technologies (AMcT): NC, CNC, DNC,
- Integrated Manufacturing technologies: TQM, JIT, etc

Section C: *Impact of AMT on Company Competitiveness* – Success and Failures of AMT. This section examines the impact of AMT on company competitiveness. In detail, it extracts information on:

1. The impact of AMT on the company's competitive priorities
2. The impact of AMT on the manufacturing parameters and
3. 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 AMTs. In detail the following are addressed:

a. The factor influencing the decision to introduce AMT
b. The planning level of the AMT transfer process
c. 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

3.2.2 Document Analysis

The information for this study was collected from different sources. To mention few of them; from policy documents, online data bases, brochures, state reports, historical studies, reports of GiZ, JICA, UNIDO, ESCA, world bank report, and unpublished graduate research paper from different university

3.3 Sampling and Sampling technique

This survey used a non-probability purposive sampling technique, because it provide the researcher more freedom in terms of number of issues that could be investigated, for an instances that may be different, extreme, usual or somewhat a typical. This sampling techniques are common when researchers prefer not to generalize, but to understand the topics in depth (Oates, 2006). Thus a total 38 Basic metal and engineering industries were surveyed, which is 46.34% of total 82 firms operating in Basic metal and engineering sector. The number and name of the firms were taken from the Addis Ababa chamber of Commerce website and Metal industries Development instate the institute (MIDI). The sub-sector included in this survey were Engineering industries, Basic metal industries and Automotive Industries. The location of surveyed firms were from Addis Ababa, Bishoftu and Adama. The questionaries' were distributed and delivered for selected samples firms and data were collected based on personal interviews. But, a total of 29 completed response were received, resulting a responses rate of 76.3%. Therefore a total of 29 response were deemed usable and were included in analysis. Although the sample size may not yield significant statistical results, it provided important qualitative insights into advanced manufacturing technology adoption by the manufacturing industries.

3.4 Data analysis and Interpretations

Based on the collected data, the data analysis, discussion and interpretation was be made. Both inferential statistics and Descriptive Statistical techniques supported by SPSS software was used to analysis data collected from questionnaires. SPSS software was used for analysis.

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CHAPTER 4: RESULTS AND DISCUSSION

4.1 Introduction

This research work is primarily interested in assessing the Trends, Challenges and Prospects of Advanced Manufacturing Technologies Transfer and Implementation in Ethiopian Basic Metal and Engineering Industries. This chapter covers the presentation, analysis and interpretation of data collected from primary and secondary sources. The data here are the replies collected from questions laid out in the questionnaires distributed to the respondents. In other to present the data analyse the data collected through questionnaires; all questions in the questionnaire were analysed including the ones with close relationship with the research questions, objectives, through the Software Package for Social Science (SPSS) after which the results were interpreted.

4.1.1 Respondent Profile

A letter of cooperation accompanying the questionnaire was addressed to the Production Manager/Managing Director of the company. Thereafter the letter was followed up to fix an appointment since the questionnaire was to be self-administered. 50 letters were written to all the BMEIs companies identified and delivered or posted. Gaining admission to industrial organizations for the purposes of research in Ethiopia is difficult and the author dependent to a large extent on the efficacy of personal contact networks for the purposes of getting information. Deliberate efforts were made to ensure that in every sub-sector at least 58% of the identified companies responded. The plants were located at different places, geographically ranging from 5 to 100 Km.

Data collection process took nearly 3 months. 38 out of the 50 companies showed positive response and data from these companies were used for analysis. The response rate for this study was 58 %. In comparison with other researchers in manufacturing companies, Mirmadi (2012) had a response rate of 43% while Pong and Butcher (2009) had a response rate of 52%; the response rate was deemed adequate and representative of the population. Further analysis of the data collected showed that out of the 38 respondents the credibility of 9, representing about 19.4%, did not meet the standard required and so were rejected in the analysis. The analysis was therefore based on 29 companies. The majority of the respondents of the instrument (51.1%) were from directly responsible for manufacturing or operations or production issues of their companies or industries. and 34.5% where from other management levels, that is to say, directors, managing directors, chief executive officers or chairmen, and 17.5% of respondents were executives holding non-manufacturing-related positions such as administration manager (5) and finance manager (2), Research and Development manager. The presentation of these figures is as shown in Table 4.1.

Table 4-1: Respondents profile for Questionnaire

	Job Title	Number of Respondent	Percent %
1	Top Management level	4	13.8
2	Production and Engineering Related managers	15	51.7
3	other Managers	10	34.5
	Total	29	100.0

The researcher has also tried to assess the educational background of respondents. The Figure 4-1 show that 31.03 % of the respondents had first degree, were 68.97 % of the respondents were 2nd Degree holders. This shows that most of the firms are managed by educated personnel and they are able to decide what technology to be adopted or not to be adopted for their efficient operation.

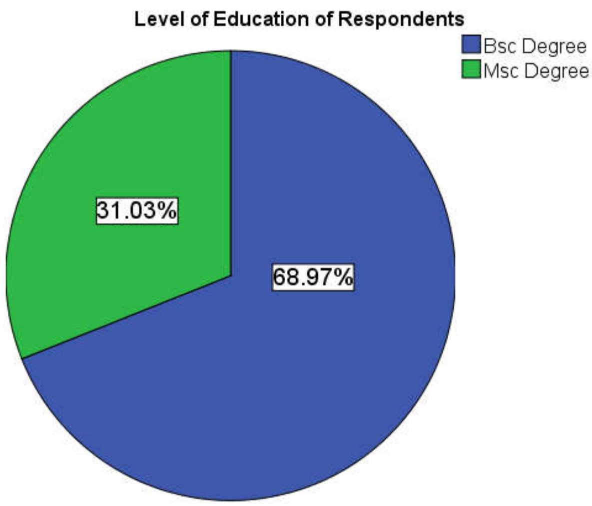


Figure 4.1 Level of Educations of respondents

4.1.2 BMEIs Sub-Sector distribution

As the focal point of the study was on BMEIs, data was presented in a disaggregated form by sub-sector. The collected data on the BMEIs sub-sectors in Ethiopia provided a basis for understanding why companies in different sub-sectors acted differently in terms of transferring and implementing Advanced Manufacturing Technologies. Five sub-sectors under BMEIs, which are considered as the priority area of the industry, were taken for investigations in this study as a sample. The results as shown on Table 4-2 indicates, the majority of respondents, 18 were from Engineering Industry, which account for 62.1% followed by automotive industry, reinforced bar manufacturer and corrugated sheet manufacturer each at 10.3 %.

Table 4-2: BMEIs sub-sector distributions

Sub-sector	Percent (%)
Reinforced bar manufacturer	10.3
hollow section manufacturer	3.4
corrugated sheet manufacturer	10.3
Automotive industry	10.3
Engineering industry	62.1
Aluminum profile and house hold manufacturer	3.4

Source: own data (May, 2017)

4.1.3 Size of company by number of Employees

Figure 4-2 shows that the sample consists of medium and large-sized companies. Almost majority (58.6 per cent) of the sample consists of medium companies, employing between 100 and 500 people. Just 37.5 % of surveyed sample are largest companies, employing more than 500 people, and the remainder, representing almost 3.4% of the respondents, are from small companies, employing less than 100 people.

4.2 Status of Research and Development activity

Research and development activities are the main tools to achieve state of the art technology for the industry. In sense having an intensive R&D activity will enable the industry to participate in technology transfer activity of Advanced Manufacturing Technology to improve their productivity and to compute in global markets. To assess the level of the research and Development activities in BMEIs the respondent where asked whether their respective industries have R& D activities. The figure 4.3 shows the status of R&D in Ethiopian BMEIs.

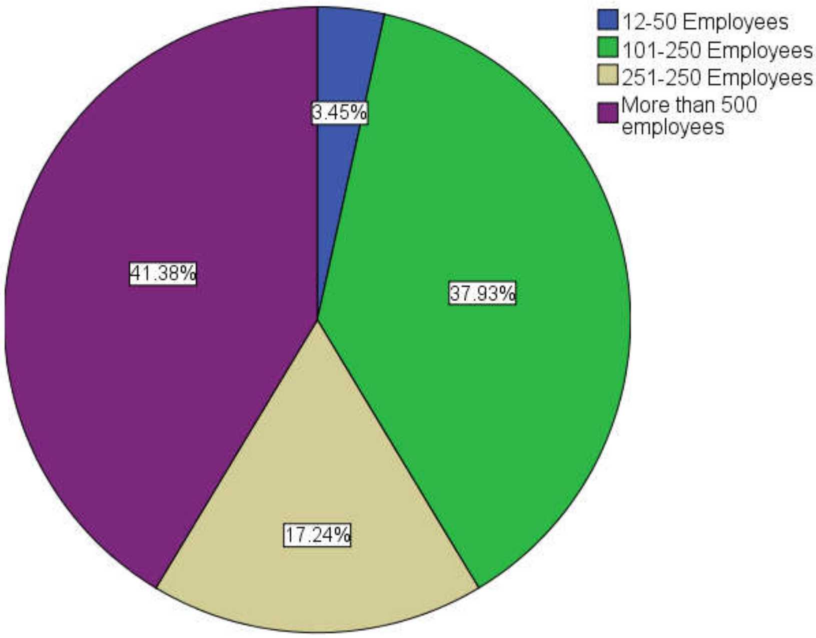


Figure 4.2 Total Number of Employees

The response of survey showed that in in Basic Metal and Engineering Industry the level of R&D is very low. Only 34.48% of the industry in engage in R&D activities. While 61.52 % of firms have not engaged with Research and Development in their company or industries

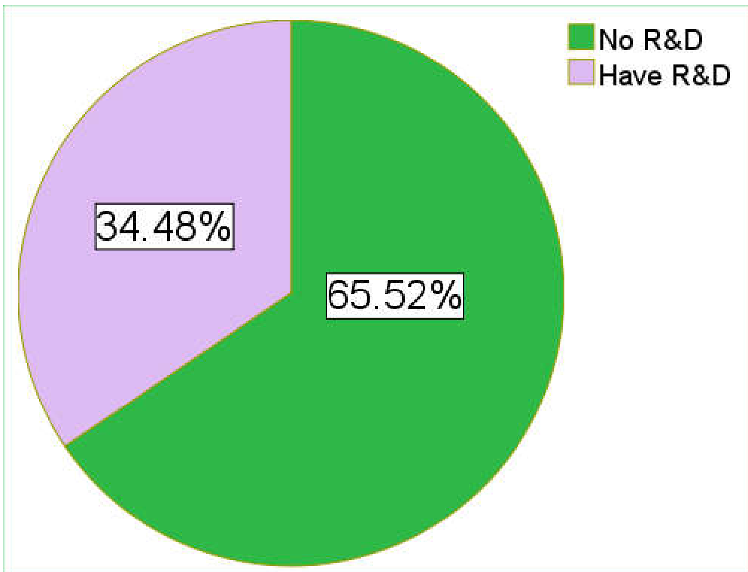


Figure 4.1: Status of R&D

4.3 Companies manufacturing Characteristics

Table 4-3 shows the manufacturing plant characteristics appearing in the Ethiopian BMEIs manufacturing companies which proceeded with the introduction of a form of AMT. The plant flexibility is moderate, its mean value being up to 3.3 with standard deviation 1.07. The technology intensity of these companies scores a mean value of 3.27 with a standard deviation of 0.95. All the companies which proceeded with the Implementation of AMT have a high degree of vertical integration, the mean value being 2.65 with a standard deviation of 1.14. 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 4-3 Manufacturing Plant Characteristics

Variable	N	Mean	Std. Deviation
Plant Flexibility	29	3.3103	1.07250
Capacity utilizations	29	3.4138	1.01831
Technology Intensity	29	3.2759	.95978
Degree of Vertical Integration	29	2.6552	1.14255
Degree of sub-contracting	29	1.6207	.97884
Degree of operating as sub- contractor	29	1.5862	.94556
Valid N (listwise)	29		

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

As shown on Table 4-4. The matrix indicate that a strong relationship between capacity utilizations and plant flexibility “with a correlation coefficient of 0.761. A high correlation coefficient of 0.709 also exists between '"technology intensity" and '"plant degree of vertical integrations”.

Table 4-4: Correlation matrix of company plant characteristics

Variable	A1	A2	A3	A4	A6	A7
A1	1	0.761**	0.537**	0.587**	-0.088	0.036
A2		1	0.677**	0.644**	0.048	-0.010
A3			1	.709**	0.001	0.052
A4				1	0.358*	0.392*
A5					1	0.828**
A6						1

**. Correlation is significant at the 0.01 level (1-tailed)

*. Correlation is significant at the 0.05 level (1-tailed

<u>LEGEDND</u>

A1= Capacity Utilization

A2= Plant Flexibility

A3=Technology Intensity

A4= Degree of Vertical Integration

A5= Degree of sub-contracting

A6= Degree of operating as sub-contractor

4.4 Company Cultures and Manufacturing Plant Characteristics

Table 4-5 shows the level of existence of integrative company cultures in the companies which proceeded with the implementation of AMTs. The results reveal that in general the cultures in the companies which proceeded with the implementation of AMTs are between moderate and high. A culture which is widely spread is that of "collaboration between departments" followed by the "Faster approval ". A bivariate correlation between the company's cultures and the level of the manufacturing plant characteristics could provide interesting results. **Table 4-6** shows the correlation matrix between plant characteristics and companies cultures.

Table 4-5: Company cultures

	N	Mean	Std. Deviation
Collaboration between departments	29	3.8276	.84806
Faster approval	29	3.6897	.92980
Attitude that we are always learning	29	3.6897	1.19832
Receptivity to new ideas	29	3.6207	.97884
Extra resource available	29	3.4483	.98511
Advanced warning of changes, open circulation of information	29	3.2069	.94034

Abundant praise and recognition	29	3.1724	.92848
Valid N (listwise)	29		

Table 4-6: Correlation matrix of companies' cultures and production plant characteristics

	B1	B2	B3	B4	B5	B6	B7
A1	0.342*	0.367*	0.127	0.300	0.318*	0.307	0.285
A2	0.456**	0.494**	0.257	0.303	0.288	0.269	0.244
A3	0.153	0.139	0.104	0.426*	0.370*	0.280	0.357*
A4	0.33*	0.299	0.158	0.229	0.268	0.269	0.329*
A5	0.180	0.219	0.047	0.271	0.166	0-.003	0.048
A6	0.094	0.133	0.041	0.328*	0.301	0.130	0.292

LEGEND:

A1= Capacity Utilization
A2= Plant Flexibility
A3=Technology Intensity
A4= Degree of Vertical Integration
A5= Degree of sub-contracting
A6= Degree of operating as sub-contractor
B1=receptivity to new ideas
B2=Faster approval
B3=Collaboration between departments
B4=Abundant praise and recognition
B5=advance warning of changes, open circulation of information's
B6=Extra resource available
B7=Attitude that we are always learning

The results reveal a relatively strong relationship between the companies ability for "fast approval" with plant "capacity utilization", giving a correlation coefficient of 0.342. The correlation for "capacity cushion" with "faster approval" gives 0.367. Companies which give special attention to" Faster approval" arises with high "plant flexibility". High "plant flexibility" exists in companies where "receptive to new idea" is high and the "abundant praise and recognition "is abundant. The correlation coefficient between these factors is 0.494, 0.456 and 0.303 respectively. Companies where the attitude that "we are always learning" is high, advance warning of changes, open circulation of information's is and the "praise and recognition" is abundant, managed to achieve higher plant "technology intensity" than others. The respective correlation coefficients are 0.426, 370 and 0.357. 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 0.329.

4.4 Advanced Manufacturing Technologies: Present and Future Implementations Trends

Advanced manufacturing technology results from substantive advancements over the current state of art in the production of materials and products. These advancements include improvements in manufacturing processes and systems, which are often spurred by breakthroughs in basic science and engineering disciplines. These technologies are often referred to as intelligent or smart manufacturing systems and often integrate computational predictability within the production process. The study investigates different types of advanced manufacturing technology (AMT), which are commonly used by manufacturing industries. These technologies were grouped, based on their functionalities, into 7 domains namely; Advanced Product design and Engineering Technologies, Advanced Production Planning Technologies (APPT), Advanced Material Handling Technologies (AMHTs), Advanced Assembly and Machining Technologies (AMcT), and Planning, control and Integrations technologies, Network communication for Engineering and production purpose and Quality control and Inspections technologies. These domain of AMT status and investment level were assessed in this study as follows.

4.4.1 Present status and plan for future of AMT in Ethiopian BMEIs

The researcher asked industries respondents the current status of their implementation on each 24 AMTs on the three scale (1- no-plan/not in use, 2- planned next for 5 years, 3- in use/Implemented). Table 4-7 indicate response of surveyed industries AMT implementation status in Ethiopian Basic Metal and engineering sector. Among AMTs implemented CAD has the highest degree of Implementation with a 96.6%. Another AMTs that have highest Degree of implementation is Computer Aided Engineering (CAE) with (72.7%), Local area networks for Engineering and Production purpose with (51.7%), CNC machine with (31.1%), Material Requirement planning (MRP) with (34.79% and statically quality control with (31.01%). There is no investment found in one of Material Handling technologies in BMEIs. In next five year the survey industries have a planned to implement Total Quality management with (48.3%), MRP (41.4%), MRPII (20.7%), ERP (17.02 %), CAM (13.8%) and CNC (10.3%,)

Table 4-7 present status of AMT in use and Future plan

	Advanced Manufacturing technologies (AMTs)	In use	Plan to use next 2 year		No plan to uses	Rank
	Design and Engineering					
1	Computer-aided design (CAD)	96.6 %	3.4%		0%	1
2	Computer-aided engineering (CAE.	72.4%	6.9%		20.9%	2
3	Group technology (GT)	6.9%	6.9%		65.5 %	12
4	Computer-aided manufacturing (CAM).	20.7%	13.8%		65.5%	7
	Process, Fabrication and Assembly					
5	Numerical control machines (NC/CNC/DNC)	31.1%	10.3%		58.6%	6
6	Flexible manufacturing cells/systems (FMC/FMS)	0%	3.4%		96.6%	
7	Laser technologies to process materials and measures	10.3%	13.8%		75.9%	10
8	Computer aided process planning (CAPP)	13.8%	3.4%		82.8%	9
9	Robotics	0%	13.4%		86.2%	15
10	Rapid Prototyping systems	0%	3.4%		96.6%	16
	Automated Material Handling					
11	Part identification for Manufacturing Automation (e.g bar coding)	0%	0%		100%	22
12	Automated storage and or retrieval systems (ASRS)	0%	0%		100%	22
13	Automated guided vehicles (AGV)	0%	0%		100%	22
	Planning , Integration and Control					
14	Material requirement planning (MRP)	34.5%	41.4%		24.1%	4
15	Manufacturing resources planning (MRPII	0%	20.7%		79.3%	13
16	Enterprise resources planning (ERP)	0%	17.2%		82.8%	14
17	Computer-integrated manufacturing (ClM)	0%	3.4%		96.6%	16
18	Total Quality Management (TQM)	6.9%	48.3%		44.8%	11
19	Just in Time (JIT)	0%	6.9%		89.7%	
	Network communication					
20	Local area Network (LAN) for engineering and/or production	51.7%	10.3%		37.9%	3
21	Company-Wide area network (including intranet and WAN)	6.9%	10.8%		82.3%	
22	Inter-company computer Networks (including Extranet and EDI)	0%	0%		100%	22
	Quality control and Inspection					
23	Computer-aided quality control system (CAQCS)	20.6%	0%		79.3%	8
24	Statically quality control	31.0%	17.2%		51.7%	5

4.4.2 Investment level of AMTs in BMEIs

Respondents were asked to indicate degree of investment Advanced Manufacturing Technologies in their companies on five point Likert scale (where 1-No Investment and 5-Heavy investment).

4.4.2.1 Product Design and Engineering Technologies

Manufacturing companies invested in various product design and engineering technologies. These technologies included CAD, CAE, CAM and GT. Companies used these technologies to assist them in designing and testing a product, controlling of manufacturing machinery and also for part classifications and coding systems. Table 4-8 shows the mean and Standard Deviation value of for each PDET. The results show that the most common PDET among the companies surveyed is CAD, with a mean investment score of 3.96; followed by CAE, with mean score of 2.55. The results show that the least investment is CAM and GT with mean score of 1.48 and 1.344 respectively. It reflects that Companies are investing more in CAD.

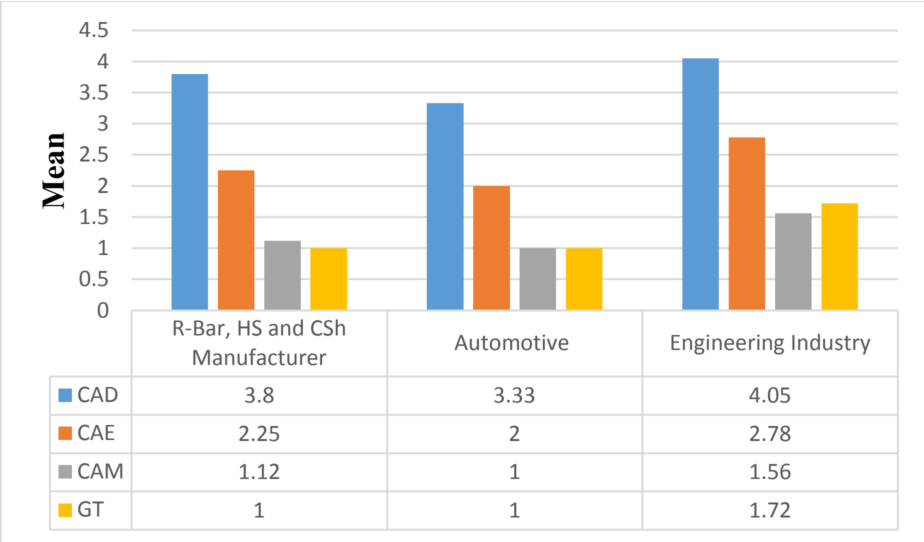
Table 4-8: Level of Investment in Design and Engineering Technologies

	N	Mean	Std. Deviation
Computer-aided design (CAD)	29	3.9655	1.01710
Computer-aided engineering (CAE).	29	2.5517	1.12078
Group technology (GT	29	1.4828	.94946
Computer-aided manufacturing (CAM).	29	1.3448	.89745
Valid N (listwise)	29		

On five point Likert scale (Interval scale 1-5: 1 – No investment and 5 - High investment

Source: own data

Fig. 4.3 shows that across all sub-sectors investment in CAD takes the most important position while GT and CAM is worth the least. Per sub- sector engineering industry relies on CAD the most which registered mean score of 4.05, followed by Reinforced bar, hollow section and corrugated sheet manufacturer and Automotive Industry with mean score of 2.78 and 2.25 respectively. Similarly, CAE is relatively more important in Engineering and Reinforced bar and Hollow section Manufacturer and Corrugated Sheet manufacturer but. For CAM and GT investments all sub-sector registered lowest mean score.



Where, R-bar: Reinforced bar Manufacturer, HS: Hollow section Manufacture and Csh: Corrugated sheet Manufacturer

Figure 4.3 Investment of Product design Engineering Technologies by Sub-sector

Comparison of the mean score of PDET investments with the employment band, as shown in Fig. 4.3, reveals that all surveyed industries invested the most in CAD followed by CAM then CAE and GT was the least. However in small industries investments of CAE and GT are very low. This indicates that these two technologies are not important for small industries. In general, the importance of these technologies increases with company size. Larger companies seem to depend on these technologies for their operation.

4.4.2.2 Process, Fabrication and Assembly Technologies

The study examined the level of investment of 6 types of process, Fabrication and Assembly technologies (PFATs); numerical control machines (NC/CNC/DNC), Flexible Manufacturing cells/systems, Laser technologies, Computer aided Process planning CAPP, Computer Aided quality control systems, Robotics and Rapids Prototyping system (3D-Printing).These PFATs are used to perform repetitive functions and work without permanent alteration of the equipment. Robotics are used to carry out various operations like handling, process or assembly tasks, whilst numerical control machines exist for almost all types of machining, like turning, boring and milling.

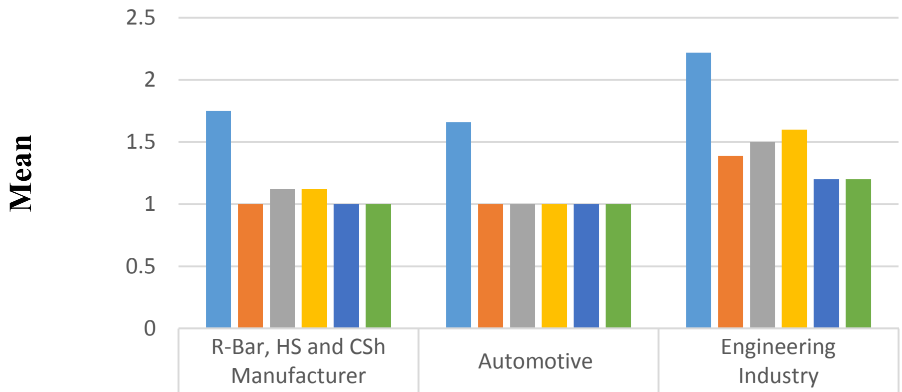
Table 4-9: Investment of AMTs in BMEIs

Advanced Manufacturing Technologies (AMTs)	N	Mean	Std. Deviation
Design and Engineering			
Computer-aided design (CAD)	29	3.9655	1.01710
Computer-aided engineering (CAE).	29	2.5517	1.12078
Group technology (GT	29	1.4828	.94946
Computer-aided manufacturing (CAM).	29	1.3448	.89745
Process, Fabrication and Assembly			
Numerical control machines (NC/CNC/DNC	29	2.0345	1.32241
Flexible manufacturing cells/systems (FMC/FMS)	29	1.2759	.75103
Laser technologies to process materials and measures	29	1.3448	.89745
Computer aided process planning (CAPP)	29	1.4138	.82450
Robotics	29	1.1379	.51576
Rapid Prototyping systems:	29	1.138	.5158
Automated Material Handling	0		
Part identification for Manufacturing Automation (e.g bar coding)	29	1.1724	.53911
Automated storage and or retrieval systems (ASRS)	29	1.1379	.51576
Automated guided vehicles (AGV)	29	1.3103	1.03866
Planning , Integration and Control	0		
Material requirement planning (MRP)	29	1.8966	1.04693
Manufacturing resources planning (MRPII)	29	1.8276	1.03748
Enterprise resources planning (ERP) -	29	1.3448	.72091
Computer-integrated manufacturing (ClM)	29	1.2069	.55929
Total Quality Management (TQM)	29	1.3103	.66027
Just in Time (JIT)	29	1.1379	.51576
Network communication	0		
Local area Network (LAN) for engineering and/or production	29	1.7241	.95978
Company-Wide area network (including intranet and WAN)	29	1.5862	.94556
Inter-company computer Networks (including Extranet and EDI)	29	1.2759	.88223
Quality control and Inspection			
Computer-aided quality control system (CAQCS)-	29	1.6897	1.03866
Statically quality control	29	1.6552	.89745

Rapid prototyping systems used for producing prototype parts from the output of a Computer-aided design. Table 4-9 shows that the investment of AMTs for Process, Fabrication and Assembly purpose are less than moderate in Ethiopian Basic Metal and Engineering Industries, the highest value is for Numerical control Machines (NC/CNC/DNC) with mean score 2.03.

There is somewhat little investment in computer aided process planning and laser technologies with mean score of 1.41 and 1.35 respectively and no investment in Robotics and Rapids prototyping systems.

As shown on Figure 4.4 Engineering Industry invests in numerical control machines (NC/CNCDNC) than the other industries even though its investment is less than moderate with mean score of 2.2. The investment in numerical control machines for other industries very least with a mean score of 1.75 and 1.65 for Automotive and other industry respectively. The Investments laser technologies in were limited, the Engineering industry only invested on it with mean value of 1.6. The No invested technology in this domain was in flexible manufacturing cells/systems, Rapid prototyping systems and robotics technology.



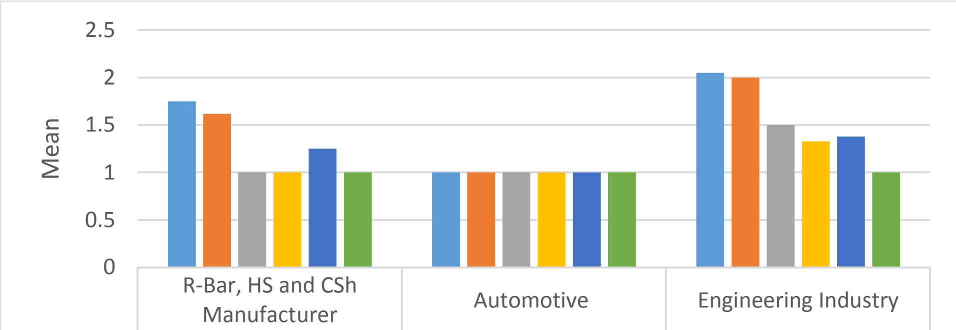
	R-Bar, HS and CSh Manufacturer	Automotive	Engineering Industry
NC/CNC/DNC	1.75	1.66	2.22
FMC/FMS	1	1	1.39
LT	1.12	1	1.5
CAPP	1.12	1	1.6
Robotics	1	1	1.2
RPT	1	1	1.2

Figure 4.4: Investment of Fabrication and AssemblyTechnologies by Sub-sector

4.4.2.3 Production planning, integration and control (PPTs)

Six technologies were identified in the literature in this domain. These technologies were material requirement planning (MRP), manufacturing resources planning (MRP II) and enterprise resources planning (ERP) computer integrated manufacturing (CIM), Total Quality Management (TQM) and Just in Time (JiT). Manufacturing companies used these technologies to assist them in planning, scheduling and controlling of material and resources requirements. ERP covered a wider scope by integrating the operations throughout the companies and also by facilitating global integration.

The whole advanced manufacturing industry seemed to have similar trend on the investments in production planning technologies (PPTs). As shown in Figure 4-5, surveyed companies‟ investments in material requirement planning (MRP), manufacturing resources planning (MRP II) and enterprise resources planning (ERP) are generally moderate. The ranking of investments in the three technologies, from highest to lowest.



	R-Bar, HS and CSh Manufacturer	Automotive	Engineering Industry
MRP	1.75	1	2.05
MRPII	1.62	1	2
ERP	1	1	1.5
CIM	1	1	1.33
TQM	1.25	1	1.38
JIT	1	1	1

Figure 4.5 : investments of production planning technologies (PPTs) by subsector

4.4.2.4 Automated Material handling technologies

Material handling technologies are Advanced Manufacturing Technologies (AMTs) used by manufacturing industries to facilitate the handling of material in manufacturing operations. Automated storage and retrieval systems use computer to direct automatic loaders to pick and place items for production processes or storage by automatic high lift trucks. Industries employ transport automation by using automated guided vehicles (AGVs) to move materials from one place to another.

An industry where asked to state the level of Implementation/Investment available in their company on the automated material handling and storage systems (AS/RS), Automated Guided vehicle (AVG) and part identification for Manufacturing Automations .The respond as shown in Figure 4-6 show that there is no investment in any of Automated material handling technologies

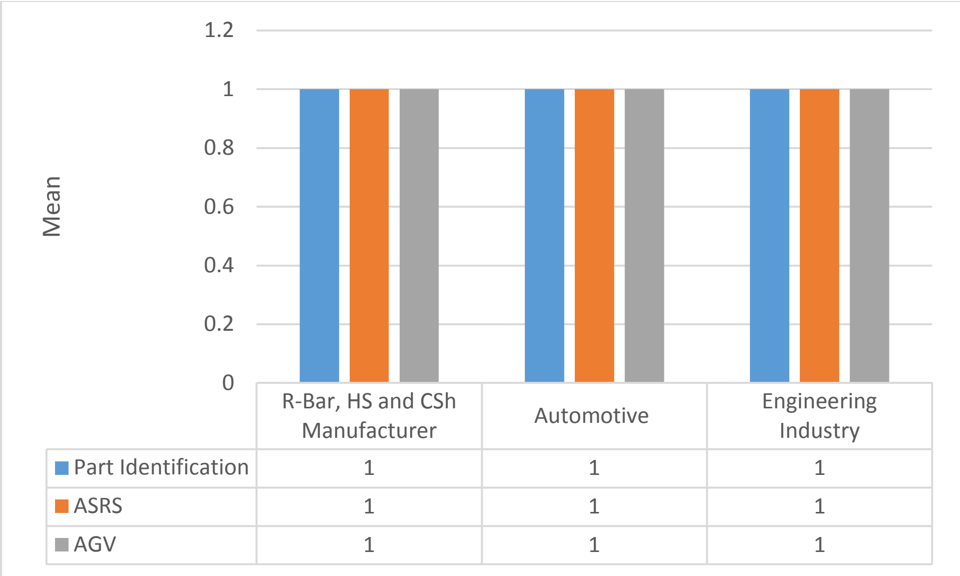


Figure 4.6 investment of automated Material handling technologies by subsector

4.4.2.5 Network Communications

The identified technologies from Literature in this area was Local area network for Engineering and or Production, Company-Wide area network and Inter-company computer Networks. As shown in Table 4-9 the trend in investing Local area Network for Engineering and or production purpose is less than moderate in Ethiopian BMEIs Industries with mean score of 1.72. Level of Investment in Company-Wide area network (including Intranet and WAN) were also less moderate with mean score 1.58. Inter-company Networks (Including Extranet and EDI) were least invested by companies under BMEIs. The figure 4.7 shows the investment of Network commutations technologies in different sub-sector under BMEIs. The results indicate that Engineering Industry somewhat invest in Local area Network for Engineering and production purpose.

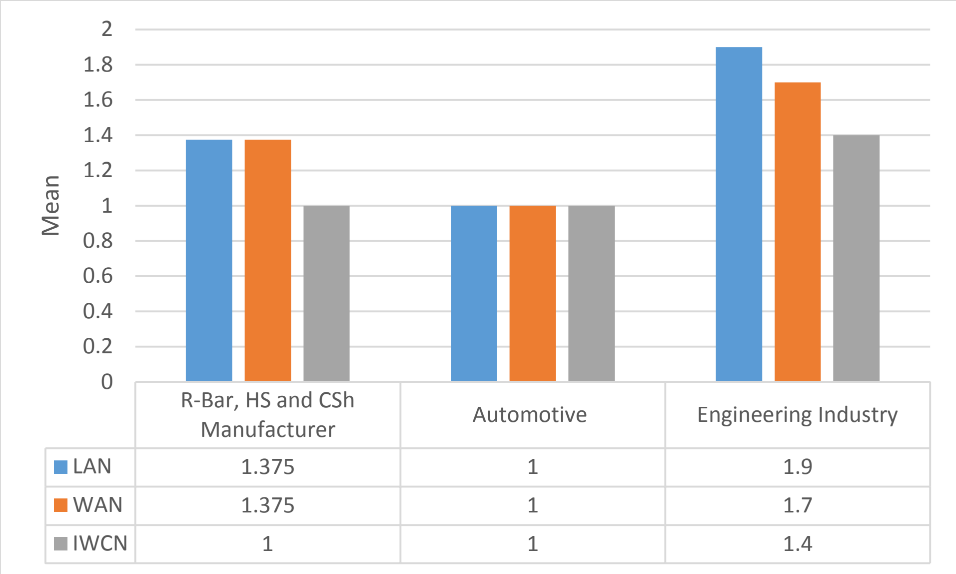


Figure 4.7 investment of Network communication by sub sector

4.4.2..6 Quality control and Inspection

As shown in Table 4-9 the trend in investing computer aided- quality control and statically quality control is less than moderate in Ethiopian BMEIs Industries with mean score of 1.68 and 1.65 respectively. The figure 4.8 shows the investment of quality control and Inspection technologies in different sub-sector under BMEIs. The results indicate that Engineering Industry somewhat invest in statically quality control purpose.

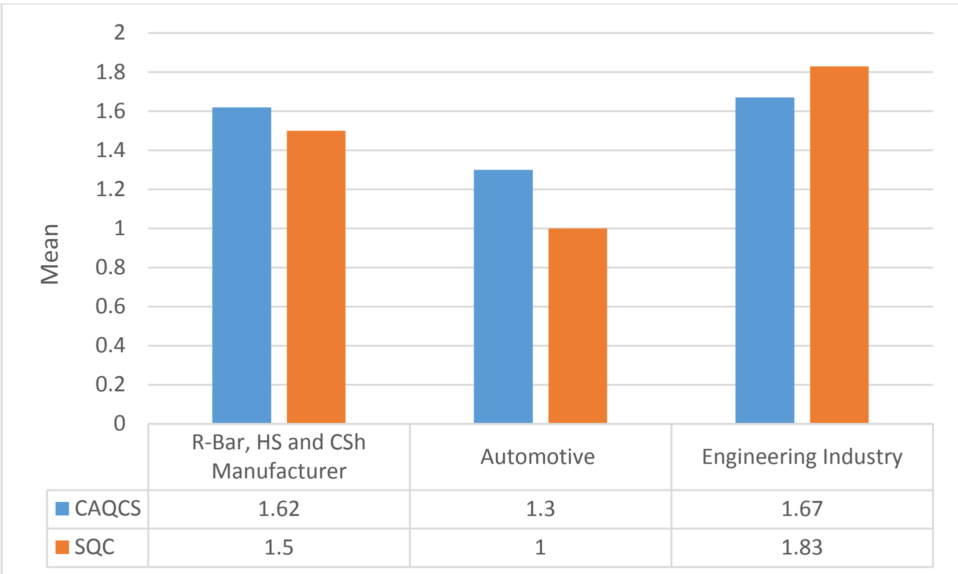


Figure 4.8: Investment of Quality control and inspections by subsector

4.5 Factor Influencing the Decision to Introduce AMT Justification

In order to identify the factor that influence the decision to introduce AMT respondent where asked to indicate level of influence of each individual factor market characteristics, competitive priorities and manufacturing parameters on a five point likert scale (1 = very low influence to 5= very high influence). The results from questionnaires were analysis as follows:

4.5.1 Level of influence of Market related factor to Introduce AMT

Table 4-10 shows the influencing level of the market related factors in the decision to introduce AMT. The results reveal that the main reason for the introduction of AMT in the Ethiopian manufacturing industry, 13 out of 29 companies studied, is to increase/maintain the existing market share, followed by the desire to introduce new products to existing markets. The above results show the heavy local competition (either from local products or foreign imports) the Ethiopia BME industry is facing and the need to survive in the local market.

Table 4-10: level of the market related factors in the decision to introduce AMT.

Variable	Total	CAD	CNC	CAD/CAM
Increasing/ Maintaining Market share	4.13	2.6	4.45	3.86
Entering new markets with existing products	4.03	2.8	4.5	4.02
Introducing new product to existing market	4.07	3.5	4.6	4.2
Entering new markets with new products	3.79	3.6	4.2	3.95

4.5.2 Level of influence of the Competitive Priorities to 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' 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.

In the survey companies were asked to indicate the importance given to six competitive priorities i.e price, consistent quality, design performance, delivery performance, productive/design flexibility and volume flexibility in their companies to introduce AMTs. Table 4-11 shows the level of influence of the company’s competitive priorities to the introduction of AMTs. It is observed that the top most important for Ethiopian Basic Metal and Engineering Industries is that "consistent quality, followed by delivery performance" and "design performance" with mean score of 4.41, 4.27 and 3.65 respectively. The lower score is given to the price factor thus indicating that AMT is not generally seen as contributing significantly to cost reduction.

Table 4-11: level of influence of the company's competitive priorities to the introduction of AMTs

Variable	Mean	Std. Deviation	Rank
Price	2.72	.959	**6**
Consistent quality	4.41	.627	**1**
Performance design	3.65	1.232	**3**
Delivery performance	4.27	.648	**2**
Product/design flexibility	2.86	.875	**4**
Volume flexibility	2.83	.711	**5**
Valid N (listwise)			

Table 4-12 shows that the level of influence of competitive priority for introduction of some individual AMTs in particular. An examination of the results relating to the introduction of individual AMT technologies reveals:

Table 4-12: Level of influence of the Competitive Priorities on some individual AMTs

Variable	CAD	CNC	CAD/CAM	CAE	MRP
Price	1.23	3.25	3.56	2.89	3.20
Consistent quality	3.54	4.65	4.34	4.22	0
Performance design	4.75	2.51	4.65	4.22	0
Delivery performance	4.54	3.82	2.44	4.02	3.05
Product/design flexibility	4.71	4.05	4.02	3.52	1.23
Volume flexibility	3.75	4.02	4.05	2.35	2.45
Valid N (listwise)					

On five point Likert scale (Interval scale 1-5: 1 - least important and 5 - most important)

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 Ethiopian BMEI.

4.5.3 Level of influence of Manufacturing Parameters

Table 4-13 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.

It can be seen that one of the most important manufacturing parameters is the; .Average Order Quality Level" illustrating the interest of the Ethiopian Basic metal and Engineering manufacturer to improve the quality of their 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.

Table 4-13: Level of influence of the manufacturing parameters

Variable	CAD	CNC	CAD/CAM
Quotation and design lead times	4.21	0.21	3.00
Lead times (Design to Manufacture)	3.92	0.75	4.50
Ability to design and manufacture new products	4.31	4.03	4.22
Materials optimization due to design	2.9	0.5	3.50
Improved product quality due to design	3.75	0.45	4.45
Component and tooling standardization/reduction	3.17	3.85	2.10
Throughput time (Manufacturing)	3.23	1.44	3.85
Scrap rate and rework	2.25	3.25	2.34
Change overtime	.65	3.02	3.35
Manufacturing Lead times	2.81	3.11	2.85
Batch size improvement	1.25	3.74	1
Space and assets (as a result of stock, WIP, etc)	1.17	2.19	2.85
Plant down time (as a result of planned maintenance)	.375	.65	0
Direct labour cost	2.61	3.44	.55
Finished goods stocks	1	1.20	0
Supervision utilization (less Routine administration	1.94	1.44	0.85
Average order Quality (A.O.Q.L)	3.85	4.47	4.05
Work in Progress (WIP)	0.65	2.14	0.72
Response to quality control traisability	2.35	2.14	1.75
Management time utilization	2.46	1.59	1.62

On five point Likert scale (Interval scale 1-5: 1 - least important and 5 - most important)

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".

4.5.4 Process Analysis, Fitness of AMT into the process

One of the major steps in justifying the introduction of AMT into the manufacturing environments is the determination of fitness level of AMT into process. By the fitness we mean the compatibility of existing production process and manufacturing philosophy with the new equipment.

Table 4-14 shows the survey results of the level of process analysis carried out and the actual level of fitness of AMT into the process. 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 industries 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 moderate.

Table 4-14 Level of process analysis and fitness level of AMT into the manufacturing process

Variable	N	Minimum	Maximum	Mean	Std. Deviation
Process analysis	27	1.00	5.00	2.9630	1.95097
Knowledge of AMT characteristics	29	1.00	5.00	3.2414	1.68301
Determinations of fitness of AMT into process	28	1.00	5.00	3.1429	1.79947
Fitness of level of AMT into the process	29	1.00	5.00	3.1724	1.85297

N=number of surveyed industry

4.5.5 Planning for the selection, Transfer and Implementation process

Table 4-15 indicates that Ethiopian Basic Metal and Engineering sectors 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 4-15: Level of planning for utilization of the technology selection and buying related factors

Level of planning for utilization of the technology selection and buying related factors			
	N	Mean	Std. Deviation
Information about of alternatives sources	28	3.1786	1.63421
Knowledge of various constituents of technology	28	3.3929	1.39680
Knowledge of different production units or different manufacturing practices (knowlege of the state of the art technology	28	3.5357	1.26146
Valid N (listwise)	28		

The results presented in Table 4-16 indicate that planning for overcoming budgetary constraints 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 10 out of 29 industries studied planning is almost non-existent

Table 4-16: Planning for overcoming constraint during AMT implementations

	N	Mean	Std. Deviation
Budgetary constrains	29	4.0690	.96106
Technical and workforce infrastructure constrains	29	2.8276	1.48970
Lack of local technical support	29	3.0000	1.30931
Valid N (listwise)	29		

4.6 channel of AMT Technology Transfer

As mentioned earlier, the process of technology selection and transfer is quite complicated and requires skills and managerial know-how. The results of the questionnaire shown in Figure 4.9 indicate that all the AMTs were transferred to the companies under the foreign direct investment, joint venture channel , state import mode , licencing and the contract signed in the majority of cases was the turnkey one..

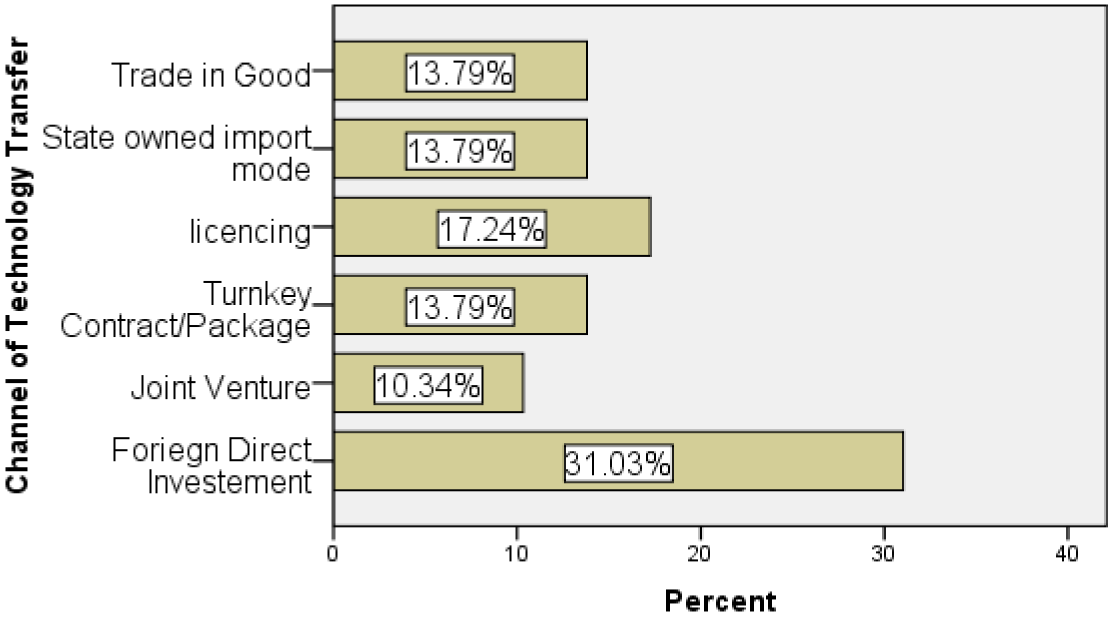


Figure 4.9. Channel of AMT Transfer

4.7 Challenges hindering AMT technology Transfer process

The technology transfer process can be hindered by factors which can normally be classified as company related, supplier related and government related. Tables 4–17 give the degree of hindrance that these factors exerted in the transfer of AMT to the Ethiopian BMEIs industry. The results reveal that supplier related factors (Table 4-18) had the highest negative influence on the technology transfer process. Amongst these, the distance from supplier of the technologies which also made provision of post-implementation technical support by the supplier difficult as well as the Bureaucratic delays with foreign countries instituted by individuals or groups unknowledgeable about technology transfer were the most important. With regards to the Company related factors (Table 4-19), the major negative influence was found to be lack of knowledge in work force whereas Management have little experience outside their own particular company were also very important. The results in Table 4-19 show that government related factors had less significant negative influence on the transfer of technology

Table 4-17 Company related factors

Variables	N	Mean	Std. Deviation
lack of staff	29	2.9655	1.05162
limited managerial resources	29	2.3793	0.56149
Management have little experience outside their own particular company	29	3.3793	0.49380
Lack of knowledge in the workforce	29	4.0345	0.32544
Valid N (listwise)	29		

Table 4-18: Supplier related factors

Variables	N	Mean	Std. Deviation
Bureaucratic delays with foreign countries instituted by individuals or groups unknowledgeable about technology transfer	29	3.0345	1.20957
Cultural and social differences from supplier of technology	29	1.3448	0.55265
Distance from the supplier of technology	29	4.9310	0.37139
Lack of communication with the supplier of technology	29	2.5172	0.98636
Lack of trust and goodwill with the supplier of technology	29	2.8621	0.58089
Lack of support (technical) from the supplier of technology	29	2.5172	0.82897
Valid N (listwise)	29		

Table 4-19 Government related factors

Variable	N	Mean	Std. Deviation
Government intervention and regulations	29	2.3448	0.66953
Taxation effect	29	3.9655	0.56586
The transmission channels	29	1.5517	0.68589
Lack of appropriate legislation	29	2.4828	0.50855
Frequent changes in current policies and commercial laws	29	1.34483	0.552647
Valid N (listwise)	29		

4.8 Success Factors and Barriers for AMT Implementation

To gain an in-depth and detailed view of the company and their structures, the researcher chose direct structured interviews as our method of data collection. The interviews were designed as partially standardized interviews using open to semi-open questions as initial starting points for the conversation. Personal (face-to-face) interviews were conducted by the researcher. An interview guideline was developed based on the questions of appendix-II. The researcher changed the questions to align with our identified Key success (see Figure 4-20) to ensure that all of the factors were discussed in the interviews. The interview guideline consisted of 31 main questions with further sub-questions that referred to the 31 identified CSFs. These questions were formulated in an open way so that it would be possible to identify "new" key success factor that were not results of the literature review. This questionnaire was sent to interviewees before the interviews took place to allow them to prepare for their interviews. The complete listing of the formulated questions and their assignment to the success factors will not be part of this paper but will be provided by the author upon request.

4.8.1 Key success Factor for AMT implementations

To evaluate the key success factors, the interviews were analysed with reference to each key success factors question block, and the statements of the interviewees were classified according to a 5 likert scale. For further understanding the factors affecting implementation of AMT, respondents were asked to indicate their critical success factors and barriers.

(I) Strategic Factors

Table 4-20 shows the result of twelve factor variables along strategic dimension. From the table, it is found that management commitment, need to revise policies and procedure, degree of financial support , clear vision and objective, identifying the technology which the strategy requires need to recognize the organizational structure, Appoint a champion for AMT design and implementation, selection of vendor based on planned strategy , need for external consultants establish working partnerships with supplier and establishing a project team are found to be most important while perform a comprehensive environmental analysis and prime the corporate culture for change are found to be least important.

Table 4-20 strategic factor

Key factors	N	Mean	Rank
Degree of Management commitment and support	29	4.3103	1
Degree of financial support	29	4.2069	3
Need for external consultants	29	3.2759	9
Need to revise policies and procedures	29	4.2069	2
Need to recognize organizational structure	29	3.9655	5
Clear vision and strategy	29	3.6552	8
Prime the corporate culture for change	29	2.5517	13
Appoint a champion for AMT design and implementation	29	3.931	6
perform a comprehensive environmental analysis	29	2.6207	12
Selection of Vendor based on planned strategy	29	3.7931	7
establish working partnership with supplier	29	3.1034	10
identify the technology which the strategy requires	29	4.0690	4
establish a project team	27	3.0741	11
Valid N (listwise)			

(II) Technological Factors

Importance average of technological factors is presented in Table 4-21 which indicates that Understanding the potential contribution of AMT to current operations is most important factor for successful implantation of AMT. while Understanding what new technologies can achieve , degree of availability of skill, convenience in using the technology, and understanding the potential contribution of AMT to current operations degree to which the organization obtained experience with a pilot project prior to implementation, and configuration of hardware are the most important factor in importance average.

Table 4-21Technological factor

Variable	N	Mean	Rank
Understanding the potential contribution of AMT to current operations	29	4.1724	1
Understanding what new technologies can achieve	29	3.8276	2
Convenience in using new technologies	29	3.4828	3
Degree of Availability of skill	29	3.4138	4
Configuration of hardware	29	3.3448	5
degree to which the organization obtained experience with a pilot project prior to implementation,	29	3.2759	6
Valid N (listwise)	29		

(III) Human resource and management Factors

Table 4-22 shows the result of nine factor variables along human dimension. From the table, it is found that employee motivation, degree of availability of training program, employee relation and cooperation, existence of an employee education & training program prior to implementation, safety of performing job, and need for team members to be familiar with the new technology are found to be very moderately important while degree of turnover of team members, experience level of workers, active participation from the in-house engineers, and education level of workers are found to be slightly important.

Table 4-22 Human Factor

Variable	N	Mean	Rank
Employee relations and cooperation	29	3.5517	1
Degree of availability of employee education and Training program Prior to implementations of AMT	29	3.3103	2
Experience level of worker	29	3.2759	3
Educational level of worker	29	3.2414	4
Human resource practices(Organizational structure, motivation level	29	3.2069	5
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	29	3.2069	6
Active participation from in-house engineer	29	2.569	7
Safety of performing Jobs	29	2.4724	8
Employee motivations	29	2.3379	9
Valid N (listwise)	29		

4.8.2 Barrier of AMT implementations

The result of table 4-23 indicates ‘resistance to change’ was considered as extremity influential barrier for companies AMT implementations. This was followed by very influential barriers ‘lack of budget’ (Mean=4.51), lack of skilled worker’ (Mean=4.47), ‘‘lack of technical supporting services’ (Mean=4.07) and ‘lack of strategic perspectives’ (Mean=3.57).

Table 4-23 Barrier of AMT implementations

Barriers to Technology implementation	Mean
Lack of Government support	4.21
Lack of strategic perspective	3.56
Lack of skilled worker	4.47
Lack of technical supporting services	4.07
Shortage of budgets	4.51
Resistance to change	4.57

***

CHAPTER 5: AN INTEGRATED PLANNING FRAMEWORK FOR AMT TRANSFER AND SUCCESSFUL IMPLEMENTATION

Implementing a new technology is a greater burden for developing countries like Ethiopia than for the developed countries, which have better recourses through a skilled employees and broader basis of know-how.

Based on the review of literature on the planning and implementation requirements and the results of the research, an integrated model/framework is proposed, to help management in correct justification and implementation of AMT to ensure Technical, Manufacturing and Business Success.

The framework/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:

1. The planning phase
2. The Selection, Transfer and pre- implementation phase, and
3. The post implementation phase

This planning framework shown in a diagrammatic form in figure 5.1, establishes the methodology that can be adopted by the manufacturers. Each of the phases of the model are discussed below

5.1 The Planning Phase

Based on the results from the surveyed BMEIs and literature reviews it is proposed that the following steps should be followed during the planning of Advanced Manufacturing Technologies

5.1.1 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.

5.1.2 Identifying the product / market characteristics

Identification of product/ market characteristic should be as the result of business strategy taking into consideration of existing strategies, product or markets. Having established corporate and business objectives the industry should proceed with strategic decision combining products and markets. This 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

5.1.3 **Establishing the level of the company's competitive priorities**

Each strategic decision relating product/market characteristic should be followed with the establishment of the level of the competitive priorities a product should possess in order to meet the set strategic goals. It is proposed that the following competitive priorities should be included:

1. Price
2. Consistent quality
3. Performance design
4. Delivery lead time
5. Delivery performance
6. Product / Design flexibility
7. Volume flexibility

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

After establishing the required level of the order winner criteria the company should proceed to establish the required level of the manufacturing parameters within the manufacturing environment in order to support the already established order winner criteria. The model gives an indication of the relationship of the manufacturing parameters and the competitive priorities based on the research results. It is proposed that the following manufacturing parameters should be included:

- ☞ Quotation and design lead times
- ☞ Design to manufacture lead times

- ☞ Ability to design and manufacture new products
- ☞ Materials optimization from the design
- ☞ Improved product quality from the design
- ☞ Tooling standardization *I* reduction
- ☞ Manufacturing throughput time
- ☞ Scrap rate and rework
- ☞ Change over time
- ☞ Manufacturing lead times
- ☞ Batch size
- ☞ Space and assets
- ☞ Plant down time
- ☞ Direct labour cost
- ☞ Finished goods stocks
- ☞ Raw materials stocks
- ☞ Supervision utilization
- ☞ Work In Progress (\VIP)
- ☞ Average Order Quality Level (A.O.Q.L)
- ☞ Response to quality control trainability queries
- ☞ Management time utilization

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

The establishment of the required level of the manufacturing parameters should be followed by a comprehensive process analysis and the determination of the existing level of the above parameters. As a result the gap between the existing and desired level of the manufacturing parameters is calculated**.**

5.1.6 Obtaining adequate knowledge of the AMT characteristics and their impact on the company's 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 parameter

5.1.7 Establishing any defensive factors which might be taken into consideration

It is very important that during the justification of the technologies the manufacturer should take into consideration some other defensive factors that could be decisive in the selection of the appropriate advanced manufacturing technology. These factors might provide critical information regarding the selection of the technology. Such factors include:

- ❖ Main contractor's requirements
- ❖ Solution to skilled labour problems
- ❖ Solution to safety problems

- ❖ Replacement of existing (old) equipment
- ❖ Vertical integration (Sub- contractor replacement e.t.c.)

5.1.8 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 result from literature review 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.

5.1.9 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.

5.1.10 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 reveals that technology selection is an important part of the technology implementation process and should consist of the following:

1. Gathering information about alternative sources

2. Knowing the various constituents of the technology

3. Knowing the different production units and different manufacturing practices

5.1.11 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 financial justification of AMT appears to be the difficulties in the evaluation of the intangible benefits that are likely to be achieved by the AMT introduction.

5.1.12 AMT specific equipment manufacturer adoption decision

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

5.1.13 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.

5.2. The selection, transfer and pre-implementation phase

This phase consists of all the necessary activities that should be followed for the selection, transfer and installation of the technology in the manufacturing environment. In order to be successful in selection and transfer and implementations of advanced manufacturing it need to consider follow perspective:

- Performing on going adjustments during AMT transfer and pre-implementation together with continuous measurement and control during this process
- Providing adequate training by the equipment manufacturer before AMT installation
- Taking considerable support by the equipment manufacturer before the installation and actual operation of the technology.
- Continuing management support and attention to supportive human resource practises.

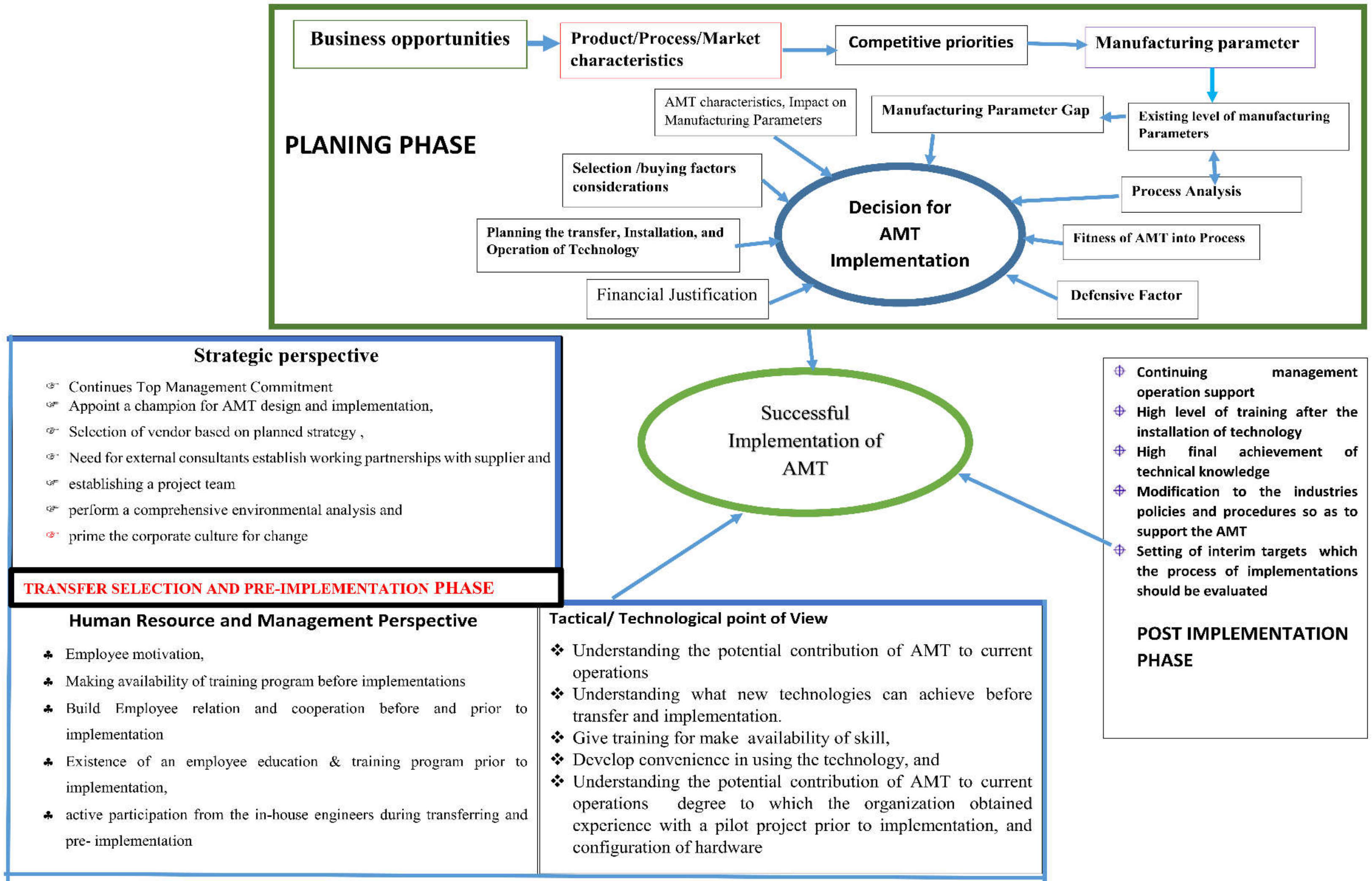


Figure 6-1. Proposed integrated Framework plan for successful Implementation of AMT implementation

Figure 6. 1proposed strategic frame work for successful implementations of AMT in Ethiopian BMEI

5.2. The selection, transfer and pre-implementation phase

This phase consists of all the necessary activities that should be followed for the selection, transfer and installation of the technology in the manufacturing environment. In order to be successful in selection and transfer and implementations of advanced manufacturing it need to consider follow perspective:

- ❖ Performing on going adjustments during AMT transfer and pre-implementation together with continuous measurement and control during this process
- ❖ Providing adequate training by the equipment manufacturer before AMT installation
- ❖ Taking considerable support by the equipment manufacturer before the installation and actual operation of the technology.
- ❖ Continuing management support and attention to supportive human resource practises.

5.3. The post-implementation phase

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

1. Continuing management and operators support
2. Level of training given and high final achievement of Technical knowledge
3. Modification to the company’s policies and procedures so as to support the AMT implementation
4. Setting of interim targets on which the process of implementation should be evaluated

***

CHAPTER 6. CONCLUSION AND RECOMMENDATIONS

6.1 Conclusion

The primary focus of this thesis was to empirically assess current status, trends and challenges of advanced manufacturing technology transfer and implementations in Basic Metal and Engineering Industry, investigate key success factors and barriers in technology transfer and implementations process. The final aims of the thesis was to prepare an integrated plan for strategic planning and implementations of AMT in the key manufacturing industry based on research results. The survey was conducted on a sample of 29 companies using personal interviews based on a purposively designed comprehensive questionnaire. The surveyed population consisted of medium to largest size firms in the Engineering industry, automotive industry, and reinforced bar and corrugated sheet manufacturer.

In general, the sample of the of industries surveyed showed that level of AMT implementation in Ethiopian BMEIs is very low with the investment levels at mean of 1.58 in five point scale of 1 to 5 where 1 indicated no investment and 5 indicated heavy investment. The study show that no sub-sector can claim to be dominant in all AMTs and the level of investment is also Different in all sub-sector.

- The most common advanced manufacturing technology for Design and Engineering is Computer Aided design (CAD). CAD is the most popular technology and Group Technology (GT) is the least favourable technology for BMEIs. The **largest sub-**sector in number among surveyed companies, Engineering Industry have highest level of Investment in Design and Engineering technologies and Automotive sector invested relatively less in Design and Engineering Technology.
- The investment level in Process, fabrication and Assembly technologies are less in BMEIs industries. The only Invested technologies in this area is NC/ CNC technologies which is highly invested in Engineering Industry followed by corrugated sheet and reinforced bar manufacturer and Less investments in Automotive Industry. There is no investments in Robotics and Rapid Prototyping (3D- printing) technology in surveyed industries.
- The investment in Production planning, Integration and control are still at early stage of Material Requirement Planning (MPR). There were no investments found on enterprise resource planning (ERP.)

- There is no investment found in Material Handling technologies in surveyed industries under Basic metal engineering sector.

The result from the survey reveal that the main reason for introduction of AMT to BMEIs are:

- To increase/maintain the existing market share followed by the desire to introduce new products to existing markets.
- Among the competitive priority the main driver for AMT introduction were the need to improve quality, performance design and delivery performance
- Amongst the manufacturing parameters the main drivers for AMT introduction were the need to improve the Average Order Quality Levels (AOQL) of the products followed by the expected reduction in the manufacturing lead times and . Other important factors were the reduction of change over times and the ability of the companies to design and manufacture new products.

The finding on Factor hindering technology transfer reveal that:

- With regard to **supplier related factors** the distance from supplier of the technologies which also made provision of post-implementation technical support by the supplier difficult as well as the Bureaucratic delays with foreign countries instituted by individuals or groups unknowledgeable about technology transfer were the most important.
- With regards to the **Company related factors** the major negative influence was found to be lack of knowledge in work force whereas Management have little experience outside their own particular company were also very important.
- With regards to **government related factors** the major negative effect was found on Taxation systems

Based on the results, the important **factors for successful implementation of advanced manufacturing technologies** in Basic Metal and Engineering Industry along different dimensions as presented below.

☞ Among **strategic Factors,** management commitment, need to revise policies and procedure, degree of financial support , clear vision and objective, identifying the technology which the strategy requires need to recognize the organizational structure, Appoint a champion for AMT design and implementation, selection of vendor based on planned strategy , need for external consultants establish working partnerships with supplier and establishing a project team are found most important factor

- ☞ Among the **human resource and management factors**, positive employee motivation, degree of availability of training program, employee relation and cooperation, existence of an employee education & training program prior to implementation, safety of performing job, and need for team members to be familiar with the new technology are found to be important
- ☞ From **technological point of view** ,Understanding the potential contribution of AMT to current operations is most important factor for successful implementation of AMT. while Understanding what new technologies can achieve , degree of availability of skilled man-power, convenience in using the technology, and understanding the potential contribution of AMT to current operations degree to which the organization obtained experience with a pilot project prior to implementation, and configuration of hardware are the most important factor.

Finally, based on the above results from the survey the integrated planning framework was developed to facilitate the successful implementations of advanced manufacturing technologies.

6.2 Recommendations

Based on the finding and conclusion found from the study, the researcher forwards the following important recommendations.

- The proposed framework would be very useful guide for success of implementation of AMT technologies for the Ethiopian BMEIs to seek ways of Introducing Advanced manufacturing Technologies to their manufacturing environment and, include AMTs in their Strategy and thinking considerations.
- The government need to establish institutions that bridge the gap of linkage, integration, coordination and implementations of all advanced manufacturing technology transfer stockholders of the sector. The researcher strongly recommend the stack-holder of BMEIs have to work strongly towards establishing Advanced Manufacturing technology centre that work on the research and development of AMTs.
- The government should place great incentive schemes to attract foreign investors that have capacity to implement Advanced Manufacturing Technology in the area of BMEIs, as the technology spill over is usually much higher in comparison with the direct benefits the other industries could bring in

6.3 Scope for Future works

- Need for testing the proposed integrated frame work model in Ethiopian Manufacturing Industries
- Need to work on financial Justification of AMTs transfer and implementations
- This study is focused on four Basic BMEI other sectors can be included.
- It does not permit the assessment of performance impact of AMT implementation over time. So that the Impact of AMT on the competitive priorities and Manufacturing Technologies will be next work.

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APPEDIX-I: SURVEY QUESTIONNAIRES

ADAMA SCIENCE AND TECHNOLOGY UNIVERSITY

SCHOOL OF MECHANICAL, CHEMICAL AND MATERIAL ENGINEERING

Mechanical Design and Manufacturing Engineering Program

SURVEY QUESTIONNAIRE

Survey questionnaire to be filled by owners or managers of the firms

This research questionnaire is in support of fulfilling the Master's Thesis study on "**Trends, challenges and Prospects of Advanced Manufacturing Technologies (AMT) Transfer and Implementation in Ethiopian Basic Metal and Engineering Industry".** The purpose of this questionnaire is to assess the transfer and Implementation of AMT in the Ethiopian Manufacturing Industry, investigate and quantify its impact on the Business and Manufacturing environment and analyse the contributing factors to the Success or Failure of the technologies. The outcome of this study should help fellow academics and vendors to understand critical factors for the transfer of advanced manufacturing technology in manufacturing firms. The student researcher will respect the information with strict confidentially and used only for academic purpose.

This questionnaire divided into five sections

Section "A": Company General Characteristics

Section "B": Advanced 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

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

Thank You In Advance for Sparing Your Precious Time to Fill This Questionnaire

Sincerely,

Solomon Dufera

PART A: COMPANY GENERAL CHARACTERISTICS

Company name:____

Address :____

Interviewee name____

Position____

1. Give Detail of products manufactured by your company:

____
____
____
____
____

Company's classification

2. Indicate which sub-sector of industry your company falls in. (tick as appropriate)

1	Reinforced bar manufacturer	
2	Hollow section manufacturer	
3	Corrugated sheet manufacturer	
4	Automotive Industry	
5	Engineering Industry	
6	Aluminum profile and house hold	

3. Locations: ____

4. Years of firm was originally founded: _________________________

6. Estimated Capital of your company (Birr________________________

7. Work force structure

7	**Work force structure**	
7.1	No of full time employees	
7.2	Total no. of managers	
7.3	Total no. of engineers	
7.4	No. of employees in the administration dept	

7.5	No. of employees in the finance dept	
7.6	No. of employees in the marketing/sales dept	
7.7	No. of employees in the manufacturing dept	
7.8	No. of employees in the engineering dept	
7.9	No. of draftsmen	
7.10	No. of employees in the production dept	
7.11	Production managers Supervisors	
7.12	Skilled workers	
7.13	Unskilled workers	

8. Do you have a research and development activity in your company or industry?

Yes No

If "yes", how do you think that Research and Development activity help your company to transfer and implement advanced manufacturing technology?

Extremely Valuable slightly valuable Highly Valuable Not valuable Valuable

9. Reasons for under capacity Utilizations

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

5= extremely influence, 4= highly influence, 3= somewhat influence, 2=low influence, 1= no influence						
		1	2	3	4	5
1	Labour shortage	1	2	3	4	5
2	Market problems	1	2	3	4	5
3	To absorb fluctuations in the demand	1	2	3	4	5
4	Any other (identify)	1	2	3	4	5

10 Production/ plant characteristics

State the level of existence of the following in your company

Key: 1=very low, 2= low , 3= moderate, 4= high , 5= very high

		1	2	3	4	5
1	Capacity cushion					
2	Plant flexibility					
3	Technology intensity					
4	Degree of vertical integration					
5	Degree of sub-contracting					
6	Degree of operating as contractor					

11. Company cultures

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

Key: 1=very low, 2= low , 3= moderate, 4= high , 5= very high

		1	2	3	4	5
1	Receptivity to new ideas					
2	Faster approval					
3	Collaboration between departments					
4	Abundant praise and recognition					
5	Advanced warning of changes, open circulation of information					
6	Extra resource available					
7	Attitude that we are always learning					

SECTION B: ADVANCED MANUFACTURING TECHNOLOGIES: PRESENT AND FUTURE APPLICATIONS

B1.Please indicate (√) whether you are currently using, plan to use (within two years), or have no plans to use the following advanced manufacturing technologies in your plant

	Advanced Manufacturing technologies (AMTs)	In use	Plan to use next 2 year	No plan to uses/not applicable
	Design and Engineering			
1	**Computer-aided design (CAD)** - to design new products or modify existing products.			
2	**Computer-aided engineering (CAE)** - to examine and test designs from a structural or engineering point of view.			
3	**Group technology (GT)** - the parts and process classification, and coding systems used to specify machine types that go into a cell			
4	**Computer-aided manufacturing (CAM)** - control manufacturing machinery, by determining the process of manufacture, i.e. the movement, speed etc of the machinery.			
	Process, Fabrication and Assembly			
5	**Numerical control machines (NC/CNC/DNC)** - machining tools which is controlled by information stored on disk (CNC) or in a form of a punched paper tape (NC).			
6	**Flexible manufacturing cells/systems (FMC/FMS)** - a group of NC/CNC automated workstations interconnected by a material handling system.			
7	Laser technologies to process materials and measures			
8	Computer aided process planning (CAPP)			
9	**Robotics** - a reprogrammable, multifunctional machine to perform repetitive tasks such as pick-and-place			
6	**Rapid Prototyping systems**: Systems capable of producing a prototype part from the output of a computer-aided design			
	Automated Material Handling			
7	Part identification for Manufacturing Automation (e.g bar coding)			
8	Automated storage and or retrieval systems (ASRS) -automated material handling system to help store or retrieve parts using computerized devices.			

9	Automated guided vehicles (AGV) - to direct driverless vehicles to deliver materials in the plant			
	Planning , Integration and Control			
10	Material requirement planning (MRP) - to plan production and raw materials requirements by working backward from the sales forecast.			
11	Manufacturing resources planning (MRPII) - Extension of MRP. Planning of manufacturing resources, i.e. manufacturing, marketing, finance and engineering, based on one integrated system.			
12	Enterprise resources planning (ERP) - extension of MRPII. Integrates business processes by using a centralized database. More functions such as reporting, decision making etc			
13	Computer-integrated manufacturing (ClM) - integrate CAD, CAM, and FMS, i.e. from design to distribution			
14	Total Quality Management (TQM)			
15	. Jist in Time (JIT)			
	Network communication			
16	Local area Network (LAN) for engineering and/or production			
17	Company-Wide area network (including intranet and WAN)			
18	Inter-company computer Networks (including Extranet and EDI)			
	Quality control and Inspection			
19	Computer-aided quality control system (CAQCS)-to carry out inspection and testing on final products or incoming or in process materials			
20	Statically quality control			

B2. Indicate (√) the level of investment your manufacturing plant has in the following technologies. Refer to the Glossary attached for detailed definition of each technology. (Tick as appropriate**)**

5= Heavy investment, 4=Substantial investment, 3=moderate investment, 2=some investment, 1= little investment							
s/n	**Advanced Manufacturing technologies (AMT)**	1	2	3	4	5	N/A
	Design and Engineering						
1	Computer-aided design (CAD)						
2	Computer-aided engineering (CAE).						
3	Group technology (GT						
4	Computer-aided manufacturing (CAM).						
	Process, Fabrication and Assembly						
5	Numerical control machines (NC/CNC/DNC						
6	Flexible manufacturing cells/systems (FMC/FMS)						
7	Laser technologies to process materials and measures						
8	Computer aided process planning (CAPP)						
9	Robotics						
10	Rapid Prototyping systems:						
	Automated Material Handling						
11	Part identification for Manufacturing Automation (e.g bar coding)						
12	Automated storage and or retrieval systems (ASRS)						
13	Automated guided vehicles (AGV)						
	Planning , Integration and Control						
14	Material requirement planning (MRP)						
15	Manufacturing resources planning (MRPII)						
16	Enterprise resources planning (ERP) -						
17	Computer-integrated manufacturing (ClM)						

18	Total Quality Management (TQM)						
19	Just in Time (JIT)						
	Network communication						
20	Local area Network (LAN) for engineering and/or production						
21	Company-Wide area network (including intranet and WAN)						
22	Inter-company computer Networks (including Extranet and EDI)						
	Quality control and Inspection						
23	Computer-aided quality control system (CAQCS)-						
24	Statically quality control						

SECTION C: IMPACT OF AMT ON COMPANY COMPETITIVENESS-SUCCESSES AND FAILURES OF AMT

I) Successes and failure of AMT implementation

1) How systematic have the effect of the implementations of AMT been assessed?

A) Very systematically B) systematically C) somewhat systematically D) Not assessed

2) State the Main product/market characteristics before and after the introduction and operations of AMT

2) Level of impact of AMT introduction

State the level of impact of AMT introduction on the following

1=very low, 2= low , 3= moderate, 4= high , 5= very high							
		1	2	3	4	5	N/A
	Increasing/ Maintaining Market share						
	Entering new markets with existing products						
	Introducing new product to existing market						
	Entering new markets with new products						

3) Competitive priorities

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

		Before						After				
s/n	Competitive priorities	Poor				ideal		Poor				ideal
		1	2	3	4	5		1	2	3	4	5
1	Price											
2	Consistent quality											
3	Performance design											
4	Delivery Lead time											
5	Delivery performance											
6	Product/design flexibility											
7	Volume flexibility											

A) Manufacturing Parameters

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

		Before						After				
	Competitive priorities	Poor				ideal		Poor				ideal
		1	2	3	4	5		1	2	3	4	5
1	Quotation and design lead times											
2	Lead times (Design to Manufacture)											
3	Ability to design and manufacture new products											
4	Materials optimization due to design											
5	Improved product quality due to design											
6	Component and tooling standardization/reduction											
7	Throughput time (Manufacturing)											

8	Scrap rate and rework											
9	Change overtime											
7	Manufacturing Lead times											
8	Batch size improvement											
9	Space and assets (as a result of stock, WIP, etc)											
10	Plant down time (as a result of planned maintenance)											
11	Direct labour cost											
12	Finished goods stocks											
13	Supervision utilization (less Routine administration											
14	Work in Progress (WIP)											
15	Response to quality control traisability											
16	Management time utilization											

SECTION D: PLANNING FACTORS, AMT STRATEGIC PLANNING FACTORS

1. Level of importance

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

A) Competitive priorities

*5= very important, 4= important, 3=moderately important, 2= slightly important, 1= not importa*nt

s/n	Competitive priorities	Codes				
		1	2	3	4	5
1	Price					
2	Consistent quality					
3	Performance design					
4	Delivery Lead time					
5	Delivery performance					

6	Product/design flexibility					
7	Volume flexibility					

B) Manufacturing parameters

5= very important, 4= important, 3=moderately important, 2= slightly important, 1= not important												
S/N	Competitive priorities	Before						After				
		1	2	3	4	5		1	2	3	4	5
1	Quotation and design lead times											
2	Lead times (Design to Manufacture)											
3	Ability to design and manufacture new products											
4	Materials optimization due to design											
5	Improved product quality due to design											
6	Component and tooling standardization/reduction											
7	Throughput time (Manufacturing)											
8	Scrap rate and rework											
9	Change overtime											
10	Manufacturing Lead times											
11	Batch size improvement											
12	Space and assets (as a result of stock, WIP, etc)											
13	Plant down time (as a result of planned maintenance)											
14	Direct labour cost											
15	Finished goods stocks											
16	Supervision utilization (less Routine administration											

17	Work in Progress (WIP)											
18	Response to quality control traisability											
19	Management time utilization											

2. 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

A) Market Related

Codes: 5=extremely influence , 4= highly influence , 3= moderately influence, 2= slightly influence , 1= no influence								
		Yes	NO	1	2	3	4	5
1	Increasing/ Maintaining Market share							
2	Entering new markets with existing products							
3	Introducing new product to existing market							
4	Entering new markets with new products							

B) Defensive factors

Codes: 5=extremely influence , 4= highly influence , 3= moderately influence, 2= slightly influence , 1= no influence								
s/n		Yes	NO	1	2	3	4	5
1	Main contractor’s requirement							
2	Solution to skilled labour shortage problem							
3	Solution to safety problem							
4	“ Me too approach”							
5	Replacement of existing (old) equipment							
6	Vertical integration (sub-contractor replacement etc.)							

C) **Competitive priorities**
5=extremely influence, 4= highly influence , 3= moderately influence, 2= slightly influence, 1= no influence

		Yes	NO	1	2	3	4	5

1	Price							
2	Consistent quality							
3	Performance design							
4	Delivery Lead time							
5	Delivery performance							
6	Product/design flexibility							
7	Volume flexibility							

D) Manufacturing parameters

5=extremely influence , 4= highly influence , 3= moderately influence, 2= slightly influence , 1= no influence												
	Competitive priorities	Before						After				
		1	2	3	4	5		1	2	3	4	5
1	Quotation and design lead times											
2	Lead times (Design to Manufacture)											
3	Ability to design and manufacture new products											
4	Materials optimization due to design											
5	Improved product quality due to design											
6	Component and tooling standardization/reduction											
7	Throughput time (Manufacturing)											
8	Scrap rate and rework											
9	Change overtime											
10	Manufacturing Lead times											
11	Batch size improvement											
12	Space and assets (as a result of stock, WIP, etc)											

13	Plant down time (as a result of planned maintenance)										
14	Direct labour cost										
15	Finished goods stocks										
16	Supervision utilization (less Routine administration										
17	Work in Progress (WIP)										
18	Response to quality control traisability										
19	Management time utilization										

4. Technology Selection and Buying related factors

State the level of planning for utilization of the following buying factors:

1=very low, 2= low , 3= moderate, 4= high , 5= very high						
		1	2	3	4	5
1	Information about alternative sources (other suppliers)					
2	Knowledge of the various constituents of the technology					
3	Knowledge the different production units or different manufacturing practices (knowledge of the state of the art technology)					
4	Group buying					
5	Break the technological package					
6	Finance from the suppliers					

5. Constraints

State the level of planning for overcoming the following constraints

1=very low, 2= low , 3= moderate, 4= high , 5= very high						
		1	2	3	4	5
1	Budgetary constrains					
2	Technical and workforce infrastructure constraints					
3	Lack of local technical support					

6. Planning the technology Transfer/Implementation

State the degree/level of performing the following during AMT planning:

6.1 Planning of the technology transfer process

1=very low, 2= low , 3= moderate, 4= high , 5= very high						
		1	2	3	4	5
1	Long term planning (How AMT will integrate into the System)					
2	Knowledge of the various constituents of the technology					
3	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)					
4	Improvements on existing activities (operation, transport, inspection and storage).					
5	Simplification and planning to achieve a smooth flow through the Manufacturing process					
6	Policies/procedures modifications					
7	Pattern work organization changes					

6.2Training for HRD

1=very low, 2= low , 3= moderate, 4= high , 5= very high						
		1	2	3	4	5
1	Overcoming Workforce reservations					
2	Overcoming Operators perception as being more skilled or deskilled					

5.3 Workforce preparation and training

1=very low, 2= low , 3= moderate, 4= high , 5= very high						
		1	2	3	4	5
1	Personnel utilization					
2	Timing of training to be given					
3	Level of training to be given					
4	Type of training to be given					
5	Learning process					

6.**4 Ongoing adjustments during AMT implementations**

1=very low, 2= low , 3= moderate, 4= high , 5= very high						
		1	2	3	4	5
1	Planning and budgeting to realize the benefits (allocation of the necessary resources, money, people and time)					
2	Measurement and control					

7. Which channel /mode your company used to transfer AMT?

A) Direct investment B) Joint Ventures C) State import mode D) specify (any other)___________

8. Mode of contract signed

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

1=very low, 2= low, 3= moderate, 4= high , 5= very high

		yes	No	1	2	3	4	5
1	Supply of technical personnel to start up production or to provide technical assistance							
2	Turnkey contract							
3	Product in hand contract							
4	An indicative technical service to operate the technology							

9 . Factors hindering Technology Transfer process

Level of hindering the technology transfer process the following factors:

I. Supplier related factors

5=extreme, 4= high, 3= moderate, 2=somewhat, 1=Not hindering						
		1	2	3	4	5
1	Bureaucratic delays with foreign countries instituted by individuals or groups unknowledgeable about technology transfer					
2	Cultural and social differences from supplier of technology					
3	Distance from the supplier of technology					
4	Lack of communication with the supplier of technology					
5	Lack of trust and goodwill with the supplier of technology					
6	Lack of support (technical) from the supplier of technology					

II. Government related factor

5=extreme, 4= high, 3= moderate, 2=somewhat, 1=Not hindering						
		1	2	3	4	5
1	Government intervention and regulations					
2	Taxation effect					
3	The transmission channels					
4	Lack of appropriate legislation					
5	Frequent changes in current policies and commercial laws					
6	Management have little experience outside their own particular company					
7	Lack of knowledge in the workforce					

III. Buying related factors

Regarding the selection and transfer of AMT to your company state the level of utilization of the Wing buying factors

4= highly utilized, 3=moderately utilized, 2= somewhat utilized, 1=not utilized					
		1	2	3	4
1	Group buying				
2	Break the technological package				

IV. Technology selection related factors

Regarding the selection and transfer of AMT to your company state the level of utilization of the following technology selection related factors.

4= highly utilized, 3=moderately utilized, 2= somewhat utilized, 1=not utilized					
		1	2	3	4
1	Foreclosing options at the design and selection stage due to budgetary constraints etc				
2	Proper information about the supplier and the product				

10. Infrastructure preparation

Improvements on existing activities (operation, transport, inspection and storage). Simplification and planning to achieve a smooth flow through the Manufacturing process

Key: 1=very low, 2= low, 3= moderate, 4= high, 5= very high

		Before						After				
		Low				high		Low			high	
		1	2	3	4	5		1	2	3	4	5
1	Operation activities											
2	Proper information about the supplier and the product											
3	Transport activities											
4	Inspection activities											
5	Storage activities											
6	Procedures covering materials Handling											
7	Procedures covering purchasing											
8	Procedures covering testing											

9	Procedures covering quality Control											
7	Procedures covering inventory Control											
8	Procedures covering design											
9	Procedures covering scheduling											
10	Procedures covering training											
11	Wages and salary systems											
12	Any other (identify)											

11. Pattern work organization (changes)
State the degree of changes in the pattern of work organization (design and manufacturing) as follows
Key: 1=very low, 2= low , 3= moderate, 4= high , 5= very high

		Before						After				
		Low				high		Low				High
		1	2	3	4	5		1	2	3	4	5
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)											
2	Formulation of small autonomous working groups with a greater degree of flexibility and internal control											
3	Closer working relationship between departments (merging of the design and manufacturing activities, closer co-operation between the marketing and manufacturing dept etc) i.e all departments working as fingers on the same hand											
4	Interim targets setting on which the process of implementation shall be evaluated											
5	Changes in the manufacturing Philosophy											

6	Changes in plant layout (relocation of the equipment etc), production scheduling and organizational design											
7	Converged individual roles											
8	Operations manager support											
9	Users support											

12. Workforce preparation

State the level of formulation/existence of the following during the process of AMT implementation

Key: 1=very low, 2= low , 3= moderate, 4= high , 5= very high

		Before						After				
		Low		high				Low		high		
s/n		1	2	3	4	5		1	2	3	4	5
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	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											
8	Fear of redundancy or job loss											
9	Fear of being unable to cope with the new system											
10	They try to minimize the threads to their skills and employment levels											
11	Specialists feel threatened by newcomers trained in later Developments											
12	Preference for continuing familiar operations and responsibilities											
13	Union reservation towards AMT Introduction											

12. Operator's attitudes

State the level of existence of the following:

		Before						After				
		Deskilled				more skilled		Deskilled				more skilled
		1	2	3	4	5		1	2	3	4	5
1	Operators perception as being more skilled or deskilled											

13. Personnel utilization

State the level of personnel utilization during AMT operation

Key: 1=very low, 2= low , 3= moderate, 4= high , 5= very high

		Low				high
		1	2	3	4	5
1	Utilization of existing personnel by providing adequate training					
2	Recruitment of newly appointed trained personnel					

14 Work force preparation

I. Level of technical knowledge of personnel

State level of existence/ achievement of the following:

Key: 1=very low, 2= low, 3= moderate, 4= high, 5= very high

		Low				high
		1	2	3	4	5
1	Existing technical knowledge of your employees to implement AMT					
2	Achievement of technical knowledge of your employees by giving them training before the introduction of AM					
3	Training abroad					
4	In house training with experts from a broad					
5	In house training with experts from local					
6	You have sent them to private institutions in local					
7	You have sent them to Government institutions in local					
8	Other (specify)					

II. Cross training of the employees

Key: 1=very low, 2= low , 3= moderate, 4= high , 5= very high						
		1	2	3	4	5
1	Cross training of the employees on various machines as a result of AMT introduction					

III. Supplier support

State the level of technical support given by the equipment manufacturer

Key: 1=very low, 2= low , 3= moderate, 4= high , 5= very high

		Before						After				
		Low				high		Low				high
		1	2	3	4	5		1	2	3	4	5

1	Support given by the equipment manufacturer											
2	Dependency on the supplier for AMT operation, software system modifications or upgrading.											

IV. Learning process

State the level of learning process followed during AMT implementation as follows:

Key: 1=very low, 2= low , 3= moderate, 4= high , 5= very high						
		1	2	3	4	5
1	Make it work approach					
2	Minimize output approach					
3	Leave well enough approach					
4	Learn and improve approach					

Thank You for your cooperation!

Appendix II: Interview Questionaries'

Interview Development and Administrations

The interview process is part of a larger investigation on the evaluation of the critical success factors in the full implementation of advanced manufacturing technologies in manufacturing environments. The goal is to collect data from experts' views in their field work attempts at advanced manufacturing technologies that ultimately support the findings found in the critical review of literature.

Interview Script Development

The first step in developing the interview script was an extensive review of existing research in an effort to identify variables and factors relating to AMT implementation challenges. Upon completion of this review, it has been determined that four topic headings were of particular importance and should be investigated further through interviews. These topic headings include:

Contextual Factors and Organisational Strategy: this section searches to identify both the internal and external factors and drivers that can influence an organisation's decision to engage in adopting the Advanced Manufacturing technologies.

Implementation Process and Outcomes of AMT: this section searches to identify and outline key guidance features to the implementation process from relevant insights and recommendations given regarding the programme methodology, the appropriate objective-setting mechanisms and metrics evaluation. There may be some overlap with Organisational Readiness section above.

Critical Failure Reasons in Implementing and Transferring AMT: in order to learn from past failures, this section searches to determine which implementation failure reasons occurred most frequently and are more critical as the organisations tried to implement AMT and the strategies to overcome them.

Administration The individuals interviewed were sent an email with a general description of the study, and soliciting their participation. The interviews were semi-structured, divided into key topic headings, with key questions to be asked. The interviews were conducted during July and August 2008. Notes were taken of all interviews and most were recorded on digital audio and then transcribed so a full record could be available.

Interview Questionaries'

Introduction

Thank you for agreeing to take part in this research that I am conducting as a part of my MSc thesis at the Adama science and Technology University. The aim of the research is to identify and evaluate the critical success factors in the full implementation of an Advanced manufacturing Technologies in manufacturing environments. I am especially interested in your perceptions as it relates to instituting the best practices in AMT transfer and implementations process. I am looking at both the content of which implementation problems you have found and the strategies you have applied to overcome these problems. The interview includes questions designed to determine the following:

1. What is driving manufacturers today to implementation advanced manufacturing technologies?
2. What are their business needs and expectations? How are "best-in-class" implementing AMTs?
3. What are their critical success factors for AMT implementations and how are these being measured?

Interview Questionnaires check list

State the level of the following success factors of AMT implementations

*5= very important, 4= important, 3=moderately important, 2= slightly important, 1= not importa*nt

	Strategic Factors	1	2	3	4	5
1	Management commitment and support					
2	Degree of financial support					
3	Need for external consultants					
4	Need to revise policies and procedures					
5	Need to recognize organizational structure					
6	Clear vision and strategy					
7	Prime the corporate culture for change					
8	Appoint a champion for AMT design and implementation					
9	perform a comprehensive environmental analysis					
10	Selection of Vendor based on planned strategy					
11	establish working partnership with supplier					
12	identify the technology which the strategy requires					
13	establish a project team					
	Technological Factors					
14	Degree of Availability of skill					
15	Convenience in using new technologies					
16	Understanding the potential contribution of AMT to current operations					
17	Understanding what new technologies can achieve					
18	degree to which the organization obtained experience with a pilot project prior to implementation,					
19	Configuration of hardware					

	Human Factors					
20	Employee relations and cooperation					
21	Degree of availability of employee education and Training program prior to implementations of AMT					
22	Safety of performing Jobs					
23	Experience level of worker					
24	Active participation from in-house engineer					
25	Educational level of worker					
26	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					
27	Human resource practices(Organizational structure, motivation level					
28	Technological Infrastructure development					

Appendix-III: List of Survey Company

List of Companies

	Name of companies	Address	remark
1	Hibret Manufacturing and Machine building Industry	Addis Ababa	
2	Akaki Basis Metals Industry	Addis Ababa	
3	Metal Fabrication Industry	Addis Ababa	
4	Bishoftu Automotive Industry	Bishoftu	
5	Ethiopian Iron and steel factory	Addis Ababa	
6	Gafat Armament Engineering Industry	Bishoftu	
7	Adama Agricultural Machinery industry	Adama	
8	Adama Steel Factory	Adama	
9	Amio Engineering plc	Addis Ababa	
10	Sintec Ethiopia Plc	Addis Ababa	
11	Tectra Engineeing Plc	Addis Ababa	
12	Nigat Mechanical Engineering Plc	Addis Ababa	
13	Nehemieh Mechanic Engineering Plc	Addis Ababa	
14	Kality Metal product Factory	Addis Ababa	
15	Inter Africa extrusion plc	Addis Ababa	
16	Walia Steel Factory	Alemgena	
17	Dejen Avation Industry	Bishoftu	
18	Homichu Aumation	Ambo	
19	Mame Steel Factory	Addis Ababa	
20	Ethiopian Steel Plc	Addis Ababa	
21	KASMA Engineering plc	Addis Ababa	
22	Shadeka spare part Manufacturing	Bishoftu	
23	Maru Metal Engineering Plc	Addis Ababa	
24	Automotive manufacturing Company of Ethiopia	Addis Ababa	Refused to give information

25	Belay Motors Plc	Adama	
26	Absyinia integrated Steel Plc	Bishoftu	
27	Ethiopian Steel Profiling and Building Materials PLC.	Bishoftu	
28	Hi-Tech Industry	Lega Dadhi	
29	Construction & Engineering Machinery Industry	Addis Ababa	
30	Ethiopian Leaf Spring M.B shared company	Addis Ababa	
31	KG Engineering plc	Addis Ababa	
32	Kolfe Household Utensils Factory Plc	Addis Ababa	
33	United Steel and Metal Industry PLC.		
34	Bethel Engineering Plc.	Addis Ababa	Not assessed
35	Beza Industry plc.	Addis Ababa	Refused
36	Ethiopian Crown Cork and can Manufacturing Industry sc.	Addis Ababa	
37	East steel plc	bishoftu	
38	Zuquala steel Product Factory	Bishoftu	

Source: AACCA and Metal Industry development Institute (MIDI) (screening own)