ADVANCED MANUFACTURING TECHNOLOGY, HUMAN FACTORS, COMPANY SIZE AND STRUCTURE OF ADVANCED MANUFACTURING TECHNOLOGY COMPANIES IN KENYA

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DECLARATION

This thesis is my own original work and has not been presented for an award of any degree in any other University

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DEDICATION

This Thesis is dedicated to my wife Rahab, My sons Manasseh and Ephraim and my daughter Mercy for their endless love, support and encouragements

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ABBREVIATIONS AND ACRONYMS

AGOA	African Growth and Opportunity Act
AGV	Automated guided vehicles
AMH	**Automated Material Handling**
AMT	Advanced Manufacturing Technology
AMTs	Advanced Manufacturing Technologies
AMTI	Advanced Manufacturing Technology index
ANOVA	Analysis of Variance
AsMTs	Assembly and Machining Technologies
ASRS	Automated Storage and Retrieval Systems
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
COMESA	Common Market for Eastern and Southern Africa
CSI	Company Size Index
DNC	Direct Numerical Controlled
EAC	East African Communities
ERP	Enterprise Resource Planning
FDI	**Foreign Direct Investment**
FMC	Flexible Manufacturing Cells
FMS	**Flexible Manufacturing System**
FTE	Full Time Equivalence
GDP	Gross Domestic Product

GT	Group Technology
HFI	Human Factor Index
IMTs	Integrated Manufacturing Technologies
IT	Institutional Theory
JIT	Just-in-Time
KAM	Kenya Association of Manufacturers
MANOVA	Multivariate Analysis of Variance
MHTs	Material Handling Technologies
MNCs	**Multinational Corporations**
MRP	**Material Requirement Planning**
MRP II	Manufacturing Resources Planning
MSME	Micro, Small and Medium Enterprises
NARC	National Rainbow Coalition
NC	Numerical Controlled
NCM	*Numerically Controlled M*achine
OI	Organizational Index
PDETs	Product Design and Engineering Technologies
PPTs	Production Planning Technologies
PT	Process Technology

ABSTRACT

Over the past few decades, manufacturing has evolved from a more labour-intensive set of mechanical processes to a sophisticated set of information based technology processes. With the introduction of various advanced manufacturing technologies (AMTs), more and more functions or jobs are performed by these machines instead of human beings. The major benefits of AMTs include faster machine cycle, greater reliability, reduced inventory, saving on labour, greater flexibility and improved quality. For these benefits to be realized, organizations will require a flexible structure, higher level of skilled labour and higher company's capabilities in managing and planning the manufacturing processes. Thus, this study aimed at investigating the nature of the relationship between AMT adoption and organizational structure and if this relationship depended on human factors and company size. A survey was conducted via questionnaires that were sent to all the 183 identified AMT manufacturing companies in Kenya. 101 companies responded positively but 9 companies were rejected on basis of unreliability. Analysis was therefore based on 92 companies. Data showed that all the 92 companies had a measure of investment in at least 2 and at most 9 of the 14 types of AMTs investigated. In general the results showed that the level of AMT adoption in Kenya was very low with investments levels at a mean of 2.057 and integration levels at a mean of 1.639 in a scale of 1-5. The results obtained indicated that at early stages of AMT adoption there was a clear positive relationship between AMT adoption and organizational structure. The study also showed a linear dependence of this relationship on human factors indicating that human factors positively moderated the relationship. The study revealed that when size was measured in terms of capital invested and workforce number it linearized the relationship between AMT adoption and company size. Thus, company size positively moderated the relationship between AMT adoption and organizational structure. From the study a unifying model which cumulated human factors, company size, AMT adoption and organizational structure showed that the joint effect of the predictor variables was different from their individual effect. The study confirmed that the strength of fit between AMT adoption and organizational structure depends on human factors, thus adding to the body of knowledge on contingency theory. This thesis show that successful investment in AMT can allow companies to succeed and remain competitive in the global market and thus encouraging investment in AMTs is a means by which policy makers can protect the capacity and employment levels within manufacturing sector.

CHAPTER ONE: INTRODUCTION

1.1 Background to the Study

Manufacturing processes, equipment and systems used in design and production have undergone dramatic changes in response to new customer needs, competitive challenges and emerging technologies (Dornfeld, 2011). Complexity, dynamism and uncertainty have become dominant characteristics of recent competition patterns which have resulted in a demand-diversified market with more multifaceted products (Efstathiades *et al*., 1999). Advanced Manufacturing Technology (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, reduced inventory, saving on labor, greater flexibility and improved quality. For these benefits to be realized, organizations would require a flexible structure, higher level of skilled labor and higher company's capabilities in managing and planning the manufacturing processes.

Historically, contingency theory has sought to formulate broad generalizations about the formal structures that are typically associated with or best fit the use of different technologies. The perspective originated with the work of Joan Woodward (1965), who argued that technologies directly determine differences in organizational attributes such as span of control, centralization of authority and the formalization of rules and procedures. The work of other researchers (Thompson, 1967; Perrow, 1970) on technology and structure complements this argument.

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 Kenya are under increasing pressure to adopt AMTs to simply survive the global competition. Exposure to global competition reveals that manufacturing companies in Kenya can no longer rely on simple conversion of raw material into goods, but on process of conversion constantly reinventing itself. Globally products are now made better, faster and cheaper and manufacturing companies in Kenya cannot afford to do otherwise, else they will produce goods that are not globally competitive. Many researchers have studied various determinants of AMTs adoption strategies. Nevertheless, there are a small number of published studies with comprehensive frameworks for developing countries. This study investigated the relationship between the adoption of AMT and organizational structure, the influence of employees' reactions to the new technologies and the company size on this relation in the Kenyan socioeconomic aspect.

1.1.1 Advanced Manufacturing Technology

Over the past few decades, manufacturing has gone from a highly labor-intensive set of mechanical processes to an increasingly sophisticated set of information technology-intensive processes. This trend is expected to continue to accelerate as advances in manufacturing technologies are made. The major strategic benefits that these technologies offer are the increased flexibility and responsiveness, enabling an organization to improve substantially its competitiveness in the marketplace (Efstathiades *et al.,* 1999). Godwin *et al*. (1995) emphasized that these manufacturing technologies have the potential to improve production performance dramatically and create vital business opportunities for companies capable of successfully implementing and managing them. The benefits of advanced techniques can be realized by investing only a few AMTs and as a result companies can gradually integrate these technologies into the production process to get the most benefit from it (Yusuff *et al*., 1997).

Different studies have adopted wider definitions of AMTs. Youssef (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 (Hunt, 1987). 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 Chen (1997) 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 adopted the narrower form of AMT as the use of innovative technology to improve production processes or products and it was this concept that is further explored within this study.

The use of AMTs is often said to achieve higher quality levels, reduce manufacturing cycle times and lower costs since it permits the integration of the full spectrum of production functions and manufacturing processes with computer technologies (Sun *et al*.,2007). With the use of computer technology, AMTs makes the data storing and manipulation possible, that is, data held electronically can be changed and distributed easily and cheaply between technologies. Companies therefore adopt these technologies for a wide range of activities, ranging from scheduling to quality inspection.

Computer aided design (CAD) is extensively used in the design of tools and machinery used in the manufacture of components. It 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). Computer aided design consists of CAD computer, computer peripherals, operations software and user software. Computer-aided manufacturing (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 (Rosnah *et al*., 2003).

The nature of manufacturing companies that deal with a variety of products and the type of processes involved demand the technology advancement in material requirements planning (MRP). Material Requirements Planning is software developed to determine material requirements for manufacturing companies. 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) and capital cost. In this case, MRP II is integrated with other computer files that provide data to the MRP system. An enterprise-wide resource planning tool, which is called Enterprise Resource Planning (ERP), is an information system for identifying and planning the enterprise-wide resources needed to take, make, ship and account for customer orders, which is the extension of MRP and MRPII (Heizer and Render, 2004).

Automated materials handling (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. The AMH can take the form of monorails, computerized conveyors, robots, or automated guided vehicles (AGVs). AGVs use embedded floor wires to direct driverless vehicles to various locations in the plant delivering materials (Chase and Aquilano, 1995). Industrial robots are substitutes for many repetitive manual activities (Chase and Aquilano, 1995). A robot is a reprogrammable mechanical device that may have a few electronic impulses stored on semiconductor chips that will activate motors and switches. Robots are used to perform repetitive tasks such as picking and placing devices, spot welding and painting.

Computer Numerically Controlled machines (CNC) or numerical controlled machines **(**NC**)** are machining tools directly linked to a computer that controls it. The information can either be stored on disk computer (CNC), or in a form of a punched paper tape (NC). This information controls the movements of its tools and the speed of the machine throughout the processing operation. The set of coded instructions and the computers attached to the machine have taken the place of the operator who would previously have controlled the machine by hand. Today CNC controls are mostly applied for turning machines, boring and milling machines, horizontal boring machines and machining centres (Kotha and Swamidass, 2000).

Flexible manufacturing cells (FMC) or systems (FMS)consists of two or more NC/CNC machines which are interconnected by handling devices (such as robots) and transport system. A FMS can work on more than one different work piece simultaneously. It allows varying machining operations on different work pieces to be performed within a given area (Chase and Aquilano, 1995). The NC workstations perform 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 operated under the guidance of a central computer system. The FMC is capable of single path acceptance of raw materials and single path delivery of a finished product, while FMS is capable of multiple paths. When all the above technologies are integrated with system-wide production control, inventory and other systems, full computer-integrated manufacturing (CIM) is achieved. The CIM incorporate CAD, CAM and also the control of FMS. It integrates all elements in the manufacturing process from product design to distribution. It links beyond company departments by integrating computer systems, thus islands of computer application in the companies are integrated (Rosnah *et al*. 2003).

Given the wide range of computer-based technologies that can be found in manufacturing companies, the holistic technology perspective, which covers the whole range of AMTs, is believed to be the research wave of the future in production technology. The focus of this study falls within this approach. Given the wide range of AMTs, this study adopts a similar list as that put forward by Small and Chen (1997). However, the management practice element Just-in-Time (JIT), is excluded as the researcher considered it not a technology, but more of a practice. The list of AMTs investigated in this study, together with their definitions is presented in appendix 4.

1.1.2 Organizational Structure

As manufacturing companies adopt AMTs, organizational structure is affected at operational and administrative levels. Organizational structure is the formal allocation of work roles and the administrative mechanism to control and integrate work activities (Child and Mansfield, 1972). An organizational structure defines how activities such as task allocation, coordination and supervision are directed towards the achievement of organizational aims (Pugh, 1990). The structure of an organization allows the expressed allocation of responsibilities for different functions and processes to different entities. The structure of an organization will determine the modes in which it operates and performs. From an organizational structure a co-ordination mechanism between the various players in a given company is created (Mintzberg, 1979).

The models of organizational design are mechanistic or organic. A mechanistic structure is characterized by hierarchical functions, vertical communication, rigid job description and centralized decision making (Burns & Stalker, 1961; Mintzberg, 1979). Mechanistic organization is comparatively simpler and easy to organize, but difficult to cope with rapid change. An organic structure is characterized by flexible job description, decentralized decision-making, minimum levels, temporary work groups and lateral communication (Mintzberg, 1979). Organic models are comparatively more complex and harder to form but are highly adaptable, flexible and more suitable where external environment is rapidly changing and is unpredictable. Burns and Stalker (1961) state that organizational structure should be related to the environment in which the organization operates. Where the environment is very stable and predictable, a mechanistic structure is suitable and where the environment is one of change and unpredictable an organic structure is more preferable.

The adoption of new manufacturing technologies by companies warrants a review of organizational structure. In the 21st century, organizational theorists such as Lim *et al*. (2010) have proposed that organizational structure development should be dependent on the behavior of the management and the workers as constrained by the power distribution between them and should be influenced by their environment. However, theorists such as Lawrence and Lorsch (1969) found that companies operating in less stable environments operated more effectively if the organizational structure was less formalized, more decentralized and more reliant on mutual adjustment between various departments in the company and the outcome.

Ideally, organizational structure should be shaped and implemented for the primary purpose of facilitating the achievement of organizational goals in an efficient manner. The Structure of an organization, therefore, entails the degree and type of horizontal differentiation, vertical differentiation, mechanisms of coordination and control, formalization and centralization of power. Characteristics of organizational structure are explained in terms of division of task, job description, decision-making, communication, control system, coordination and span of control at supervisory level, vertical levels and ratio of white-collar to blue-collar employees.

Given the wide range of structure orientations the concerns in this study is with the basic specializations. This study adopts a similar list as that put forward by Harvey (1968) that includes sub-units, levels of authority, span of control, role programming, communication programming and output programming. Sub-unit is a specialized functional area within the organization headed by a specialized manager. A sub-unit, then, is a group of individuals within the organization charged with a formally defined set of responsibilities directed toward the attainment of a basic but circumscribed goal of the organization. A sub-unit could be a department such as production, research and development, maintenance or any differentiation of tasks by small groups and individuals (Harvey,1968).

Levels of authority within organizations is a formally delimited zone of responsibility along the organizational hierarchy bounded, at the lower limits, by delegation of authority to a lower level and, at the upper limits, by the necessity of reporting to a higher level in the organization. Span of control is the ratio of managers and supervisors to total personnel. A manager or supervisor is an incumbent of the organization charged with the responsibility of overseeing and co-coordinating the work of others in the organization (Harvey,1968).

Programs are defined as the mechanisms or rules in terms of which an attempt is made to give direction to organizational activity. Role programming is the variable extent to which the formalization of duties and responsibilities as in sets of job specifications is detailed or spelled out. Communication programming is the variable extent to which the formal specification of the structure, content, and timing of communication within the organization is detailed or spelled out. Output programming is the formal delineation of steps through which raw materials pass in the course of becoming the organization's output (Harvey,1968). This conceptualization of program specification is intended as a more precise equivalent to the distinction between organic and mechanistic organization derived from Burns (1961) and subsequently used by Woodward (1965).

1.1.3 **Human Factors**

Once an organization structure exists changing it will need to be done carefully so as not to alienate or frustrate key players, but to efficiently guide the behavior of individuals and groups so that they would be productive, efficient, flexible and motivated. Human factors, herein, refer to blue collar employee reactions that arise in most periods of technological and structural change. The current trend in sophisticated automation have the power to democratize manufacturing industries, starting at the lower end of the value chain, but increasingly moving toward complex decision-making roles. Contract manufacturing companies that specialize in mass production are using robots to push back against rising wages and to increase competitiveness (Dornfeld, 2011). Psychologically, unprepared employees will naturally resist new technology for reasons such as uncertainty, phobia, alienation, technological stress, job security, fear of loss of role identity, de-skilling among others (Ghani, 2002).

Successful adoption of AMTs does not only depend on whether the employed technology is in a state-of-the-art or not but also requires employee support. Cascio (2010) stated that the behaviors, attitudes, and qualities of the employees can add an edge to the competitiveness of an organization and make its advantages more distinctive. This approach can improve relational requirements and skills of human capital of the company, which is supposed to exploit the new technologies (Noe *et al*., 2008).Several studies suggest that technology implementation is more likely to be successful when the technology, organization structure and employee issues have been designed to complement and integrate with each other (Ghani, 2002; Rosnal *et al*., 2003).

Advanced Manufacturing Technologies requires workers to be equipped with a variety of new skills at various levels. The operating and technical people responsible for running, maintaining, and organizing the new technologies require new skills, attitudes, system procedures and social structures (Ghani, 2002). Higher knowledge intensity is required by workers in automation, even low level jobs will require more responsibility for results, more intellectual mastery and abstract skills and more carefully nurtured interdependence (Cagliano, 2000). The increase in task complexity linked to integrated manufacturing requires employees to expand their scope of attention and process significantly more information. These changes are necessary as the competitive advantage of AMTs hinges on the creation of a flexible, multi-skilled, knowledgeable workforce.

The human factors in this study included employees' work attitude, levels of psychological barriers and employee empowerment. Work attitude is concerned with job-related perspectives such as job satisfaction, job involvement and organizational commitment (Waldeck, 2007). Job satisfaction is simply how content an individual is with his or her job, job involvement is the psychological and emotional extent to which employees participate in their work and organizational commitment is the individual's emotional attachment to the organization. The psychological barriers is the anxiety and emotional fear of new technology caused by anxiety and tension associated with technological change (Ghani, 2002). Employee empowerment is the degree of autonomy and responsibility given to employees for decision-making regarding their specific organizational tasks(Coates, 1983)

1.1.4 Company Size

The skill demand of AMTs is a formidable challenge for smaller manufacturing companies to acquire which leads to reluctance in smaller companies to invest in AMTs (Love *et al*., 2001).Company size plays an important role in determining an organisation's ability to adopt AMTs. The larger the company, the greater the need for increased complexity and divisions to achieve synergy. Larger companies with a wider range of operational initiatives require careful structural considerations to achieve optimization. For companies in the manufacturing sector, the definition of size considers the workforce number in plant and machinery and the capital invested in the company (Rosnah *et al*., 2003).

According to Mirmahdi, (2012) smaller companies tend to use AMTs as a source to acquire competitive advantages, while larger companies tend to take it as a way to simplify company operation and lower costs. The skill demand of AMT is a formidable challenge for smaller manufacturing companies to acquire and retain. The strongest determinants of the level of AMT adoption are by far the technical skills of blue-collar workers followed by the influence of customers and vendors. Mansfield (1993) found that larger companies tend to use Flexible Manufacturing System (FMS) in order to make manufacturing easier, more accurate, flexible, sophisticated, faster and cheaper. Meredith (1987) noted that large companies are able to afford the often extreme expense of these computerized manufacturing technologies and the cost of the failure should the investment fail. Large companies also are likely to have the skills and human resources it takes to understand, implement, and manage such technologies (Noe *et al*., 2008).

The implementation of AMT in smaller companies is necessary in order to face the challenges of globalization and to ensure their future survival. Rosnah *et al*. (2003) reported that the level of AMT implemented in smaller companies are low and maybe due to the lack of understanding of the ways in which AMT can help them. It has been noted by researchers that company size is an enabler variable in the use of AMTs and that it is common for smaller companies to lag behind larger companies in implementing the new technologies (Ettlie, 1990, Voss, 1988; Scott and Davis; 2007). The obvious fragile financial resource of smaller companies has been stated as the main obstacle which leads to reluctance to invest in AMTs (Love *et al*., 2001). Likewise, Pearson and Grandon (2004) found that availability of monetary assets is indispensably significant to managers and owners, and such subjects often determine the fate of AMT implementation, particularly in smaller manufacturing companies.

In this study the definition of size took into account the workforce number in plant and machinery and the capital invested in the company. The workforce number considered the number of full-time equivalent employees where one part-time equals to half a full-time employee. The logic behind this consideration is that as the trend in sophisticated automation increases many roles are played by these machines and thus decreasing the workforce number as the capital invested is increased (Rosnah *et al*., 2003).

In terms of workforce numbers and according to Kenya (2007), companies employing 10 workers or less are termed as micro companies, 10 to 99 workers as small companies, 100 to 199 workers as medium companies and 200 and above workers as large companies. In terms of capital invested according to World Bank (2007) companies having a capital invested of less than Kshs. 500,000 are termed as micro companies, capital investment of Kshs. 500,000 to Kshs. 5M as small companies, capital investment of Kshs. 5M to Kshs. 800M as medium companies and capital investment of over 800M as large companies. It is however unlikely those micro-companies will invest in AMTs and so the attention mainly focused on the continuum small to large companies. The term smaller and larger company purely describes the side of continuum of a company.

1.1.5 Advanced Manufacturing Technology Companies in Kenya

Although Kenya's manufacturing sector enjoyed relatively rapid growth in the early post-independence years (1970s) (World Bank, 2007), it has generally been sluggish without dramatic shifts in performance. Performance of manufacturing sector in Kenya has been shaped by some notable developments. The first of these is the carry forward of IS policies that were implemented during colonial rule and adopted by the independent government. The IS policy served to ensure the availability of basic products in the domestic market. However, such products were overpriced and the policy distorted the evolution of industry by encouraging excess capacity and generalized inefficiency that undermined the ability of Kenyan products to penetrate external markets (World Bank, 2007). A change came when the government eventually recognized the need to shift focus toward export promotion in the mid-1980s. However, immediate efforts to encourage exports were overshadowed by macroeconomic challenges and externally driven SAPs that were implemented half-heartedly and opportunistically.

With globalization and free trade agreements, the manufacturing companies in Kenya are under increasing pressure to adopt AMTs to remain competitive. Globally products are now made better, faster and cheaper and manufacturing companies in Kenya cannot afford to do otherwise, else they will produce goods that are not globally competitive. Implementation of AMTs requires manufacturing companies to adopt new ways of thinking and doing work (Ghani, 2002). Adoption of AMTs in Kenya is expected to receive challenges in achieving its full potential due to the current companies' capacity to assimilate technology.

A distinctive feature of the AMT sector in Kenya is the coexistence of the modern sector alongside a rapidly expanding informal sector. While the former comprises mainly of medium and large companies, the informal sector consists of semi-organized, unregulated, small-scale companies that use low level technologies and employ few people (KAM, 2014). Even though large proportion of industrial output is directed towards satisfying basic needs, Kenya is currently the most important source of FDI in Uganda and Rwanda. The region, particularly Uganda, is the most important export destination for Kenyan products (Kenya, 2007).

The AMT companies in Kenya are segregated into several mutually exclusive sub-sectors. While data on these sub-sectors is inadequate, medium and large-scale companies form part of the formal economy and are characterized by some degree of specialization. These companies produce discrete products, covering the whole range of the industry. The sub-sectors that have been acknowledged to employ AMTs includes Food, beverage and animal feeds industry, Construction and material industry, Chemical and Pharmaceuticals industry, Plastics, packaging and stationery industry, Power generation and electrical and electronic industry, Fabricated metals industry, Textiles, apparel, leather and footwear industry and Automobile and parts industry. This is deemed representative of the current AMT manufacturing companies in Kenya (KAM, 2014). Thus, the study of AMT adoption in manufacturing companies in Kenya is timely in order to examine their current practice in view of their technological adaptability. Indeed it is hoped that the ideas and suggestions based on the findings from this study can be made in order to help enhance the effectiveness of manufacturing companies in Kenya and thus maximize their contribution to the Kenyan economy.

1.2 The Research Problem

The underlying premise of this study is the notion that the better the fit between an organizational structure and AMT the superior the performance. The study however is guided by the contingency theory, which asserts that there is no universal right or wrong answer to a given situation. A fundamental assumption of the study is that companies strive to perform at their best, which in this study is taken to mean that companies aim to strengthen the relation between organizational structure and AMT adoption. Thus, the research proposition is that organizational structure will seek to configure AMT adoption in such a way as to maximize performance. Alignment or lack thereof, between organizational structure and AMT adoption is hypothesized as a determinant of manufacturing performance. It can also be argued that the fit between AMT adoption and organizational structure of a company depends upon employees' reactions to the new technology and the size of the company. As such company size and human factors have the potential to significantly influence the overall relation between organizational structure and AMT adoption.

With globalization and free trade agreements, manufacturing companies in Kenya are under increasing pressure to adopt AMTs to remain competitive. However, global competition stresses on the company's ability to innovate, to capture global levels of manufacturing efficiency (Rockart and Short, 1989). For manufacturing companies in Kenya to survive in the face of global competition AMT is required to assume the increasingly important role in all aspects of production. The globalization of markets, growing inter-linkages of economies and increased interdependence amongst players are changing the conditions of competitiveness (Marmadi, 2012). Traditionally, competition was static and success or failure hinged on production factors. Modern competition is dynamic where new technology, new products and new management concepts are constantly emerging.

Rahman and Bennett (2009) have contended that adopting AMTs, manufacturing companies have to redesign their organizational structures and organizational processes. According to Song *et al*. (2007), the structure of a company plays a crucial role in the implementation process of AMT adoption. Designing correct organizational structure would help a company to grasp the advantages of successful implementation of AMTs (Sun *et al*., 2007). Traditional structure may not fit the new AMTs and the emerging internal environment, because such structure is based on hierarchical management and specialization of task. Boyer *et al*. (1996) indicated that the several layers of decision making authorities, followed by organization's hierarchical structure, frequently create impediments to AMT application. Establishing a flat structure with minimum layers of authority enables a manufacturing company to integrate AMTs effectively.

Successful implementation of AMT will require companies to have a workforce with higher level of skills, a flexible organizational structure and appropriate culture for managing, training and planning of the manufacturing processes. A change in manufacturing technology will influence change in the organizational structure at operational and administrative levels (Ghani, 2002). This structural change involves redefining jobs, changing the reporting relationships and even eliminating some units. Consequently jobs/tasks have to be redesigned. A structure that does not fit AMT can easily cause behavioral problems and the effectiveness of the decision-making system. A structural mechanism that is not congruent with technology in use will impair business performance and may even cause the company to fail.

Manufacturing companies in Kenya face many uncertainties when they venture into global market since most technological development happens in developed countries. To reduce manufacturing costs, improve quality and respond to the changing needs of customers, many manufacturing companies in Kenya have introduced AMTs. However, many of these AMTs have failed to meet the expectations of their adopters and increasing signs of operational and administrative difficulties have emerged. A good example is the tea picking automated machine in Kericho Tea Factory that was rejected by the union even after management had invested heavily in the equipment. These difficulties may be attributed to fear of change that has led to low technology uptake and structural mechanisms that are not congruent with the adopted manufacturing technology. Applying and adopting AMTs indicates therefore that there are broader managerial issues that have to be considered. Management of companies that are considering the adoption of AMT ought to recognize, understand and address these issues in order to overcome or circumvent the problems of previous installations.

Though several attempts have been made to find and analyze the strategic significance of technology and its influence on organizational structure (Sun *et al*., 2007, Ghani *et al*., 2002; Blau *et al*., 1976; Woodward, 1965), there is a lack of a unifying model which integrate human factors and company size in this relationship. It is also theorized that when the correct organizational structure is in place, a company will be more successful with the AMTs (Hajipour *et al*., 2011; Li and Xie, 2012). However no local studies have been done to investigate the organizational structure changes consequent to implementation of AMTs. This study aimed to empirically investigate the fit in the relationship between AMT adoption and organizational structure in Kenyan socioeconomic aspect and also to investigate the effects of human factors and company size in the relationship between AMT adoption and organizational structure. The inquiry may be stated as: to what extent do AMTs influence Organizational Structure and to what extent do company size and human factors affect the relationship between AMT adoption and organizational structure of manufacturing companies in Kenya?

1.3 Research Objectives

The broad objective of this study was to establish the influence of human factors and company size on the relationship between AMT adoption and organizational structure in manufacturing companies in Kenya. The specific objectives were:

i. Establish the relationship between AMTs and Organizational Structure.
ii. Determine the effect of Human Factors on the relationship between AMT adoption and organizational Structure.
iii. Determine the effect of Company size on the relationship between AMT adoption and organizational Structure.
iv. Establish whether the joint effect of AMT, Human Factors and Company size on Organizational Structure is different from the individual effects.

1.4 Value of the Study

The value of this study is threefold. First, the study hoped to contribute to the wider body of knowledge in organizational theory and in production/manufacturing management on how to determine the form of AMT to be invested in and how such AMT would influence the organizational structure of the company. Using a contingency theory approach, this study emphasizes the internal consistency between AMT adoption and organizational structure. Thus this study adds to the existing conceptual and empirical work on the relationship between AMT adoption and organizational structure. On an empirical front, the study provides a statistical justification of the appropriateness of human factors and company size in the relationship between AMT adoption and organizational structure and hence contributes to the contingency theory in the organizational theory literature.

Secondly, the study provides an analytical approach to practitioners in manufacturing companies in how to determine the form of AMT to be invested in and how such AMT can be integrated into the company's organizational structure in order to maximize manufacturing performance. By identifying the types of companies' organizational structure during AMT adoption, along with the types of AMT they invested in, and how such AMT was integrated, the study sheds light on exactly what constitutes a good AMT adoption and organizational structure fit. The study therefore provides a logical, practical and effective way to selecting organizational structural adjustments during AMT adoption. It also paves the way for a framework with the right mix of AMTs adoption levels, human factors, company size and organizational structure in a developing country's socioeconomic aspect. The framework could direct managers and AMT adopters in improving congruency between these variables in implementing business strategies for better performance.

Thirdly, data from the study provides basic information in formulation of AMT management policies particularly with reference to AMT adoption. The Policies made could determine parameters for implementation of AMTs and setting standards for organizational structural changes. The study also highlights the importance of the integration of AMT; investment in AMT alone is no guarantee of success. Thus it could be important to policy makers to channel funding initiatives aimed at increasing not only the overall investment in AMTs but also in integrating the technology. Government agencies can thus enhance the importance of the role of the manufacturing sector in the Kenyan economy by actively encouraging companies to switch to the more high-technology enterprises. Further, as this sector is a good example of industries arising out of substantive advancement in the state of production technology, the information generated could benefit other similar sectors operating in an environment of blurred industrial boundaries.

CHAPTER TWO: LITERATURE REVIEW

2.1 Introduction

Having discussed the rationale for, and the background to this study in Chapter One, this chapter provides a comprehensive review of the extant literature of Advanced Manufacturing Technology (AMT), organizational structure and the fit between the two. The review concentrates on the literature of the link between AMT adoption and organizational structure and the influence of human factors and company size to this relationship. The literature review also provides a means of setting the boundaries and scope of the current research. This section is necessary in order to establish the scope of previous research as well as identify the shortcomings and gaps in the current literature that this research sought to address. A framework is then proposed for incorporating the role of human and company size in the relation between AMT adoption and organizational structure. This framework poses the hypotheses arising out of the reviewed literature.

2.2 Theoretical Foundation of the Study

This study was intended to investigate the link between the AMTs adoption and organizational structure, and the implication of the fit between them. Literature suggests that lack of alignment between AMT adoption and organizational structure is the major barrier to exploiting the full benefits of AMTs (Hill, 1994; Small and Yasin, 1997; Cil and Evren, 1998; Kotha and Swamidass, 2002). Thus, the main focus of the study was the link between these two variables. Literature on both organizational theory and production management reveals that the contingency theory of fit has always been the underlying theory when studying alignment between the two variables. Another theory that informed the study was the Institutional theory (IT) which emphasizes that modern organizations depend on their environments. These theories are reviewed below.

2.2.1 Contingency Theory

Several contingency approaches to management were developed concurrently in the late 1960s. Contingency approach to management assumes that there are no universal management principles because organizations, people and situations vary and change over time (Small and Yasin, 1997). The management principles to be applied depend on complex variety of critical environmental and internal contingencies. One of the major important contingencies is technology. Historically contingency theory has sought to formulate broad generalizations about the formal structures that are typically associated with or best fit the use of different technologies.

The perspective originated with the work of Woodward (1965), who argued that technologies directly determine differences in such organizational attributes such as span of control, centralization of authority and the formalization of rules and procedures. This has provided an extensive and supportive theoretical literature. According to Selto *et al*. (1995) there is no other theory which is directly concerned such fit except the contingency theory. In describing contingency theory Scott and Davis (2007) stated that the best way to organize an organization depends on the nature of the environment to which the organization must relate. Morgan (2007) stated that organizations are open systems that need careful management to satisfy and balance internal needs and to adapt to environmental circumstances.

The central theme of contingency theory is that all components of an organization must 'fit' well with each other or the organization will not perform optimally (Kimberly, 1986; Hill, 1994). The theory assumes that an organization's ability to achieve its goals is a function of the congruence between selected organizational components and its environment (Perrow, 1970). The lack of fit in organizational elements cause diminished performance (Perrow, 1970; Van de Ven and Drazin, 1985; Egelhoff, 1982; Joshi *et aI*., 2003). Van de Ven and Drazin (1985) for instance, contend that each organization has its own optimal configuration or best fit of context, structure and control. Deviation from that ideal fit (which is misfit) would cause lack of coordination, miscommunication, misunderstanding, poor morale and poor motivation, which, in turn, would lead to poor performance.

Many studies in the production management field have been carried out using this contingency approach in study of the relationship between technology implementation and organizational elements (Lai and Guynes, 1997; Germain, 1996; Thong and Yap, 1995; Schroder and Sohal, 1999). Despite criticism, the intuition behind the theory continues to be appealing. Besides, it offers plentiful opportunities for measurement and observations, and explicit linking of organizational characteristics and AMT adoption.

In-spite of the various studies, contingency approach has received only partial acknowledgement by scholars as a unified theory of management because it suffers from some limitations. First the suggestion of the approach is very simple, that is, managers should adapt their actions to the needs of the situation. However, when put into practice, this becomes very complex. Determination of situation in which managerial action is to be taken involves analysis of a large number of variables with multifarious dimensions (Van de Ven and Drazin, 1985). Second, contingency approach presents problems in testing the percepts of the theory because of the involvement of too many factors (Joshi *et aI*., 2003). Thirdly, contingency approach is basically reactive in nature, therefore suggesting that managers are not proactive to manage the environment in such a way that they avoid the undesirable aspects of environment.

To address these limitations, this study consequently followed the procedure of pentagonizing each dimension in the variable, attempting wherever possible to employ equal intervals. In terms of the pentagonized operational measures, each dimension had the value span of 1-5. The lowest score in a dimension was 1 and the highest score was 5. The hypothesis resting behind the scale is that a company which is high on any given dimension will also be high on all other dimensions. Index score for each variable was the calculated average in terms of the average score for each dimension.

2.2.2 Institutional Theory

Institutional theory is a widely accepted theoretical posture that emphasizes rational myths, isomorphism and legitimacy. The theory suggests that organizational structures and processes become institutionalized over time and these have an effect on performance. It acknowledges the importance of economic and social factors that shape the systems and structures of organizations (North, 1990). These factors would include economic, social and politics that constitute a structure of a particular environment that affect organizational competitiveness.

This theory looks at environmental factors experienced by an organization such as external or societal norms, rules and requirements that an organization must conform to, in order to receive legitimacy and support. It considers the processes by which structures, including rules, norms and routines, become established as authoritative guidelines for social behavior (Scott, 2004).

Scott (1995) asserts that Institutions are social structures that have attained a high degree of resilience. They are composed of cultural-cognitive, normative and regulative elements that, together with associated activities and resources, provide stability and meaning to social life. Institutions are transmitted by various types of carriers, including symbolic systems, relational systems, routines and artifacts. Institutions operate at different levels of jurisdiction from the world system to localized interpersonal relationships.

Institutional theory has a number of significant conceptual and methodological problems. The most important of these problems is the generally static nature of institutional explanations. Also, there is a nagging problem of the difficulties in measuring institutional variables other than simplistic and nominal categories. There is substantial evidence that firms in different types of economies react differently to similar challenges (Knetter, 1989). For instance, Multinational Corporations (MNCs) operating in different countries, with varying institutional environments, will face diverse pressures. Some of those pressures are from host country and others from home institutional environment. These factors can exert fundamental influence on competitive strategy (Martinsons, 1993; Porter, 1990) and human resource management (HRM) practices.

In order to address these limitations all dimensions, in a variable, were treated as independent and of equal weight. With regard to the first matter, attempts have been made in chapter one to illustrate the independence of these dimensions in the course of the earlier discussion and definition of them. With regard to the second matter, the absence of weighting, there is no available evidence to suggest that any one of the dimensions carries more weight than any other. In the absence of such evidence it was found not necessary to prejudge the matter but instead wait to see if the data would suggest reformulation of the suggested scale. To address the difficulties in measuring institutional variables other than simplistic and nominal, manufacturing related technology, was taken based on the advice that one should take on a more homogeneous set of applications and consider them against a relatively well-mapped-out territory. This study focused on the organizational structure of companies during AMT adoption and therefore the concept of organization served as a key factor in determining if an organization or company reaches its goals and objective while exemplifying their mission.

2.3 Advanced Manufacturing Technology and Organizational Structure

Woodward (1965) was the first researcher to empirically demonstrate the interaction of manufacturing technology with organizational structure to influence performance. She found that a linear relationship existed between manufacturing technology and structural measures such as the number of hierarchical levels, span of control and number of sub-units. Blau *et al*. (1976) investigated how manufacturing technology influenced organizational structure and reported that a linear relationship existed. The Okayama study (Marsh & Mannari, 1981) found out that technology affected all the aspects of structure–labour inputs, complexity, span of control, costs and wages.

Kim and Utterback (1983), in their study based on cross-sectional analysis, revealed that influence of technology on structure in a developing country was different from that in a developed country. Madique and Hayes (1984) in their studies of AMT companies reported that in specialization along the hierarchy such as rank and seniority are often ignored or eliminated. Nemetz and Fry (1988) identified the dimensions of AMT companies as organic with a narrow span of control, few vertical levels, high integration, decentralized decision-making, horizontal communication and adoptive behaviour. David *et al*. (1989) examined the linkages between technology and structural fit and found that the best fit between them was responsible for better performance.

Parthasarthy and Sethi (1992) asserted that superior performance could occur when there is a fit between manufacturing technology and the structure of organization. Ghani (2002) found that AMT change in an existing organizational structure examined in their study had no effect on the organizational structure that was mostly reactive in nature (less proactive), but had significant effect on the structure that was proactive. As the organizational structure of a company is evolutionary, rather than being revolutionary, in many industrial companies, the match between structure and technology takes several years after implementation (Hajipour *et al*., 2011). Li and Xie, (2012) revealed that manufacturing companies which were successful in AMT implementation had opted for a more flexible-oriented organizational structure that might have comforted the AMT implementation through creating an atmosphere of encouragement and trust.

While these studies are optimistic about the influence of manufacturing technology on structure, there are studies to indicate that there is no substantial relationship between manufacturing technology and structure (Reimann, 1980;Amoako-Gyampah and Acquuah, 2008;Olhager and Prajogo, 2012). Considering the enormous studies, which consistently focus and reiterate that manufacturing technology has an influence over structure, this researcher followed the optimistic approach of fit between manufacturing technology and organizational structure for superior performance.

For the current study, the continuum from technical complexity to technical simplicity was measured by the level of AMT investment and integration, where 1 indicated technical simplicity and 5 indicated technical complexity. The study investigated 14 types of AMTs which are commonly used by advanced manufacturing companies. In the case of organizational structure the position of the structure on 1 - 5 polar point was measured in terms of the number of sub-units, levels of authorities, span of control, role programming, output programming and communication programming. The determinants above were such that 5 indicated the structure with the highest dimension and 1 indicated the structure with the least dimension.

2.4 Advanced Manufacturing Technology, Human Factors and Organizational Structure

Historically, manufacturing has gone from a highly labor-intensive set of mechanical processes to an increasingly sophisticated set of information technology-intensive processes. Sophisticated automation and robotics have the power to democratize manufacturing industries, starting at the lower end of the value chain, but increasingly moving toward complex decision-making roles. With the current technological trend in the industry, it is expected that the future manufacturing organization will be information based and will be composed largely of operation specialists and little middle management. The influence of human factors on AMT-structure relationship is therefore paramount.

Argote, Goodman and Schkade (1983) stated that fear of work overload caused by reduction of cycle time is a factor of concern among blue collar workers. Davis (1994) found that new technology creates phobia among operators and the anxiety towards the new technology lead to emotional fear among AMT workers. Gupta *et al* (1997), however, indicated that only decentralization with fewer rules and more employee involvement were positively related to manufacturing technology whereas formalization and mechanistic structure interacted negatively with AMT. The results of this study emphasize that irrespective of the manufacturing technology type, a company needs to be as least mechanistic as possible to be effective.

In examining the relationship between structure, employee and AMT, Ghani (2002) found that, at high proactive level, the mechanistic structure of AMT plants had been found to change into an organic structure. Waldeck (2007) found that providing workers with opportunities to improve their intrinsic motivation and job satisfaction by means of employee-empowerment practices aligned the goals of employees' with the company's. Advanced Manufacturing Technology implementation requires highly skillful workers who should be provided with more autonomy facing issues such as AMT plans and problem solving (Waldeck, 2007). Moreover, works in AMT companies should become more adept with respect to skills, responsibility, knowledge and attitudes. Consequently, catering to employees` job satisfaction and intrinsic motivations by creating opportunities of employee involvement can be considered as a viable method to affiliate the goals of human elements with the company's which is adopting AMTs (Boothby *et al*., 2010).

The current study looked at human factors using five dimensions identified in the study; job satisfaction, job involvement, organizational commitment, psychological barriers and employee empowerment. The score measure for each dimension was done on a Likert scale of 1-5, measuring the extent of worker feelings, where 1 indicated not at all and 5 indicates to a great extent. Human factor index was calculated as the average score for each unit of analysis.

2.5 Advanced Manufacturing Technology, Company size and Organizational Structure

The benefits of advanced techniques can be realized equally by applying only a few components of AMTs and as a result firms can gradually invest in these technologies to get the most benefit from it (Yusuff *et al*., 1997). Larger companies often own sufficient business, human and technology resources to invest in AMTs (Xu *et al*., 2004). However, larger companies also have a great disadvantage in the form of structural inertia, which may exert a negative impact on AMT adoption. Smaller companies with flexible structures can make rapid adjustment to dynamic environment and survive the fierce competition. A company's position on the mechanistic-organic continuum can be influenced by the size of the organization. The higher the size, the more mechanistic is the structure (Dornfeld, 2011). A lack of an organic structure is detrimental to the success of AMT implementation. An organic structure allows employees to have broader defined jobs, enhanced communication and decentralized decision making. Decentralization of authority in organic organizations increases the total pool of available ideas, keeps decisions close to the source of variation or need, improves the chance that compatible technologies will be proposed and adopted, and increases the acceptance and commitment to change (Boothby *et al*., 2010).

Fry (1982) reported a mild positive relation between size and structure. Pearson and Grandon (2004) found that availability of monetary assets is indispensably significant to managers and owners, and such subjects often determine the fate of AMT implementation. However Simpson and Doherty (2004) showed that it is unlikely that the paucity of monetary fund hinders AMT acceptance in smaller companies. Spanos and Voudouris (2009) found out that the degree of fit between an organization's competitive priorities and its key decisions regarding its investments depends on the size of a company. Rahman and Bennett (2009) found that smaller companies have limited rapport with the suppliers of technology because of fragile financial resources, which leads to reluctance to invest in AMTs.

Although some authors argue that the company age has a significant role in the assimilation of technology (Simpson and Doherty, 2004). Li *et al*. (2010) reveals that there is no significant association between these two variables. However both agree that the size of a company do influence the company`s technological adoption strategy. Edwards-Schachter *et al*. (2011) found that smaller companies do not have efficient funding instruments for technology adoption as do larger companies. Smaller companies tend to employ technology to gain competitiveness, whereas larger companies regard AMT as a source to lower manufacturing costs (Li and Xie, 2012).

Company size measure for current study was determined by the workforce number and capital invested. The score measure for each dimension was done on a Likert scale of 1-5 with one indicating small and 5 indicating large. The instrument was designed in such a manner as to show a score of 5 as the largest indicator towards large company size and 1 as the smallest indicator towards small size.

2.6 Summary of Research Gaps

While organizational theorists such Woodward, 1965, Perrow, 1970, Blau *et al*., 1976, Marsh & Mannari, 1981, Ghani, 2002, Waldeck 2007, Hajipour *et al*., 2011, Li and Xie, 2012 have been optimistic about the influence of manufacturing technology on structure, there are studies to indicate that there is no substantial relationship between manufacturing technology and structure (Reimann, 1980; Amoako-Gyampah & Acquuah, 2008; Olhager & Prajogo, 2012). Considering the significant amount of available studies, which consistently focus and reiterate that manufacturing technology has an influence over structure, this study first and foremost explored the AMT adoption and organizational structure using the current data to ascertain that there was a substantial relationship.

As earlier indicated, the study was guided by the contingency theory of approach to management and assumes that there are no universal management principles because organizations, people and situations vary and change over time. The management principles to be applied depend on complex variety of critical environmental and internal contingencies. Organizational theory identifies technology, strategy, environment and size as the main contingencies to structure (Scott & Davis, 2007 and Morgan, 2007). It can also be argued that the fit of AMT adoption and organizational structure of a company depends upon employees reactions to the new technology. As such, human factors have the potential to significantly influence the overall relation between organizational structure and AMT adoption. Human factors therefore are an important contingency to structure and it is this gap that is further explored in the study.

It is also theorized that when the correct organizational structure is in place, a company will be more successful with the AMTs (Hajipour *et al*., 2011; Li & Xie, 2012). Though several attempts have been made to find and analyze the strategic significance of AMT and its influence on organizational structure (Sun *et al*., 2007, Ghani *et al*., 2002; Blau *et al*., 1976; Woodward, 1965), there is a lack of a unifying model which accumulates human factors and company size in this relationship. This study explored the elasticity of this model.

With globalization and free trade agreements, manufacturing companies in Kenya are under increasing pressure to adopt AMTs to remain competitive. Even though manufacturing technology and organizational structure have been studied across the globe, current literature showed no local studies. Kim and Utterback (1983) revealed that influence of manufacturing technology on structure in a developing country was different from a developed country. The interaction of these variables in a developing country's socioeconomic aspect needed a systematic empirical investigation to ascertain the nature of fit. This study therefore explored this gap further by focusing on a cross sectional study in Kenya. A chronological summary of the research gaps to be explored in the study is presented in Table1 below.

Table 1: Chronological summary of the research gaps

Study	Focus	Methodology	Findings	Gaps	Current study
Woodward (1965)	100 manufacturing firms in the South East Essex area of England.	A study was conducted using survey questionnaire	that a linear relationship exists between technology and structural measures	• Study was limited to developed country • study was for general manufacturing technology • was done 50 yrs ago	• Will focus on developing country • Will focus on AMTs. • Seeks current data
Blau et al (1976)	how manufacturing technology influences organizational structure	A study was conducted using survey interviews	A linear relationship existed	• Study was limited to manufacturing technology and structure	• Will focus on AMT, structure, Human factors and size
Kim and Utterback (1983),	Evolutionary pattern of relationships among technology, structure, environment and other contextual variables in 31 manufacturing organizations in a developing country.	A study was conducted using survey questionnaire	That younger firms exhibit more mechanistic structure, a higher degree in operations technology adaptability, a lower degree in indigenous technical capability, a lower degree of innovation than older firms.	•Study was limited to 31 manufacturing firms •Study focused on structure, technology and age.	• Study seeks to have a bigger sample • Focuses on the implications of human and firm size on AMT-structure relationship
Nemetz and Fry (1988)	Implications of technology for strategy formation and organization design.	A study was conducted using survey questionnaire	Identified the dimensions of AMT organization as organic with a narrow span of control, few vertical levels, high integration, decentralized decision-making, horizontal communication, adoptive behavior, group rewards and self-regulatory	Study focused more on structure and strategy	Current study will focus on impact of AMT on structure moderated by human and firm size
Gupta, A., I.J. Chen and D. Chiang (1997)	Examine the variations in company performance as a function of the simultaneous effect of the dimensions of manufacturing technology intensity and structure	A study was conducted using survey questionnaire	Data from this study indicated that decentralization, described as complementary to AMT strengths, interacts positively with AMT, whereas formalization and mechanistic structure interact negatively with AMT	• Did not incorporate firm size and human factors in the study. • -study focused on developed country socioeconomic aspect	• Will incorporate human factor and firm size in the study. • -study will focus on a developing country socioeconomic aspect
Ghani et al, 2002	To presents a framework to implement AMT in an existing environment with organic structure to achieve superior performance	A study was conducted using survey questionnaire	At high proactive level, the mechanistic structure of AMT plants has been found to change into an organic structure	Study focused on reaction of blue collar workers	Study will focus on the effects of human factors and firm size on the relation between AMT and organizational structure.

Study	Focus	Methodology	Findings	Gaps	Current study
Rosnah, Ahmad and. Osman (2004)	Investigate the ability of firms in Malaysia to implement AMT successfully	A study was conducted using survey questionnaire	The main factors preventing firms from obtaining the strategic benefits of AMT are the lack of an organic structure and understanding of the technologies, planning, the level of skilled workers and engineers and the culture of the industries	Study done in Malaysia focused on e-commerce	Study will be done in Kenya .
Spanos and Voudouris (2009)	Examine antecedents and trajectories of AMT adoption in stand-alone, intermediate and integrated technologies.	A study was conducted using survey questionnaire	AMT adoption follows an incremental, piecemeal progression from the least complicated through intermediate to integrated technologies.	Study focused on AMT implementation a case of Greek manufacturing SMEs.	take into consideration market forces causing production changes over a time in Kenya.
Boothby et al., 2010 Dornfeld 2010	Advanced technologies as complementary to skills (for training in computer literacy and technical skills)	Survey of previous reports	shows that training in computer literacy and technical skills are associated with higher productivity.	Study was limited to training and in computer literacy and technical skills	Current study will incorporate human resource factors in managing technological change
Hajipur et al., 2011).	The influence of main factors on organizational For 48 chemical and 76 food industries.	structural equations' model and based on partial least squares (PLS) methodology	Results imply that industrial structure determines organizational characteristics, which in turn leads to superior organizational performance	Study was limited to partial least squares (PLS) methodology	Current study will obtain empirical dat through self administered questionnaires
Edwards-Schachter et al.(2011)	co-operative innovation and Research and Development (R&D) behaviour between Argentine and Spanish firms.	A study was conducted using survey questionnaire	Results revealed that the determinants of success differ considerably among countries depending on the sector, the firm specific characteristics and funding.	Study compared innovation and R&D for two developed countries, Argentine and Spanish firms.	Will focus on developing country socioeconomic perspective
Li and Xie (2012)	Developing a framework that incorporates factors determining firms' adoption of AMTs.	Through literature review of previous empirical studies	Factors that determine firms' adoption of AMT are managerial attitudes, corporate strategies, external pressures and firms' technology strengths.	Study summarized previous studies in china in the field of AMT adoption	Will focus on AMTs in Kenyan socioeconomic perspective
Mirmahdi (2012)	Assess the critical factors which influence adoption of Advanced Manufacturing Technologies (AMTs)	synthesizes previous studies, on 3 contexts (Environmental, Organizational, and Technological)	Study identified 10 factors, categorized in three contexts, which influence the adoption of AMTs by firms. The developed framework creates a conceptual basis for further practical researches.	The developed framework created a conceptual basis for further practical researches.	The current study will empirically the relation between AMT, Structure, Human factors and Firm size

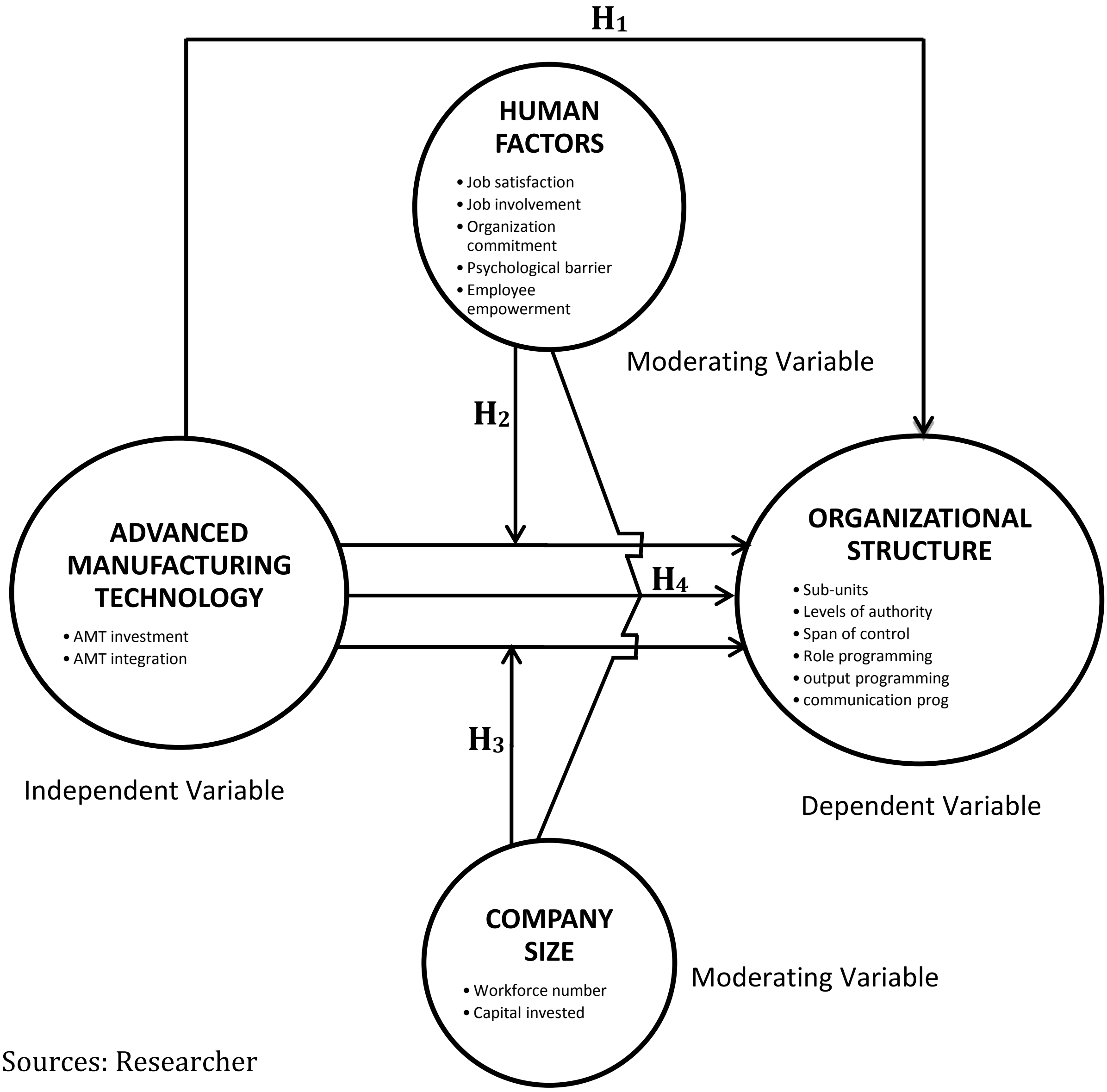
2.7 Conceptual Framework

A Company's manufacturing technology is an endogenous variable that undergoes frequent adaptation to remain technically competitive. Any change in market demand affects the product of a manufacturing company and forces it to redesign the product. Many times the existing technology may be inadequate to incorporate the required change in the products. Hence the firm is forced to introduce new technology to remain competitive in the market. The framework developed herewith provided a conceptual basis for quantitative analysis. The framework links AMT adoption and organizational structure providing for human factors and company size to moderate the relationship. The technological choice depends on the prevailing technological development in the industry and adoption by companies to achieve competitive capabilities in the areas of product design, manufacturing and testing.

Organizational structure was explained in terms of AMT adoption, human factors and company size. AMT index (AMTI) was examined in terms of the level of investment and the level of integration of the particular AMT by companies. Characteristics of organizational index (OI) were examined in terms of sub-units, levels of authority, span of control, role programming, communication programing and output programming. These particular aspects of organizational structure exert considerable influence over the organizational decision-making processes. The human factors index (HFI), perceptions of the blue collar workers' reactions that arise in most periods of technological and structural change, were explored in terms of job satisfaction, job involvement, organization commitment, psychological barriers and employee empowerment. Company size index (CSI) was explored in terms of the workforce number and invested capital.

The framework posits, inter alia, that as levels of AMT adoption increases, the organizational index (OI) increases. The framework suggests that adoption of AMT will not also ifso facto guarantee performance but will further require appropriate changes in the organizational structure. The changes will be moderated by employees' behavior and the company size. When operationalized, the research findings provided a basis for creation of theory that explained the influence of AMT adoption on organizational structure and the influence of human factors and company size on the relationship between AMT adoption and organizational structure in the context of a developing country. This conceptual framework is summarized in Figure 1.

Figure 1: Conceptual framework



Sources: Researcher

2.8 Study Hypotheses

Implementation of AMT affects organizational structure since it involves decisions relating to division of task, decision-making authority and co-ordination mechanisms (Burns & Stalker, 1961). Flexibility in structure involves managing variety rather than volume, change rather than routine, and judgment rather than standard procedures. Traditional structure that emphasizes on a high level of differentiation in task and authority would be inappropriate for these conditions (Madique and Hayes, 1984). The resulting arrangement is an organic structure that is flexible, adaptive, and multi-skill oriented (Ghani, 2002). However, a company's capacity to assimilate technology depends on its organizational structure. Thus, when the AMT complexity is higher, the organizational structural elements should also be higher.

H1: There is a positive relationship between Advanced Manufacturing Technology adoption and organizational structure.

The behavioral characteristics of employees of an AMT company must be adaptive to achieve superior performance (Boothy *et al*, 2010). When AMT complexity increases, the behavioral characteristics of employees should be more adaptive. Managers as change agents play a very important role in change situations. Credibility, expertise and objectivity of change agent contribute to change in attitudes of employees (Cascio, 2010). Employees are most likely to respond to change efforts made by someone who is liked, credible and convincing thus reducing the psychological barriers (Davis, 1994). Thus, when the AMT complexity and the organizational structural elements are higher, behavioral characteristics of employees should also be higher.

H2: The relationship between Advanced Manufacturing Technology adoption and organizational structure depends on human factors.

Larger capacity companies are able to afford the often extreme expense of these computerized manufacturing technologies and have the skills and human resources it takes to understand, implement, and manage such technologies (Yusuff *et al*., 2008).Therefore the larger a company is the greater the benefits from using these technologies. However, a company's position on the mechanistic-organic continuum can be identified based on the size of the organization. The higher the size the more mechanistic is the structure (Dornfeld, 2011).

H3: The relationship between Advanced Manufacturing Technology adoption and organizational structure depends on company size.

The framework posits, inter alia, that the adoption of AMT would suggest that a company's manufacturing technology and size would influence organization structure both at operational and administrative levels (Lim *et al*., 2010). A change in structure would lead to changes in design and manufacturing activities. Consequently, jobs/tasks of employees have to be redesigned resulting in change in job characteristics (Hajipour, 2011). Superior performance may be achieved by maximum fit between technology, structure, company size and human factors.

H4: The combined effect of Advanced Manufacturing Technology, Human factors and Company size on organizational structure is different from the individual effects.

CHAPTER THREE: RESEARCH METHODOLOGY

3.1 Introduction

Having developed the rationale for undertaking this study and its research framework in the last chapters, this chapter discusses the approach taken to answer the research questions. The methodology issues applied in conducting this study, such as research philosophy, research design, population to be studied, the survey methods, measurement skills and the operationalization of the main study variables. The principle variables are AMT adoption (independent Variable), organizational structure (dependent variable), human factors (moderating variable) and company size (moderating variable). The chapter ends with a summary table of indicators used to measure the key study variables and a data analysis model.

3.2 Research Philosophy

This study examined the link between AMT adoption and organizational structure, and the role of employee behavior and company size in the fit in the relationship between them. The study provided a conceptual and methodological approach in applying contingency theory in examining this relationship. By nature, this study is quantitative research. When undertaking such a study, it is important to consider different research paradigms and matters of ontology and epistemology. Since these parameters describe perceptions, beliefs, assumptions and the nature of reality and truth (knowledge of that reality), they can influence the ways in which the research is undertaken, from design to conclusions. While James and Vinnicombe (2002) caution that we all have inherent preferences that are likely to shape our research designs, Blaikie (2000) describes these aspects as part of a series of choices that the researcher must consider and show the alignment that must connect these choices back to the original research problem. If this is not achieved, methods incompatible with the researcher’s stance may be adopted, with the result that the final work will be undermined through lack of coherence.

In the process of establishing knowledge on any subject matter, a researcher is guided by one of the many philosophical viewpoints as suggested by Flowers (2009). These viewpoints include positivism, phenomenology and realism. The two main philosophies that guide social scientist researchers are positivism and phenomenology. Positivism is based upon reason, truth and validity with a focus on facts that are gathered through direct observations and experience and measured empirically using quantitative methods of surveys and experiments and subjected to statistical analysis. In this philosophy the researcher focuses on facts and looks for causality in the relationships through the formulation and testing of hypothesis.

Phenomenology, which is also referred to as interpretivism and constructivism, focuses on immediate experiences and gives prominence to cognition. The primary source of knowledge is reasoning or application of judgement. The phenomenologist believes that all knowledge can be deducted from known laws or basic truths about nature with problems best resolved through formal logic or mathematics and independent of observations and data collection (Cooper and Schindler, 2003). In resolving problems, the phenomenologist uses multiple methods with a flexible study design to establish different views of phenomena (Flowers, 2009).

Realism, according to Flowers (2009), was born from a frustration that positivism was over-deterministic while phenomenology was totally relativistic. Realism takes aspect from both positivist and interpretivist position. On the one hand it accepts that reality may exist in spite of science or observation, and so there is validity in recognizing realities that are simply claimed to exist or act, whether proven or not while on the other hand it holds that science must be empirically based, rational and objective and so social objects may be studied scientifically as social objects, not simply through language and discourse.

The primary aim of this study was to empirically inquire into the influence of AMTs on organizational structure hence characterized by the testing of hypothesis developed from existing theory (deductive or theory testing) through measurement of observable social realities. These realities were measured empirically using quantitative methods. The study therefore adopted a positivism position which was based upon values of reason, truth and validity focused purely on facts, gathered through direct observation and experience.

3.3 Research Design

A research design is the blueprint for fulfilling objectives and answering the research question (Cooper and Schindler, 2001). A number of research design approaches exist. The most common classifications of research design are exploratory, descriptive and causal (Churchill and Iacobucci, 2002). Exploratory studies tend toward loose structures with the objective of discovering future research tasks. Both qualitative and qualitative techniques are applicable, although exploration relies more heavily on qualitative techniques.

Descriptive studies seek to identify the frequency of a particular occurrence, or the relationship between two variables (Churchill and Iacobucci, 2002). Descriptive research assumes a degree of knowledge about the phenomenon under investigation, possibly derived from exploratory research. It has very clear specifications and well-defined boundaries. According to Cooper and Schindler (2003) if the research is concerned with finding out what, when, and how much of phenomena, descriptive research design is found to be appropriate. In a causal study, it is concerned with learning why; that is to say, how one variable produces changes in another (Fowler, 1988; Cooper and Schindler, 2001).

As the study aimed to examine the relationship between two variables and the influence of the other two, a descriptive cross-sectional approach was adopted. Data was collected from a population through questionnaires that were sent out in a period of time to examine the practice of manufacturing companies in regards to their AMT diffusion, organizational structure and the perceived influence of employees' behavior and the company size. The study used cross sectional study design since these types of studies have been found to be robust in relationship studies given their ability to capture the population characteristics in their free and natural occurrence (O'Sullivan and Abela, 2007). A cross sectional approach enhances the credence of results by providing conclusions on data as at a given point in time. Other researchers (Woodward, 1965; Fry, 1882; Kim and Utterback, 1983) used similar research design for similar studies.

3.4 Population of the Study

A population is the total collection of elements about which we wish to make some inference (Cooper and Schindler, 2001). In this case, as the focus was on the advanced manufacturing technologies diffusion in AMT companies in Kenya, manufacturing companies using AMTs were the most appropriate population. Additionally, as noted in the literature review chapters, only a few of the studies examining the relationship between AMT and structure are from developing countries and none from Kenya.

The surveyed population consisted of AMT companies whose major products were classified in several sub-sectors. These sub-sectors included companies involved in food, beverage and animal feeds industry, construction and material industry, chemical and pharmaceuticals industry, plastics, packaging and stationery industry, power generation and electrical/electronic industry, fabricated metals industry, textiles, apparel, leather and footwear industry and automobile and parts industry. Given the need for a large sample size, and the need to keep the industries relatively homogeneous (from a manufacturing/ production perspective), this group of eight sub-sectors is a reasonable compromise that accomplishes both goals. More importantly, the study focused on these segments because of their acknowledged adoption of AMTs.

The target population, therefore, to which the results were to be generalized was the AMT companies in Kenya. According to KAM (2014), by end of 2013 there were 183 companies using a form of AMT. These companies manufacture for domestic consumption and for export a variety of products. A complete list of these companies and their products is provided in Appendix 3.

3.5 Sampling Method

Sample design is an integral part of the total research design (Neuman, 1991). The basic idea of sampling is that by selecting some of the elements in a population, we may draw conclusions about the entire population (Fowler, 1988; Dillman, 2000; Cooper and Schindler, 2001). There are several compelling reasons for sampling, including; lower cost, greater accuracy of results and greater speed of data collection (Cooper and Schindler, 2001). Sampling procedure is used to maximize the chances that the sample is representative so that the conclusions drawn from the sample can be generalized to the population as a whole (Furlong *et al*., 2000). A variety of sampling techniques are available. The selection of a particular technique depends on the requirements of the project, its objectives, and the funds available (Creswell, 1999).

A census study occurs if the entire population is very small or it is reasonable to include the entire population (for other reasons) (Babbie, 1990). It is called a census sample because data is gathered on every member of the population. The census Method is suitable where the population is not vast, there is enough time to collect data and a higher degree of accuracy is required (Cooper and Schindler, 2001). Data collection through the census method gives opportunity to the investigator to have an intensive study about a problem and to gather knowledge on the subject matter. However this method is quite taxing and time consuming.

Census and sampling methods both serve the purpose of providing data and information about a population. However accurately a sample from a population may be generated there will always be margin for error, whereas in the case of Census, the entire population is taken into account and as such it is most accurate. Data obtained from both Census and sampling is extremely important for a government for various purposes, such as planning for development programs and policies for poorer sections of the society (Fowler, 1988).

As the population of AMT firms was identified at 183, this was considered as not vast and census method was adopted. The population was segregated into several mutually exclusive subpopulations and members were then taken from the given sub-grouping stratified by the type of industry. In the matter of ownership, companies under the same control of a parent company were avoided. The percentage of representation of each sub-sector in the population was determined as shown in table 2.

Table 2: Sub-Sector distribution

Sub-Sector	Population	%
Construction and material industry	27	14.75
Food, beverage and animal feeds industry	55	30.05
Textiles, apparel, leather and footwear	13	7.10
Chemical and Pharmaceuticals industry	28	15.30
Automobile and parts industry	4	2.19
Fabricated metals industry	17	9.29
Power generation and electrical/electronics	14	7.65
Plastics, packaging and stationery	25	13.66
Total	**183**	**100**

Sources: Researcher

The rationale of just choosing one area of application; advanced manufacturing technology was based on the need of a more homogeneous set of applications and consider them against a relatively well-mapped-out territory, where this brings enquiry down to more manageable proportions. However, a comparison of the companies to be studied and with published reports in the literature dealing with similar products, suggests that the group to be studied is typical.

Most of the unit of analysis of studies on manufacturing technology is on plant/ company level (Young and Selto, 1993; Kotha and Swamidass, 2000; Small and Chen, 1997; Schroder and Sohal, 1999). According to Pong and Burcher (2009), a single organization unit study minimizes confounding effects common in across-company, cross-sectional studies, and the design of the study controls the many external confounding effects. A single organization unit study is appropriate when the focus of the study is to assess the performance of each individual firm. As the objective of this study is to assess each individual AMT adoption in different organizational orientations, to explain similarities and differences in the implementation approach and the benefits achieved, single organizational unit is deemed appropriate. In this study, therefore, the unit of analysis was taken as the AMT Company.

3.6 Data Collection

The study, which is descriptive in nature, needed an objective and quantitative method to answer the research question. A number of primary data collection methods are available in the research methodology literature, such as face to face, computer administered, telephone, self-administered and postal survey (Ziesel, 1984).The postal survey and self-administered methods were chosen due to their strength over other techniques for such a study.

A questionnaire was used as the instrument to measure reality objectively. The questionnaire used in this study incorporated inputs from various sources; Woodward (1965); Small and Chen, (1997); Ghani (2002) and the researcher. Preliminary drafts of the questionnaire were discussed with academic scholars and practitioners and subsequently tested in one of the beverage manufacturing company in Nairobi to assess the content validity. The feedback from the party above was then used to improve the clarity, comprehensiveness and relevance of the research instrument. The final survey instrument incorporated some minor changes that were picked up during this preliminary test.

The questionnaire solicited information on the four variables of the study; Organizational Structure, AMT adoption, company size and perceived reactions of the blue collar workers. In order to measure organizational structure on 1 – 5 polar point the list of dimensions used by Harvey (1968) was adapted. To obtain logical response and required information of the study a five point Likert type scale was used in perception questions. The list of AMT was adapted from Small and Chen (1997) but omitted the management information technologies such as just-in-time with the reason that it is not a technology per se. The study investigated 14 types of advanced manufacturing technologies (AMTs) which are commonly used by manufacturing companies. Details of the AMTs investigated and their description is detailed in appendix 4.

Specifically, the questionnaire (appendix 1) used for collecting information from the sample companies was divided into two sections. The first section was used for collecting information from production/plant managers in the sample companies. The second section was self-administered to at least 5 blue collar employees and the researcher took more respondents where previous respondents were unable to answer the questions appropriately. An average for each company for this section was thereafter calculated.

3.7 Validity and Reliability of Tests

Validity is a measure of the accuracy and meaningfulness of inferences, which are based on the research results. It is the degree to which results obtained from the analysis of the data actually represent the phenomenon under study. It is largely determined by the presence or absence of systematic error of data (non- random error). The variables in the study have been operationalized to reflect the theoretical assumptions that underpin the conceptual framework for the study. The invalidity was attributed to the respondents skipping the questions as they were uncomfortable in answering some of the questions or unconscious judgmental actions to responses. Also, common errors occur where the respondent skips a question or selects more than one option per question without prior knowledge and or respondents characteristics such as social desirability which is the tendency to want to appear in a positive light and therefore providing the desirable response.

Reliability is a measure of degree to which a research instruments yields consistent results. The reliability of the data collection instruments was estimated using Cronbach Alpha Coefficient which assessed the internal consistency or homogeneity among the research instrument items. The alpha coefficient ranges in value from 0 to 1 and a high coefficient implies that the items correlate highly among themselves, that is, there is consistency among items measuring the concept of interest. Cronbach Alpha Coefficient (α) value of 0.7 was used as cut off point and all items whose value was less than 0.7 was considered weak, and therefore left out. Secondly the questionnaire was pre-tested with a sample of respondents and necessary corrections incorporated.

3.8 Operationalization of Research Variables

The following section examines the constructs that were measured and details the development of measures for the dimensions identified in the proposed model in order to allow testing of the associated propositions. The study contained four main variables namely: organizational structure, AMT, human factors and company size. In the case of organizational structure the position of the structure on 1 - 5 polar point was operationalized in terms of the number of sub-units, levels of authorities, span of control, role programming, output programming and communication programming. The above determinants were such that 5 indicated the structure with the highest value and 1 indicated the structure with the least value.

In the case of AMT, the continuum from technical complexity to technical simplicity was operationalized in terms of level of AMT investment and AMT integration. The study investigated 14 types of AMTs identified in the literature as commonly used by manufacturing companies. These technologies were grouped into five domains, based on their functionalities. The five domains include: Product Design and Engineering Technologies (PDETs), Production Planning Technologies (PPTs), Material Handling Technologies (MHTs), Assembly and Machinery Technologies (AsMTs), Integrated Manufacturing Technologies (IMTs). The AMTs under PDETs included Computer aided design (CAD), Computer aided engineering (CAE), Group technology (GT) and computer aided manufacturing (CAM). Under PPTs the AMTs included Manufacturing Resource Planning (MRP), Material requirement Planning (MRP II) and Enterprise Resource Planning (ERP). The MHTs included AMTs such as Automated Guided Vehicle (AGV) and Automated Storage and Retrieval System (ASRS). The AMTs under AsMTs include numerical controlled machines (NC/CNC/DNC), Computer Aided Quality Control System (CAQCS) and Robotics. The IMTs included Flexible Manufacturing Systems/Cells (FMS/FMC) and Computer integrated Manufacturing (CIM).

Companies were asked to indicate the amount of investment the company has made in the individual technology, on a Likert scale of 1-5, where 1 indicated little investment, 3 indicated moderate investment and 5 indicated heavy investment. The respondents were also asked to indicate the levels of integration of each AMT invested in the company on a Likert scale of 1-5, where 1 indicated no integration, 3 indicated moderate integration and 5 indicated extended integration.

Human factors, the blue collars workers feelings during the technological change period, were operationalized using the five dimensions identified in this study; job satisfaction, job involvement, organizational commitment, psychological barriers and employee empowerment. The score measure was done on a Likert scale of 1-5, measuring the extent of worker feelings, where 1 indicated not at all and 5 indicated to a great extent. Company size was operationalized in terms of workforce number and capital invested. The score measure was done on a Likert scale of 1-5 with one indicating small and 5 indicating large. The instrument was design in such a manner as to show a score of 5 as the largest indicator towards organizational index and 1 as the smallest indicator of organizational index.

In order not to obscure the potentially valuable middle range of data, the procedure of pentagonizing each dimension in the variable was consequently followed, attempting wherever possible to employ equal intervals. In terms of the pentagonized operational measures, each dimension had the value span of 1-5. The lowest score an element could have would be 1 and the highest score 5. The hypothesis resting behind the scale is that a company which is high on any given dimension will also be high on all other dimensions.

All dimensions were treated as independent and of equal weight. With regard to the first matter, attempts have been made to illustrate the independence of these dimensions in the course of the earlier discussion and definition of them. With regard to the second matter, the absence of weighting, there is no available evidence to suggest that any one of the dimensions carries more weight than any other. In the absence of such evidence it was preferred not to prejudge the matter but instead wait to see if the data would suggest reformulation of the suggested scale. Table 3 shows the summary of operationalization of the variables.

Table 3: Operationalization of variables

Variable	dimension	Definition	Indicators	Measure	Questionnaire item
AMT	AMT Investment	The level of investment in AMT in a company.	1. Little investment 2. Some investment 3. Moderate investment 4. Substantial investment 5. Heavy investment	Level of technical complexity	Section1 Q10
	AMT Integration	The level of integration of AMT in a company.	1. No integration 2. Limited integration 3. Moderate integration 4. Full integration 5. Extended integration	Level of technical complexity	Section1Q 11
Company Size	Number of employees	The total number of persons employed by the Company	Small, medium, large	Workforce number	Section1 Q7 & Q8
	Capital invested	The total capital a company has invested	Small, medium, large	Capital invested	Section1 Q9
Organizational structure	Sub-units	Groups of individuals within the organization charged with a formally defined set of responsibilities.	1-2, 3-4, 5-6, 7-8, over 8	Number of specialized departments	Section1 Q13
	Levels of authority	Formally delimited zones of responsibility along the organizational hierarchy	2,3,4,5, over 5.	Number of hierarchical Authorities	Section1 Q14
	Span of control	the number of workers a manager controls	Number of employee/number of managers	Ratio of workers to managers	Section1 Q8,Q9, Q13
	Communication programming	The extent to which formal communication is made to each employee	Rankings on the extent to which formal communication is made to each employee.	Five-Point Likert Type Scale	Section 2 Q4
	Role programming	The extent to which jobs are specified, detailed and spelled out.	Rankings on the extent to which jobs are specified, detailed and spelled out.	Five-Point Likert Type Scale	Section 2 Q5
	Output programming	Steps raw materials pass in the course of becoming the organization's outputs.	1-2, 3-4, 5-6, 7-8, over 8	Number of steps raw material go through	Section1 Q12
Human Factors	Job satisfaction	how contented an individual is with his or her job	The extent of a worker feelings of contentment with his/her job	Five-Point Likert Type	Section 2 Q6
	Job involvement	Extent to which an individual participates in his or her work.	Psychological/emotional extent to which one participates in their work	Five-Point Likert Type	Section 2 Q8
	Organizational commitment	individual's psychological attachment to the organization.	Ranking on the extent of a worker attachment to the organization	Five-Point Likert Type	Section 2 Q7
	Employee empowerment	degree of autonomy and responsibility a worker has in decision-making regarding their work	The degree of autonomy /responsibility a worker has in decision-making regarding his/her work.	Five-Point Likert Type Scale	Section 2 Q 9
	Psychological barriers	mind-associated problems a worker has with job security /job displacement	Rankings on the extent of a worker's feelings of job security/displacement due to technological change	Five-Point Likert Type Scale	Section2 Q10

Sources: Researcher

3.9 Data Analysis and Presentation

This section looks at the statistical techniques used to analyze data collected from the questionnaire. The first part of the section explains the technique used to perform the hypotheses testing, and the last part of the section looks at the analyses techniques used to measure the link between the variables. The framework developed in this study presents the inter-relationship among the variables. The hypothesis that was tested was that as AMT index, human factor index and company size index increased the organizational index also increased. The approach was to address the problem of AMT adoption and the questions related to its relationship with organizational structure allowing for human factors and company size to moderate the relationship.

From the observations of the selected subset, inferences about possible relationships of the various variables within an AMT company were made using statistical measures. This approach is versatile since AMT adoption – Organizational Structure relationship is an abstract concept which can best be studied using a survey. The approach provided the researcher an opportunity to develop a broad based understanding of the joint effect of AMTs, Human factors and Company size on Organizational structure within AMT companies.

Scores for each dimension of the variables were first calculated and analysed for each sub-sector. Organizational Index (OI) value per every company was calculated as a mean of the dimensions scores of organizational structure. A similar approach was done for the other variables to obtain AMT index (AMTI), company size index (CSI) and the human factor index (HFI). To determine the relationships between AMT adoption and organizational structure a bivariate regression analysis was performed. To determine the moderation effects of human factors and company size on the relation between AMT adoption and organizational stepwise forward regression analysis was performed. The joint effect of the predictor variables (AMT adoption, human factors and company size) on organizational structure was determined by performing multivariate regression analysis. Use of SPSS version 20 was adapted. On performance of statistical test at 95% significance level, the correlation matrix generated was used to check the degree of correlation between the dimensions, the model table was used to check the goodness of fit, ANOVA table was used to check the significance of the model and the coefficient table was used to determine the constant for each variable and therefore ascertain the significance of each term in the relation.

Organizational Index (OI) for each company took the form of;

$OI = (X_{01} + X_{02} + X_{03} + X_{04} + X_{05} + X_{06})/6$ where

X_{01}= Sub-unit score
X_{02}= Levels of authority score
X_{03}= Span of control score
X_{04}= Role programming score
X_{05}= Communication programming score
X_{06} = Output programming score

Advanced manufacturing technology index (AMTI) for each company took the form of;

$AMTI = (X_{11} + X_{12})/2$ where

X_{11}= AMT investment score
X_{12}= AMT integration score

Human factors index (HFI) for each company took the form of;

$HFI = (X_{21} + X_{22} + X_{23} + X_{24} + X_{25})/5$ where

X_{21}= Job satisfaction score
X_{22}= Job involvement score
X_{23}= Organizational commitment score
X_{24}= Psychological barrier score
X_{25}= Employee empowerment score

Company size index (CSI) for each company took the form of;

$CSI = (X_{31} + X_{32})/2$ where
X_{31}= Number of workers score
X_{32}= Capital invested score

A summary of the objective, hypothesis and analytical methods to be used is presented in Table 4 below.

Table 4: Research objectives, hypotheses and analytical methods

OBJECTIVE	HYPOTHESIS	ANALYTICAL METHOD	INTERPRETATION

1.
Establish the relationship between AMTs and Organizational Structure.
	H1:
	There is a positive relationship between Advanced Manufacturing Technology adoption and organizational structure
		Bivariate Regression Analysis.
		
		OI=f (AMTI)
		$OI_{11} = \alpha_1 + \beta_{11} X_{11} + \varepsilon_1$
		Where
		OI_{11}= Organizational Index
		α_1=constant (intercept)
		β_{11}, Coefficients of H1
		X_{11} =AMT index
		$\varepsilon = error$ term
			Pearson's product moment correlation coefficient (r) Range ±1
			r=0.7 plus very strong positive relationship;
			r= 0.5-0.7 strong relationship;
			r=0.3-0.49 moderate relationship;
			r=.29 or less weak relationship
			r=0 no relationship

2.
Determine the effect of Human Factors on the relationship between AMT and Organizational Structure
	H2:
	The relation between Advanced Manufacturing Technology and Organizational structure depends on Human factor.
		Stepwise Regression Analysis.
		OI=f (AMTI,HFI,AMTI*HFI)
		$OI_{21} = \alpha_2+\beta_{21}X_{21}+\varepsilon_{21}$
		$OI_{22} = \alpha_{22}+\beta_{22}X_{21}+\beta_{23}X_{22}+\varepsilon_{31}$
		$OI_{23} = \alpha_{23}+\beta_{24}X_{21}+\beta_{25}X_{22}+\beta_{26}X_{21}*X_{22}+\varepsilon$
		Where OI= Organizational Index
		α=constant (intercept)
		X_{21} =AMT index
		X_{22} = Human factor index,
		β_S=Coefficients of H2
		$X_{21}*X_{22}$= interaction term
		ε_s=Error terms
			=Pearson's product moment correlation coefficient (r) Range ±1
			r=0.7 plus very strong positive relationship;
			r= 0.5-0.7 strong relationship;
			r=0.3-0.49 moderate relationship;
			r=.29 or less weak relationship
			r=0 no relationship

3.
Determine the effect of Company Size on the relationship between AMT and Organizational Structure
	H3:
	The relation between Advanced Manufacturing Technology and Organizational structure depends on Company size.
		Stepwise Regression Analysis.
		OI=f (AMTI,CSI,AMTI*CSI)
		$OI_{31} = \alpha_3+\beta_{31}X_{31}+\varepsilon_{31}$
		$OI_{32} = \alpha_{32}+\beta_{22}X_{31}+\beta_{33}X_{32}+\varepsilon_{32}$
		$OI_{33} = \alpha_{33}+\beta_{34}X_{31}+\beta_{35}X_{32}+\beta_{36}X_{31}*X_{32}+\varepsilon$
		Where OI= Organizational Index
		α=constant (intercept)
		X_{31} = AMT index
		X_{32} = Company size index,
		β_S=Coefficients of H3
		$X_{31}*X_{32}$= interaction term
		ε_s=Error terms
			Pearson's product moment correlation coefficient (r) Range ±1
			r=0.7 plus very strong positive relationship;
			r= 0.5-0.7 strong relationship;
			r=0.3-0.49 moderate relationship;
			r=.29 or less weak relationship
			r=0 no relationship

4.
Establish the joint effect of AMTs, Human and Company factors on Organizational Structure
	H4:
	The combined effect of Advanced Manufacturing Technology, Human and Company factors on organizational structure is different from the individual effects.
		Multivariate Regression Analysis.
		OI=f (AMT,HFI,CSI)
		$OI_{41} = \alpha_{41}+\beta_{41}X_{41}+\varepsilon_{41}$
		$OI_{42} = \alpha_{42}+\beta_{42}X_{42}+\varepsilon_{42}$
		$OI_{43} = \alpha_{43}+\beta_{43}X_{43}+\varepsilon_{43}$
		$OI_{44} = \alpha_{44}+\beta_{44}X_{41}+\beta_{45}X_{42}+\beta_{46}X_{43}+\varepsilon_{44}$
		Where OI_s= Organizational Index
		α_s=constant (intercept)
		β_s=are Coefficients of H4
		X_{41} =AMT index
		X_{42} =Human Factors index
		X_{43} =Company Size index
		ε_s=Error terms
			Pearson's product moment correlation coefficient (r) Range ±1
			r=0.7 plus very strong positive relationship;
			r= 0.5-0.7 strong relationship;
			r=0.3-0.49 moderate relationship;
			r=.29 or less weak relationship
			r=0 no relationship

Sources: Researcher

CHAPTER FOUR: DATA ANALYSIS AND INTERPRETATION OF RESULTS

4.1 Introduction

The previous chapter described the methodology employed in gathering data to address the question raised in chapter two. This chapter provides the descriptive statistics and interpretations based on companies' responses given in the questionnaire. A thorough review of the descriptive statistics provided a means of testing the robustness of the data and also provided the reader with a much greater understanding of exactly what type of companies have been surveyed. The chapter also provides a snapshot of the current state of advanced manufacturing technology in Kenya, and as such can be used as a benchmark for future research to judge how this part of the industry is evolving. Hypotheses developed in chapter two are there after tested and interpreted and the results extended to the entire population.

4.2 Respondents' Profile

A letter of introduction accompanying the questionnaire was addressed to the Production Manager/Managing Director of the company. Thereafter the letter was followed up by telephone calls to fix an appointment since section 2 of the questionnaire was to be self-administered. 183 letters were written to all the AMT companies identified and either delivered or posted. Gaining admission to industrial organizations for the purposes of sociological research in Kenya 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 40% of the identified companies responded. The AMT plants were located at different places, geographically ranging from 5 to 700 km.

Data collection process took nearly 7 months. 101out of the 183 companies showed positive response and data from these companies were used for analysis. The response rate for this study was 55%. 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.

In section 1 of the instrument the respondents were required to fill up their job title and the duration in holding the position in the company. This information was deemed important in order to find out the credibility of the informant. Further analysis of the data collected showed that out of the 101 respondents the credibility of 9, representing about 9%, did not meet the standard required and so were rejected in the analysis. The analysis was therefore based on 92 companies.

The majority of the respondents in section 1of the instrument (42.5%) were from top management levels, that is to say, directors, managing directors, chief executive officers or chairmen, and approximately 40% of the respondents were directly responsible for manufacturing or operations or production issues of their companies. 17.5% of respondents were executives holding non-manufacturing-related positions such as administration manager (3), company secretary (3), marketing manager (2), commercial manager (2), purchasing manager (2), human resource manager (2) and finance manager (2). The presentation of these figures is as shown in Table 5.

Table 5: Respondents profile for questionnaire section 1

	Job Titles	No of respondents	Percentage
1	Top management levels	39	42.5%
2	Production related managers	37	40%
3	Other managers	16	17.5%
	Totals	92	100%

Numerous elements of visited company profile were collected using the designed instrument. This included the sub-sector of the industry; the year of establishment and the company size. As the mean workforce number of companies surveyed was rather low, at around 50 employees, it was no surprise that the top management level were in-charge of their manufacturing function and involved in decision making in manufacturing issues. At a glance, it can be inferred that the sampled information collected from the survey was highly credible with the average respondent duration in their respective positions being 8 years.

Section 2 of the instrument was self- administered to the blue collar workers working within the AMT machines. Five respondents were sampled from each company and an average for each unit of analysis was thereafter calculated. As this part was self-assessed the researcher took more respondents where previous respondents were either unable or unwilling to answer the questions appropriately. In this part of the instrument the respondents were required to indicate their job title, qualification and the duration in holding the position in the company. This information was deemed important in order to find out the credibility of the informant. Out of the 460 questionnaires (5 from each company), majority of the respondents (63%) were machine operators, 23% were maintenance personnel and 14% were shop stewards. The presentation of these figures is as shown in Table 6.

Table 6: Respondents profile for questionnaire section 2

	Job Titles	No of respondents	Percentage
1	Machine operators	290	63%
2	Maintenance personnel	106	23%
3	Shop stewards	64	14%
	Totals	460	100%

Qualified skilled labor is an indispensable precondition for the diffusion of AMTs. Therefore the efficiency in labor is an important driver for the diffusion of AMTs. Since section 2 of the data collection instrument was self-administered, deliberate efforts were made to get the qualification of the workers operating these AMTs. The number of trained workforce was found to be low, with most blue collar workers being either certificate holders or secondary school graduates. It was therefore no surprise that shop stewards, mostly skilled in worker's rights, were in-charge of information gathered in the manufacturing function. However at a glance, the sampled information collected from this section was highly credible with the average duration of respondents at their workstation at 10 years.

4.2.1 Manufacturing Sub-Sector Distribution

As the focal point of the study was on AMT manufacturing companies, data was presented in a disaggregated form by sub-sector. This allowed better understanding about sub-sector differences in terms of the structure and composition of the different items that constitute an aggregate. The collected data on the AMT manufacturing sub-sectors in Kenya provided a basis for understanding why companies in different sub-sectors acted differently in terms of adopting different AMT technologies.

The 92 AMT manufacturing companies were grouped into eight sub-sectors based on manufactured products. The majority of respondents, 29, were from food, beverage and animal feeds industry, which accounted for 31.5%, followed by the construction and material industry at 13 (14.1%), chemical and pharmaceuticals industry at 11 (12.0%), plastics, packaging and stationery industry at 11 (12.0%) and power generation and electrical/electronic industry at 10 (10.9%). Other respondents represent a small fraction like fabricated metals industry at 7 (7.6%), textiles, apparel, leather and footwear industry at 6 (6.5%) and automobile and parts industry at 5(5.4%). Table 7 presents the distribution of AMT companies by sub-sectors from the respondents surveyed.

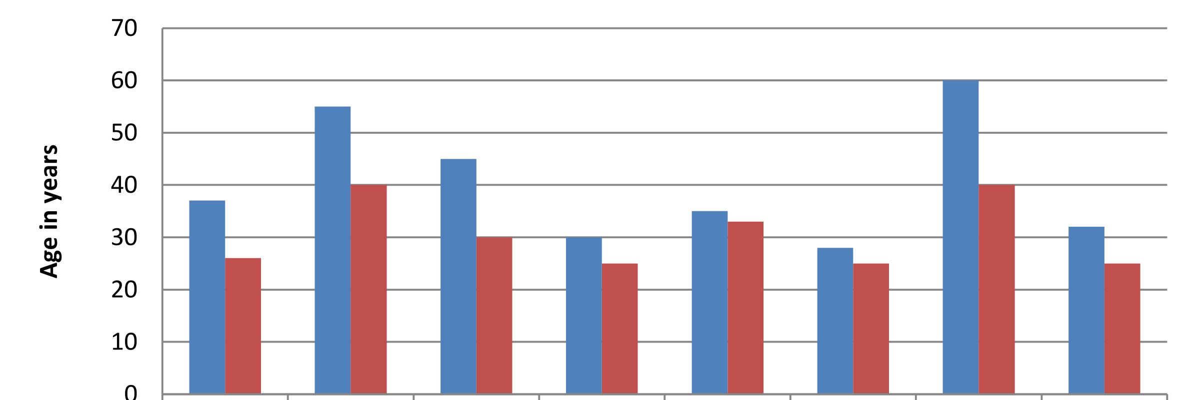
Table 7: AMT sub-sector companies distribution

Category	Respondents	Population	Percent
Construction and material industry	13	27	48.15
Food, beverage and animal feeds industry	29	55	52.73
Textiles, apparel, leather and footwear	6	13	46.15
Chemical and Pharmaceuticals industry	11	28	42.86
Automobile and parts industry	4	4	100.00
Fabricated metals industry	7	17	41.18
Power generation and electrical/electronic	10	14	71.43
Plastics, packaging and stationery	11	25	44.00
Total	**92**	**183**	50.27

4.2.2 Age of Industry Stock

The majority of companies surveyed were mature companies that have existed in the manufacturing scene for some time, with the average company age being 40 years. The median company age was around 30 years across all of the eight broad manufacturing sub-sectors. This indicated the presence of some very old companies that were in existence in each of the sub-sectors as the average age was much greater than the median. 28 percent of the companies have been trading for more than 50 years, with almost half of them in the food, beverage and animal feeds industry.12 percent of the companies were young and had existed for less than 10 years. The results are shown in Figure 2.

Figure 2: Company age by sub-sector



	Construction/ material	Food/ beverage/ animal feeds	Textiles/ apparel/ leather/footwear	Chemical/ Pharmaceuticals	Automobile/parts industry	Fabricated metals industry	Power/electrical/electronic	Plastics, packaging and stationery
mean	37	55	45	30	35	28	60	32
median	26	40	30	25	33	25	40	25

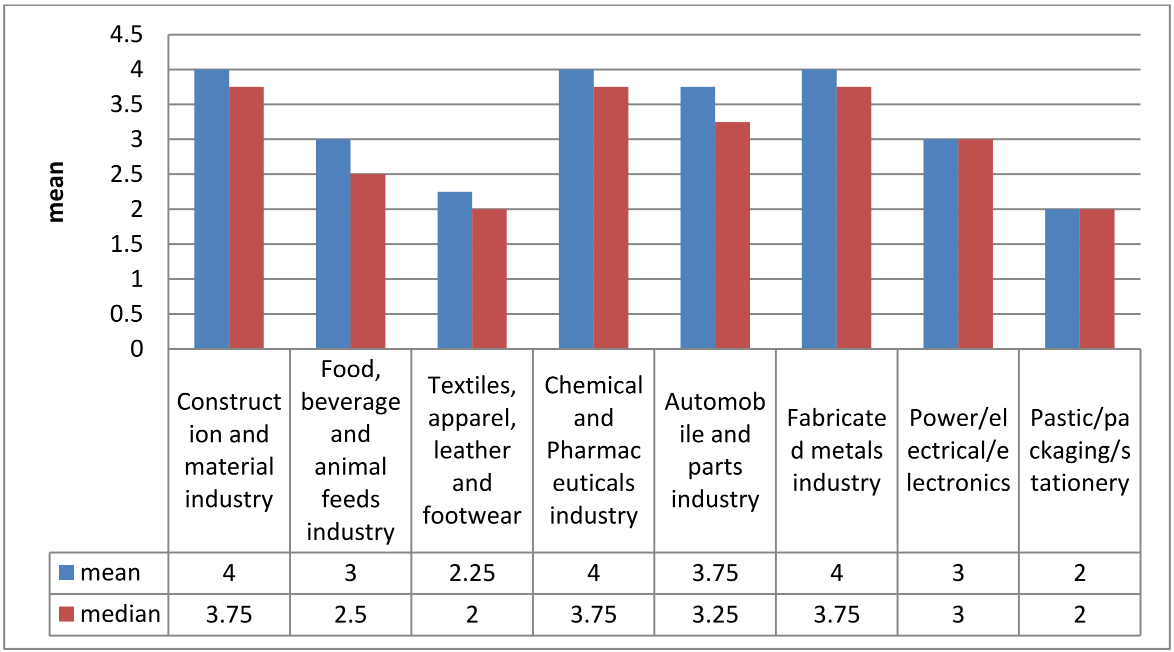
4.3 Company Size by Sub-Sector

This section focuses on company size of the surveyed companies. In this context the two orientations identified in the literature were explored, namely: the capital invested and the workforce number in the plant. These orientations were deduced directly from respondents in section 1 of the instrument. Survey data for the eight AMT manufacturing sub-sectors were presented on an array of industry characteristics.

4.3.1 Capital Invested

Based on Kenya (2007),respondents were requested to choose a response on an array of 5 choices namely; below Kshs. 5 Million meriting a score of 1, Kshs.5 Million –50 Million a score of 2, Kshs. 50 Million – 500 Million a score of 3, Kshs. 500 Million – 5 Billion a score of 4 and over Kshs. 5 Billion a score of 5. This measure of company size was anchored in the two polar point continuum of small to large company. The term smaller and larger company purely describing the side of the continuum. The results are shown in Figure 3 in which fabricated metal industry, Construction and material industry and chemical and pharmaceutical industry led with a mean score of 4.0. The lowest was plastic, packaging and stationery industry with a mean score of 2.

Figure 3: Capital invested in terms of sub-sectors.



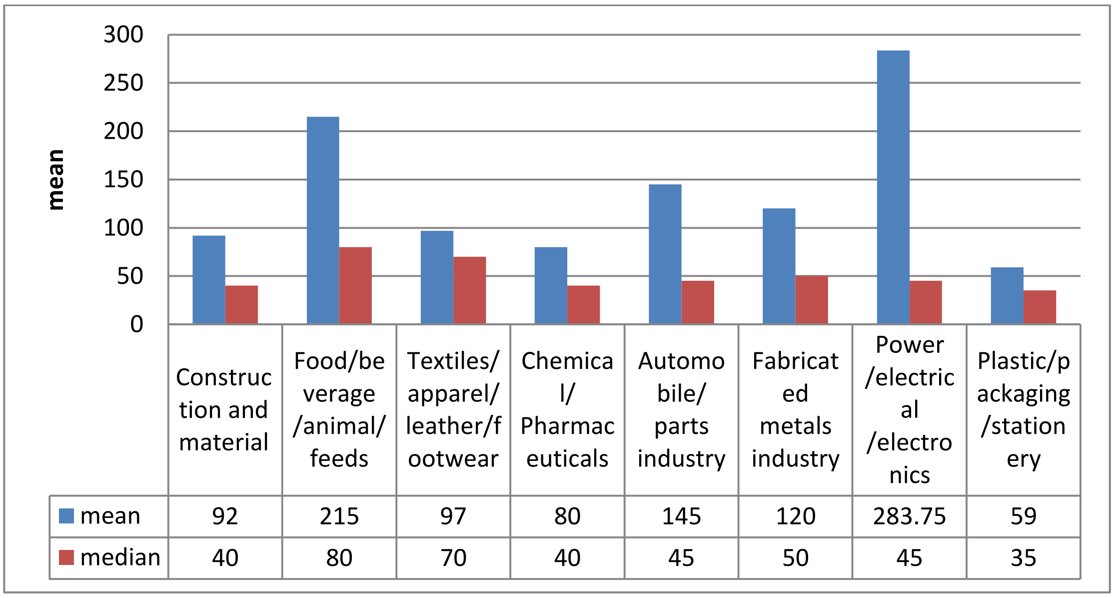
	Construction and material industry	Food, beverage and animal feeds industry	Textiles, apparel, leather and footwear	Chemical and Pharmaceuticals industry	Automobile and parts industry	Fabricated metals industry	Power/electrical/electronics	Pastic/packaging/stationery
mean	4	3	2.25	4	3.75	4	3	2
median	3.75	2.5	2	3.75	3.25	3.75	3	2

4.3.2 Workforce Number

Informal and precarious forms of employment have gained momentum in the manufacturing industry in Kenya. The industry has evolved towards employment of a diverse pool of irregular, flexible or casual workers with no formal labor contracts and employment benefits. Most of these employment effects have been witnessed during the period of intense trade liberalization and openness. This may have been largely undertaken as a cost-cutting strategy as casual workers usually do not enjoy fringe benefits or other employment benefits such as house allowance, medical allowance and so on. The study used the full-time equivalent (FTE) employees as the number of employees, where two part-time employees were equal to one full-time employee.

To have a more credible data all the respondents in this study were on full-time basis and had worked in their respective company for more than 5 years. From Figure 4, it is observable that, on average, companies in the power generation, electrical/electronic industry were the largest and employed more than twice the AMT companies average. The mean and median number of employees were284and 130respectively.Companies in the plastics, packaging and stationery industry had the highest part-time workers and the lowest FTE with a mean of 59 and a median of 45.

Figure 4: Workforce number by Sub-Sector



	Construction and material	Food/beverage/animal/feeds	Textiles/apparel/leather/footwear	Chemical/Pharmaceuticals	Automobile/parts industry	Fabricated metals industry	Power/electrical/electronics	Plastic/packaging/stationery
mean	92	215	97	80	145	120	283.75	59
median	40	80	70	40	45	50	45	35

As the median workforce number across all sub-sectors was around 50, it indicated the presence of some very large companies which were pulling the whole sector average up. This was mostly in power generation, electrical/electronic industry as well as food, beverage and animal feed industry suggesting that a few giant companies were present in these sub-sectors. This suggested that these two sub-sectors had oligopolistic tendencies dominated by a few giant corporations.

4.3.3 Company Size Index

Company size index was based on the average score of the invested capital and workforce number. As regards workforce number the largest number of employees by sector was at a mean of 283.75 and the lowest at a mean of 59. Therefore to calculate Company size score on 1-5 polar scale, then the scale was based on these two extremes and scale a of 1 was selected for51 – 100 employees, 2for 101-150 employees, 3 for 151-200 employees, 4 for 201 – 250 employees and 5 for over 250 employees. Calculation of Company size index score was as per the equation below.

Company Size Index (CSI) = $(X_{01} + X_{02})/2$where

X_{01}= Capital invested score
X_{02}= Workforce number score

The results of this equation by Sub-Sector are as shown in Table 8.

Table 8: Company size index by sub-sector

Category	Employees	Work force score	Capital Invested Score	Company size index
Construction/ material	92	1	4	2.50
Food/ beverage/animal feeds	215	4	3	3.50
Textiles/ apparel/ leather/footwear	97	1	2.5	1.75
Chemical/Pharmaceuticals	80	1	4	2.50
Automobile/parts industry	145	2	3.75	2.88
Fabricated metals industry	120	2	4	3.00
Power generation/electrical/electronic	283.75	5	3	4.00
Plastics, packaging and stationery	59	1	2	1.50

The results showed that power generation, electrical/electronic industry was leading with a mean score of 4 followed by food, beverage and animal feeds industry with a mean score of 3.5. The lowest score was registered by plastic, packaging and stationery industry with a mean score of 1.5. It is important to note that plastic, packaging and stationery industry registered the highest number, about 50%, of part-time employees.

4.4 Advanced Manufacturing Technologies (AMTs) Adoption

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 investigated 14 types of AMTs which are commonly used by AMT companies. These technologies were grouped, based on their functionalities, into 5 domains namely; Product Design and Engineering Technologies (PDETs), Production Planning Technologies (PPTs), Material Handling Technologies (MHTs), Assembly and Machinery Technologies (AsMTs) and Integrated Manufacturing Technologies (IMTs).

Analyses of the AMTs adoption of the companies surveyed was based on the level of investment of the technology and the level of integration. For Level of investment respondents were asked to indicate the amount of investment the company had made in the individual technology, on a Likert scale of 1-5, where 1 indicated little investment, 2 indicated some investments, 3 indicated moderate investment, 4 indicated substantial investment and 5 indicated heavy investment.

The level of integration was determined by ascertaining whether the piece of technology was connected to another appliance or system within the department, company or the enterprise, or it was just a stand-alone equipment. Companies were asked to indicate the level of integration, on a Likert scale of 1-5, where 1 indicated no integration (the technology was controlled by a dedicated software/system not linked to other application system within the production/operations department), 2 indicated limited integration (the technology is integrated within production or operations functions or production design or production planning or to logistics), 3 indicated moderate integration (the technology is integrated within production and operations functions or production design and production planning), 4 indicated full integration (the technology is integrated with other systems from other departments within the organization other than those in production) and 5 indicated extended integration (the technology is integrated within the organization and extended to external organizations like suppliers and customers).

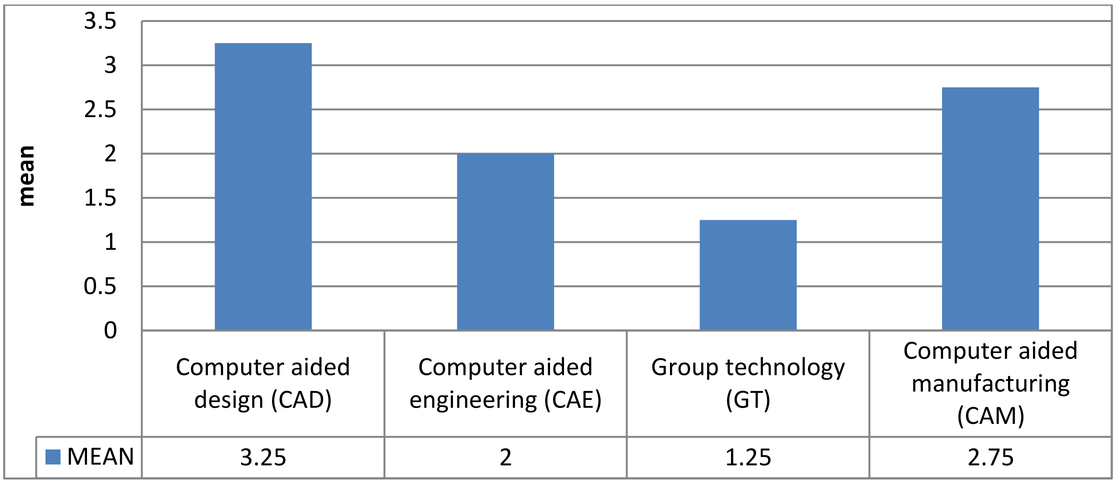
4.4.1 Product Design and Engineering Technologies (PDETs)

Four technologies were identified in the literature in this domain. These technologies included computer-aided design (CAD), computer-aided engineering (CAE), computer-aided manufacturing (CAM) and group technology (GT). Manufacturing companies used these technologies in designing and testing products, controlling of manufacturing machinery and also in part classifications and coding systems.

4.4.1.1 Investment in Product Design and Engineering Technologies

Figure 5shows the mean scores of companies which had made actual investments in each product design and engineering technology (PDET). It shows that the most common product design and engineering technology (PDET)among the companies surveyed is Computer aided design (CAD), which received above moderate investments with a mean score of3.25; followed by computer aided manufacturing (CAM), with mean score of 2.75. The results showed that the least invested was group technology (GT)with mean score of 1.25.

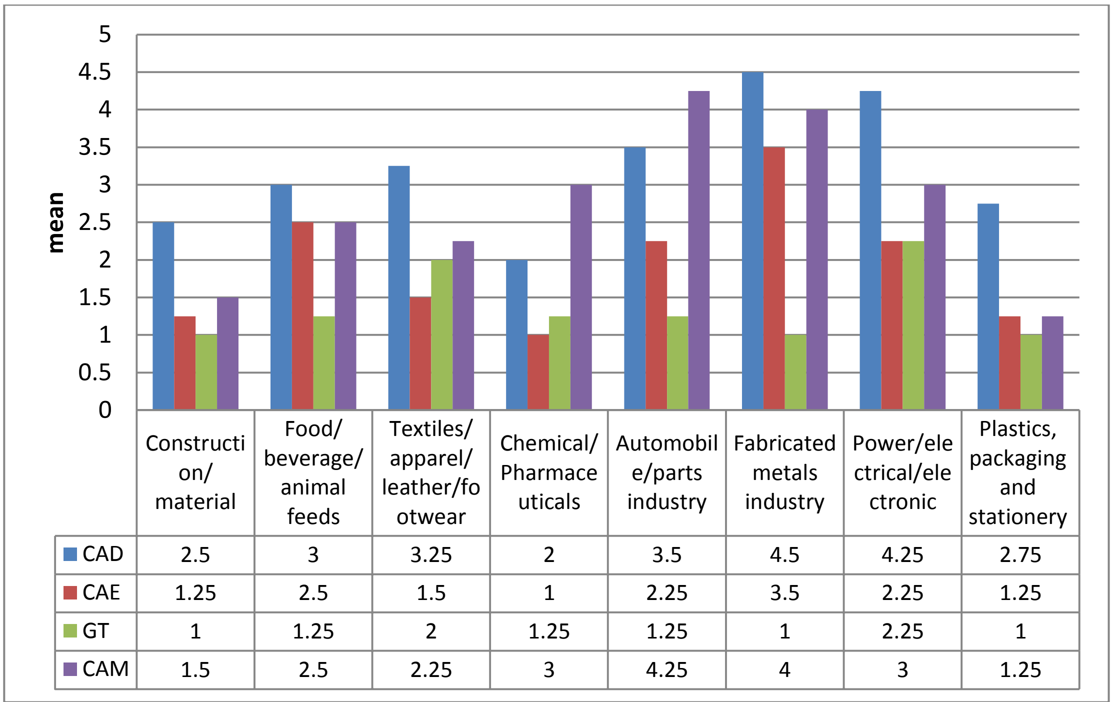
Figure 5: Investments in Product Design and Engineering Technologies



	Computer aided design (CAD)	Computer aided engineering (CAE)	Group technology (GT)	Computer aided manufacturing (CAM)
MEAN	3.25	2	1.25	2.75

Figure 6 shows that investment in computer aided design (CAD) took the most important position while group technology (GT)was worth the least. Per Sub-Sector, Fabricated metal industry relied on computer aided design (CAD) the most, followed by the Automobile and parts industry. Similarly, computer aided engineering (CAE) was relatively more important in the Fabricated metal industry and least important in chemical and pharmaceutical industry. Automobile and parts industry registered the highest mean score, 4.25, in computer aided manufacturing and on the same technology plastics, packaging and stationery registered the lowest mean score, 1.25.

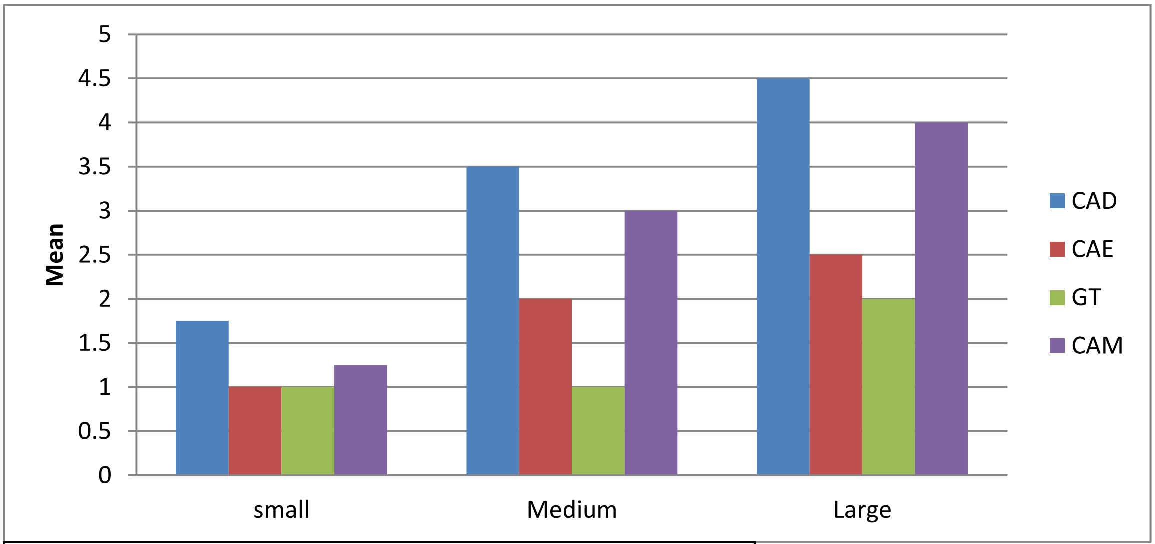
Figure 6: Investments of product design and engineering technologies by Sub-Sector



	Construction/ material	Food/ beverage/ animal feeds	Textiles/ apparel/ leather/footwear	Chemical/ Pharmaceuticals	Automobile/parts industry	Fabricated metals industry	Power/electrical/electronic	Plastics, packaging and stationery
CAD	2.5	3	3.25	2	3.5	4.5	4.25	2.75
CAE	1.25	2.5	1.5	1	2.25	3.5	2.25	1.25
GT	1	1.25	2	1.25	1.25	1	2.25	1
CAM	1.5	2.5	2.25	3	4.25	4	3	1.25

Comparison of the mean score of the product design and engineering technologies (PDET) investments with the employment band, as shown in the Figure 7, revealed that all surveyed companies invested the most in computer aided design (CAD) and computer aided manufacturing (CAM). The scale of these investments was found to increase with company size.

Figure 7: Investments of product design and engineering technologies by size



Legend.
CAD – Computer aided design
CAE – Computer aided engineering
GT – Group technology
CAM – Computer aided Manufacturing

4.4.1.2 Integration of Product Design and Engineering Technologies

Overall, the results showed that the levels of integration in product design and engineering technologies (PDETs) were limited. The mean score of PDET integration with the company's age bands and Sub-Sector showed that the levels of integration are low, with a mean score of less than 2.5. In terms of the individual product design and engineering technology (PDET), almost 90 percent of the respondents that invested moderately in computer aided design (CAD), had either stand alone, no integration, or only integrated within the department. It is the same scenario for computer aided engineering (CAE) where 66% of companies surveyed had little to moderate integrations. Majority of the companies that invested in this technology, about 80%, had the technology either with limited or no integration. Of the few companies that invested in GT (with mean score around 2), only 20% stated to have up to limited integration. The rest had not integrated the technology.

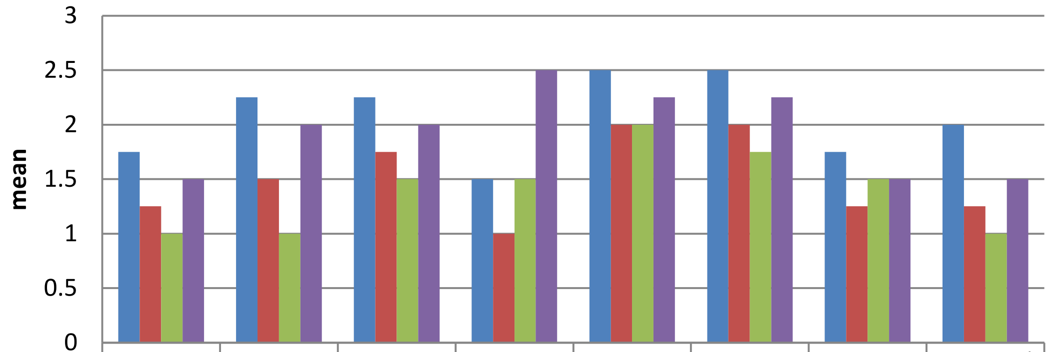
The most integrated piece of product design and engineering technology (PDETs)among the invested product design and engineering technologies was computer aided manufacturing (CAM). Among the companies that had invested in computer aided manufacturing(CAM), 19% integrated computer aided manufacturing within the company, and 4%of the companies extended computer aided manufacturing (CAM) integration to suppliers or customers. Table 9 shows computer aided manufacturing (CAM) investment and computer aided manufacturing (CAM) integration cross-tabulation. 23 companies among the 29 that indicated little investment in computer aided manufacturing did not integrate the technology into the system. 4 of them indicated limited integration and the remaining 2 showed moderate integration.

Table 9: CAM investment and CAM integration cross tabulation

		CAM Integration					Total
		none	limited	moderate	Fully	Extended	
CAM Investment	little	23	4	2	0	0	29
	some	6	4	3	1	0	14
	moderate	3	9	4	5	0	21
	substantial	2	1	5	4	0	17
	Heavy	1	2	3	2	3	11
Total		35	20	17	12	3	92

Figure 8 compares integration mean score of product design and engineering technologies with Sub-Sectors. The results showed that among the invested technologies in these domain Automobile and parts industry had the highest integration with mean score of 2.1875 followed by fabricated metal industry that had a mean score of 2.125. Construction and material industry had the lowest mean score of 1.375.

Figure 8: Integration of Product Design and Engineering Technologies by Sub-Sector



	Construction and material	Food/beverage /animal/feeds	Textiles/ apparel/ leather/footwear	Chemical / Pharmaceuticals	Automobile/ parts industry	Fabricated metals industry	Power /electrical /electronics	Plastics/ packaging / stationery
CAD	1.75	2.25	2.25	1.5	2.5	2.5	1.75	2
CAE	1.25	1.5	1.75	1	2	2	1.25	1.25
GT	1	1	1.5	1.5	2	1.75	1.5	1
CAM	1.5	2	2	2.5	2.25	2.25	1.5	1.5

Legend.
CAD – Computer aided design
CAE – Computer aided engineering
GT – Group technology
CAM – Computer aided Manufacturing

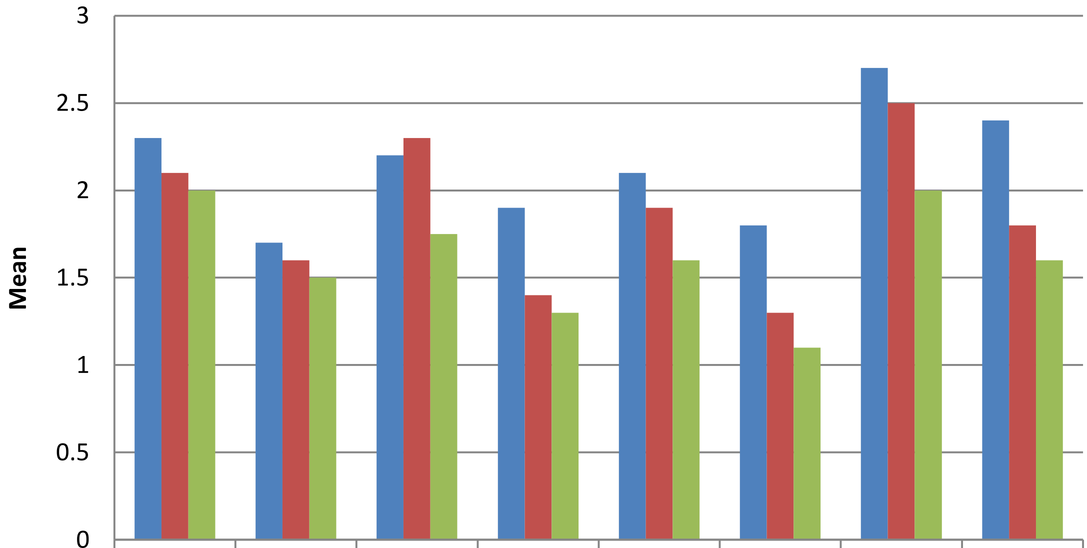
4.4.2 Production Planning Technologies (PPTs)

Three 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). 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.

4.4.2.1 Investment in Production Planning Technologies

The whole advanced manufacturing industry seemed to have similar trend on the investments in production planning technologies (PPTs). As shown in Figure 9, 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 were MRP, MRPII and ERP. The result showed that surveyed companies were still very much at the early version of the material requirements planning tool.

Figure 9. Investment in Production Planning Technologies by Sub-Sectors

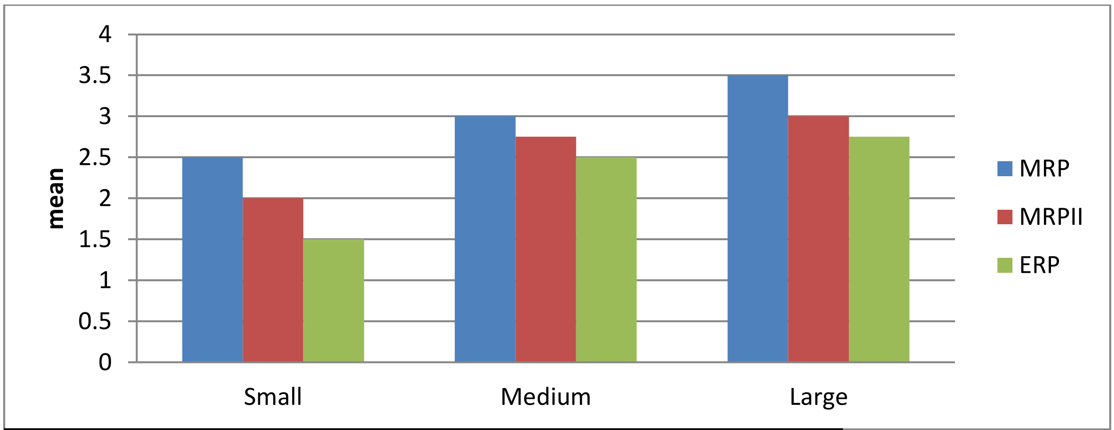


	Construction and material industry	Food, beverage and animal feeds industry	Textiles, apparel, leather and foot ware	Chemical and Pharmaceuticals industry	Automobile and parts industry	Fabricated metals industry	Power generation and electrical appliance	Plastic/Packaging/Staionary
MRP	2.3	1.7	2.2	1.9	2.1	1.8	2.7	2.4
MRPII	2.1	1.6	2.3	1.4	1.9	1.3	2.5	1.8
ERP	2	1.5	1.75	1.3	1.6	1.1	2	1.6

Legend.
MRP – material requirement planning
MRP II – manufacturing resources planning
ERP – enterprise resources planning

Investment of Production Planning Technologies among the surveyed companies, based on their size, revealed that the larger the company the more likely they will invest in Production Planning Technologies. Therefore the scale of investment grew with the size of the company. As shown in Figure 10 small companies had a mean score of 2, while medium companies had a mean score of 2.75 and large companies had a mean score of 3.08.

Figure 10: Investments in Production Planning Technologies with Company Size.

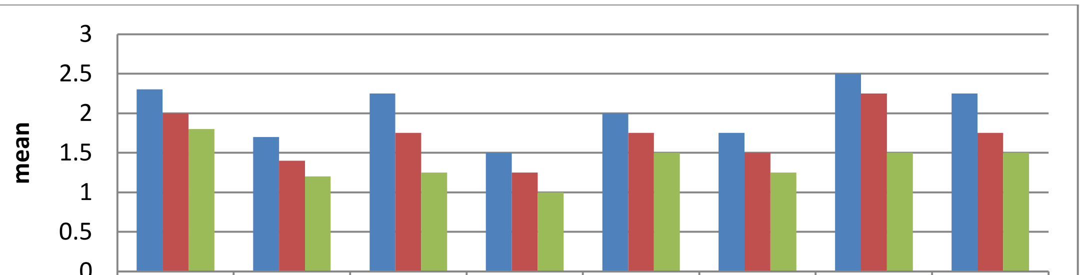


Legend.	MRP	–	material requirement planning
	MRP II	–	manufacturing resources planning
	ERP	–	enterprise resources planning

4.4.2.2 Integration of Production Planning Technologies

Generally, the level of integration for production planning technologies of companies surveyed was limited, with a mean score of 2, showing that integration was only within the department. As shown in Figure 11, power generation/electrical/electronic industry had slightly more integration compared to other manufacturing industries, with material requirement planning (MRP) and manufacturing resources planning(MRPII) above a mean of 2. Chemical and pharmaceutical industries had the least integration, with a mean score of 1.25.

Figure 11: Integration of Production Planning Technologies by Sub-Sector

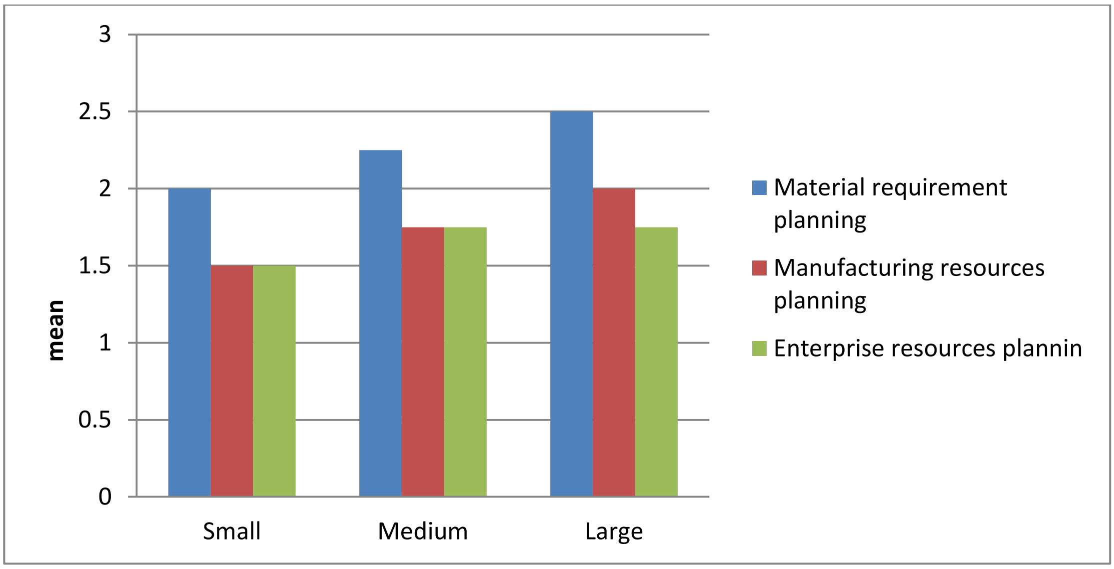


	Construction and material	Food/beverage/animal/feeds	Textiles/apparel/leather/footwear	Chemical/Pharmaceuticals	Automobile/parts industry	Fabricated metals industry	Power/electrical/electronics	Plastics/packaging/stationery
MRPI	2.3	1.7	2.25	1.5	2	1.75	2.5	2.25
MRPII	2	1.4	1.75	1.25	1.75	1.5	2.25	1.75
ERP	1.8	1.2	1.25	1	1.5	1.25	1.5	1.5

Legend.	MRP	–	material requirement planning
	MRP II	–	manufacturing resources planning
	ERP	–	enterprise resources planning

The majority of companies who invested in production planning technologies had a measure of no integration to limited integration with the ranking of scores of the three technologies not different from their investment pattern. The study also revealed that larger companies integrated their production planning technologies more than smaller companies. As shown from Figure 12 the mean scores for smaller companies were between 1.5 to 2 for all the production planning technologies, as compared to larger companies which had mean scores of all production planning technologies between 1.75 to 2.5.Medium companies had mean scores between 1.75 to 2.25.

Figure 12: Integration of Production Planning Technologies by Company Size



In terms of the individual production planning technologies, material requirement planning (MRP), was the most invested and the most integrated by companies surveyed. As shown in Table 10, the figures show that there was a positive relationship between the level of material requirement planning (MRP) investment and the extent of integration. Out of the 27 companies that showed little investment in material requirement planning (MRP), 22 indicated no integration, 4 indicated limited integration and only 1 that indicated moderate integration. The results showed that among the companies that had heavy investment in material requirement planning (MRP) only 1out of the 33 had extended it to suppliers and or customers.

Table 10: MRP investment and MRP integration cross tabulation

		MRP Integration					Total
		none	limited	moderate	Fully	Extended	
MRP Investment	little	22	4	1	0	0	27
	some	5	5	1	0	0	11
	moderate	3	7	8	2	1	21
	substantial	2	3	10	4	1	20
	Heavy	1	0	8	3	1	13
Total		33	33	19	28	9	92

As shown in Table 11, of those who invested in some levels of manufacturing resources planning (MRP II), only 20 invested substantially and heavily and the majority of them (12) fell under no integration. In general, 69 of those companies that invested in manufacturing resources planning (MRP II) did not integrate it in the company but operated it as a stand-alone.

Table 11: MRPII investment and MRPII integration cross tabulation

		MRP II Integration					Total
		none	limited	moderate	Fully	Extended	
MRP II Investment	little	34	2	1	0	0	37
	some	13	5	2	0	0	20
	moderate	10	4	1	0	0	15
	substantial	8	2	2	1	0	13
	Heavy	4	2	1	0	0	7
Total		69	15	7	1	0	92

The result also shows that enterprise resource planning (ERP)was less popular among the companies surveyed. The number of companies that invested and integrated enterprise resource planning (ERP) was significantly low. Companies either made little to moderate investment with no integration to limited integration.

Table 12: ERP investment and ERP integration cross tabulation

		ERP Integration					Total
		none	limited	Moderate	Fully	Extended	
ERP Investment	little	49	2	1	1	0	53
	some	15	6	1	1	0	23
	moderate	8	4	1	0	0	13
	substantial	2	1	0	0	0	3
	Heavy	0	0	0	0	0	0
Total		74	13	3	2	0	92

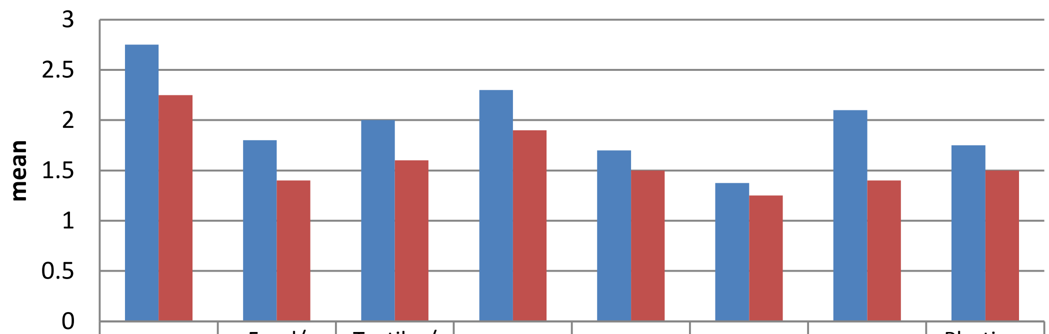
4.4.3 Material Handling Technologies (MHTs)

Two technologies were identified in literature in this domain. Material handling technologies (MHTs) are AMTs used by manufacturing companies to facilitate the handling of material in manufacturing operations. Automated storage and retrieval systems (ASRS) use computers to direct automatic loaders to pick and place items for production processes or storage by automatic high-lift trucks. Companies employ transport automation by using automated guided vehicles (AGVs) to move materials to and from value adding operations.

4.4.3.1 Investment in Material Handling Technologies

The study showed that on average companies surveyed had little investments in Material handling technologies (MHTs). Generally, companies invested more in automated storage and retrieval systems (ASRS) in comparison with automated guided vehicles (AGVs). In terms of Sub-Sectors, Figure 13 shows that construction and material industry ranks the highest in material handling technologies (MHTs) investments but had less than moderate investment in automated storage and retrieval systems (ASRS). Fabricated metal industry had the lowest investment in automated storage and retrieval systems (ASRS) with a mean score of 1.375. Automated guided vehicles (AGVs) investment was slightly lower than automated storage and retrieval systems (ASRS) investment. The leading industry, construction and material industry had a mean score of 2.25. The least investment in automated guided vehicles (AGVs) was in fabricated metal industry with almost negligible investment, that is, a mean score of 1.25.

Figure 13: Investment of Material Handling Technologies by Sub-Sector

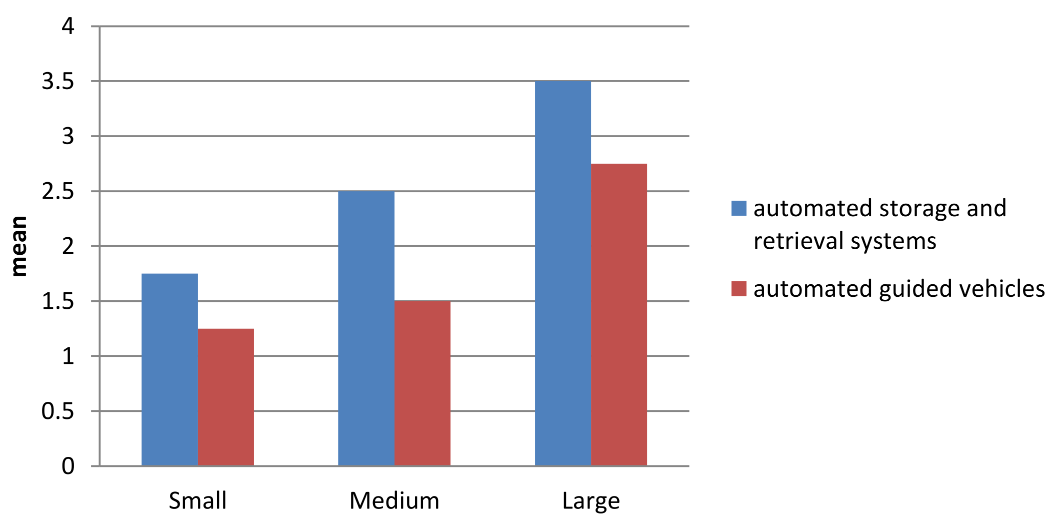


	Construction/ material	Food/ beverage/ animal feeds	Textiles/ apparel/ leather/footwear	Chemical/ Pharmaceuticals	Automobile/parts industry	Fabricated metals industry	Power/electrical/electronic	Plastics, packaging and stationery
ASRS	2.75	1.8	2	2.3	1.7	1.375	2.1	1.75
AGV	2.25	1.4	1.6	1.9	1.5	1.25	1.4	1.5

Legend.
ASRS – automated storage and retrieval systems
AGV – automated guided vehicles

In terms of the pattern of investment by the size of the company, larger companies tended to invest slightly more in material handling technologies (MHTs) as compared to smaller companies. However, the mean score of investment of material handling technologies (MHTs) for large companies was between 2.75 to 3.5 as compared to small companies with little investment (that is, a mean score of 1.5). Figure 14 shows mean Score of material handling technologies (MHTs) investment by company size.

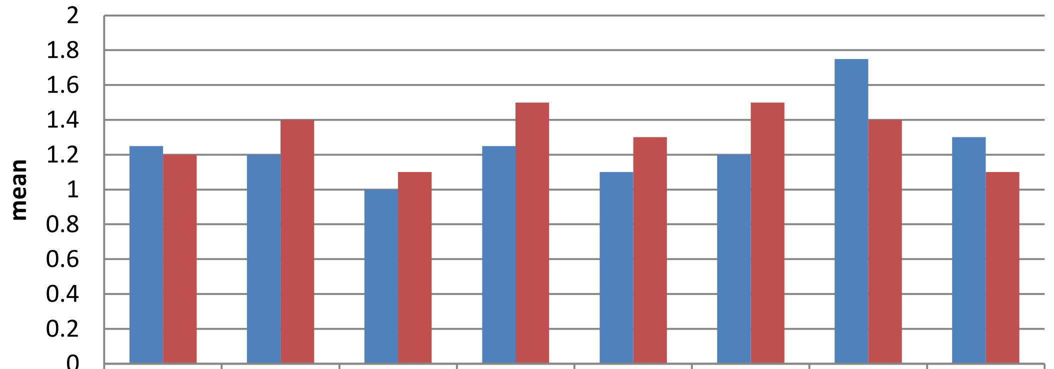
Figure 14: Investment of Material Handling Technologies by Company Size



4.4.3.2 Integration of Material Handling Technologies

In general, the level of integration of material handling technologies (MHTs)was virtually no integration. Figure 15 shows that material handling technology was either in a stand-alone mode or only linked within the department. When comparing the level of integration of material handling technologies (MHTs) by type of Sub-Sector, all industries had almost the same level of integration. Power generation, electrical and electronics industry, integrated its automated storage and retrieval systems almost within the department (mean score of 1.75). The other industries did not integrate their material handling technologies (MHTs).

Figure 15: Integration of Material Handling Technologies by Sub-Sector



	Construction/ material	Food/ beverage /animal feeds	Textiles/ apparel/ leather/footwear	Chemical /Pharmaceuticals	Automobile/parts industry	Fabricated metals industry	Power/electrical/ electronic	Plastics, packaging and stationery
ASRS	1.25	1.2	1	1.25	1.1	1.2	1.75	1.3
AGV	1.2	1.4	1.1	1.5	1.3	1.5	1.4	1.1

Legend.
ASRS – automated storage and retrieval systems
AGV – automated guided vehicles

Larger and older companies tended to integrate their automated storage and retrieval systems (ASRSs) further than younger and smaller companies. The automated guided vehicle (AGV) was a stand-alone piece of technology in many companies. In conclusion, the study showed that both the level of investments and integration of material handling technologies in the companies surveyed were very limited.

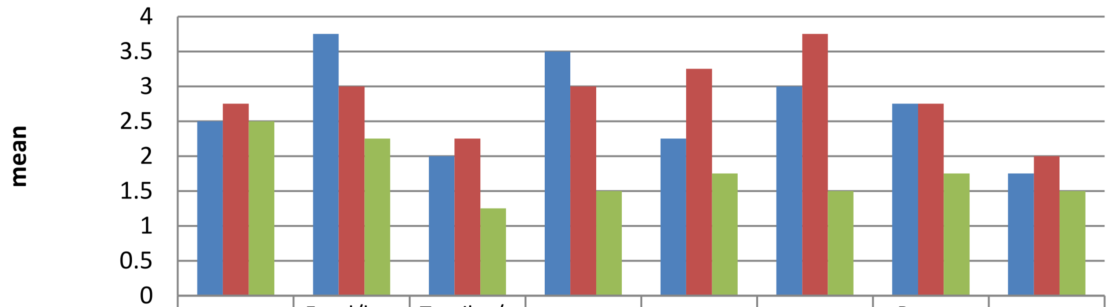
4.4.4 Assembly and Machining Technologies (AsMTs)

The study examined the level of investment and integration of 3 types of assembly and machining technologies (AsMTs); computer-aided quality control system (CAQCS), robotics and numerical control machines (NC/CNC/DNC). These assembly and machining technologies are used to perform repetitive functions and work without permanent alteration of the equipment. Computer-aided quality control system (CAQCS) is used to perform quality inspection on incoming or final materials, 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.

4.4.4.1 Investment in Assembly and Machining Technologies

Generally, industries invested the most in numerical control machines technologies. Figure 16 shows that food, beverage and animal feed industry, fabricated metal industry, automobile and parts industry and the chemical and pharmaceutical industry invested more (with a mean score of 3) in numerical control machines (NC/CNC/DNC) than the other industries. The investment in numerical control machines for other industries was less than moderate, the least being plastic and packaging and stationery industry with a mean score of 2. Investments in computer-aided quality control system (CAQCS) were limited, except for food, beverage and animal feed industry and fabricated metal industry. The least invested technology in this domain was in robotics technology with a mean score of 1.75.

Figure 16: Investment in Assembly and Machinery Technologies by Sub-Sector

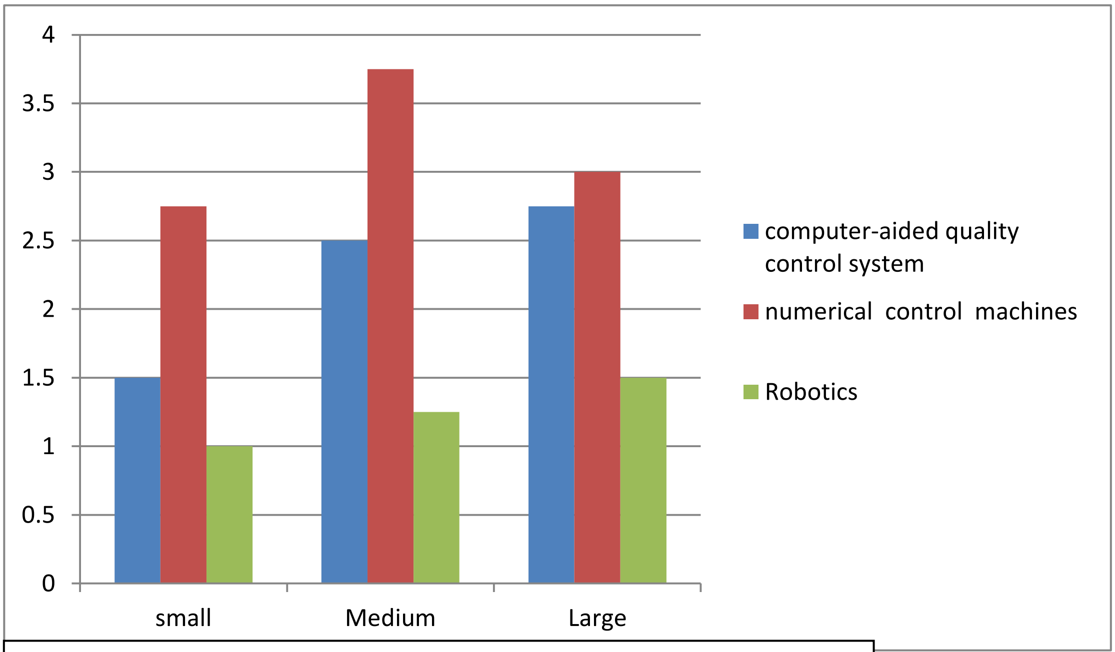


	Construction and material	Food/beverage/animal/feeds	Textiles/apparel/leather/footwear	Chemical/Pharmaceuticals	Automobile/ parts industry	Fabricated metals industry	Power/electrical/electronics	Plastics/packaging / stationery
CAQC	2.5	3.75	2	3.5	2.25	3	2.75	1.75
NC/CNC/DCN	2.75	3	2.25	3	3.25	3.75	2.75	2
Robotics	2.5	2.25	1.25	1.5	1.75	1.5	1.75	1.5

Figure 17 shows that regardless of the size of the company, most investments are made in numerical control machines technologies, followed by computer-aided quality control system technology and last robotics technology. Worth noting is that medium sized companies made substantial investments in numerical control machines technologies, significantly more than companies of the other sizes. For robotics and computer-aided quality control system technologies, investment in these technologies grew with company size.

It was also observed that investment in robotics and computer-aided quality control system technologies increased with age bands. Investments from companies younger than 10 years were among the lowest level in assembly and machinery technologies.

Figure 17: Investment in Assembly and Machinery Technologies by Company Size

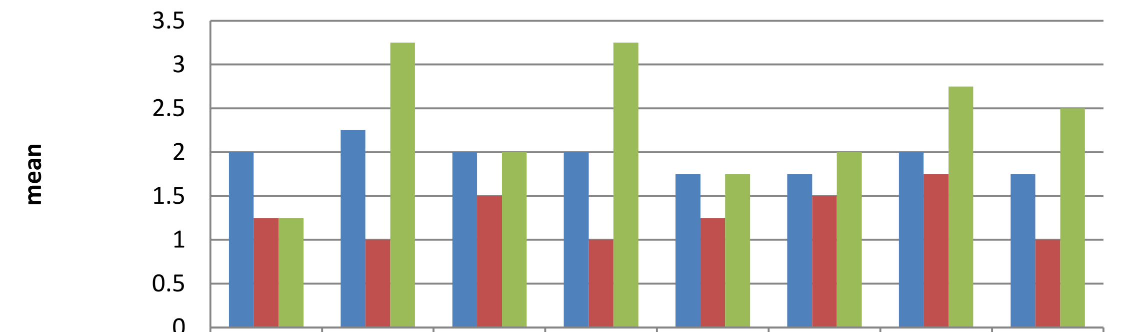


Legend.
NC/CNC/DNC – numerical control machines
CAQCS – computer-aided quality control system

4.4.4.2 Integration of Assembly and Machinery Technologies

Levels of integration of assembly and machining technologies (AsMTs) were limited. Figure 18 shows that from the highest to the lowest mean scores of integration levels were numerical control machines, computer-aided quality control system and robotics technology. Integration of computer-aided quality control system CAQCS was on the highest level in the food, beverage and animal feed industry. Power generation, electrical/electronics industry made the most integration in robotics as compared to other industries.

Figure 18: Integration of Assembly and Machinery Technologies by Sub-Sector



	Construction and material	Food/beverage/animal/feeds	Textiles/apparel/leather/footwear	Chemical/Pharmaceuticals	Automobile/parts industry	Fabricated metals industry	Power/electrical/electronics	Plastics/packaging/stationery
CAQCS	2	2.25	2	2	1.75	1.75	2	1.75
Robotics	1.25	1	1.5	1	1.25	1.5	1.75	1
NC/CNC/DCN	1.25	3.25	2	3.25	1.75	2	2.75	2.5

Legend.
NC/CNC/DNC – numerical control machines
CAQCS – computer-aided quality control system

From the data it was observed that levels of integration of AsMTs increased with company size, except that large sized companies made the most integration in numerical control technologies (NC/CNC/DNC). This result was contrary to the situation of investments analyzed by size where medium sized companies were leading. For computer-aided quality control system and robotics technologies, surveyed companies made slightly less integration. Even so, overall integration for either type of technology increased with size. The study revealed that integration of AsMTs increased with business years.

Table 13 shows that further investigation of computer-aided quality control system (CAQCS) revealed that most companies that invested in computer-aided quality control system (CAQCS) fell under little investment with no integration combination. The majority of the surveyed companies that invested in computer-aided quality control system had limited investment in their computer-aided quality control system and none in limited integration. There were 2 companies that substantially invested and fully integrated the technology. One company substantially invested and extended computer-aided quality control system (CAQCS) integration to supplier or customers. One company invested heavily and made full integration.

Table 13: CAQCS Investment and CAQCS Integration Cross Tabulation

		CAQCS Integration					Total
		none	limited	moderate	Fully	Extended	
CAQCS Investment	little	35	4	2	0	0	36
	some	20	8	2	1	0	31
	moderate	3	4	3	3	1	14
	substantial	2	2	2	2	1	9
	Heavy	0	0	1	1	0	2
Total		55	18	10	7	2	92

Table 14 shows the distribution of respondents in terms of the level of investment in robotics and its level of integration. It was observed that there were a limited number of companies that invested and integrated in robotics technology. Among the companies that provided valid answers in this section, 60% of them made little investment and no integration, with less than 25% of them making some measure of integration.

Table 14: Robotics investment and Robotics integration cross-tabulation

		Robotic Integration					**Total**
		none	limited	moderate	Fully	Extended	
Robotic Investment	little	56	2	0	0	0	58
	some	8	2	1	0	0	11
	moderate	5	3	0	0	0	8
	substantial	1	5	1	1	0	8
	Heavy	1	2	2	1	1	6
Total		71	14	4	2	1	92

Table 15 reveals that numerical control machines technology is the most invested in by the respondent companies, with a total of 77% of respondent, having some level of investments. Except for companies who made no integration, the largest group appeared in the combination of substantial investment and limited integration (9), followed by heavy investment and moderate integration (8). Worth noting is that the number of companies who made heavy investment and extended integration to suppliers or customers were 4, while the number of companies who made heavy investment and full integration were 6.

Table 15: NC/CNC/DNC investment and NC/CNC/DNC integration cross-tabulation

		NC/CNC/DNC Integration					**Total**
		none	limited	moderate	Fully	Extended	
NC/CNC/DNC Investment	little	21	1	0	0	0	22
	some	5	4	0	0	0	09
	moderate	5	6	2	1	0	14
	substantial	3	9	5	4	1	22
	Heavy	3	4	8	6	4	25
Total		37	24	15	11	5	92

4.4.5 Integrated Manufacturing Technologies (IMTs)

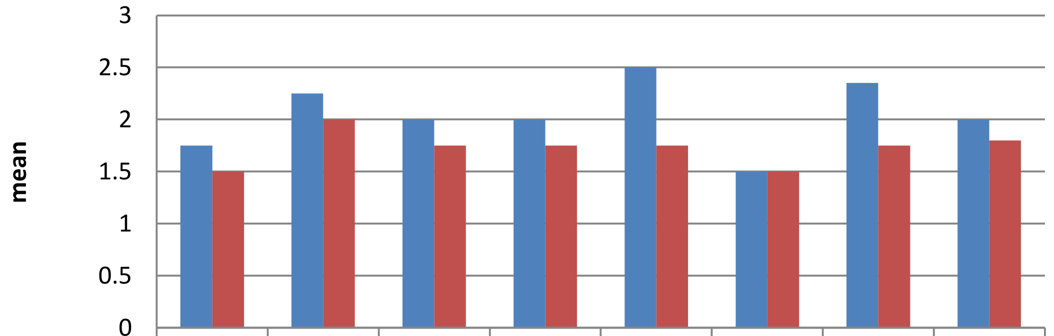
Two technologies were identified in literature in this domain. As the name of the technology group suggests, technologies within this integrated manufacturing technologies (IMTs) group are already integrated in some forms. Flexible manufacturing cells (FMC) or flexible manufacturing systems (FMS) consist of two or more NC/CNC machines which are interconnected by handling devices and a transport system. The difference between FMC and FMS that FMC is capable of single path acceptance of raw materials and single path delivery of a finished product, whilst FMS is capable of multiple paths, and may also comprised two or more FMCs linked in series or parallel.

Another technology within this domain is computer-integrated manufacturing (ClM), which incorporates all elements in the manufacturing process from product design to distribution. It links the company beyond departments by integrating computer systems, thus islands of computer application in the companies are integrated.

4.4.5.1 Investment in Integrated Manufacturing Technologies

Figure19 shows that the mean score of investments in flexible manufacturing cells (FMC)/flexible manufacturing systems (FMS) by surveyed companies was slightly higher than computer-integrated manufacturing (ClM). The FMS/FMC registered a mean score of 2.05 as compared to CIM that registered a mean score of 1.725. It is the same scenario when compared by their Sub-Sectors. For most Sub-Sectors investments in flexible manufacturing cells /flexible manufacturing systems were slightly more than computer-integrated manufacturing.

Figure 19: Investments in Integrated Manufacturing Technologies by Sub-Sector

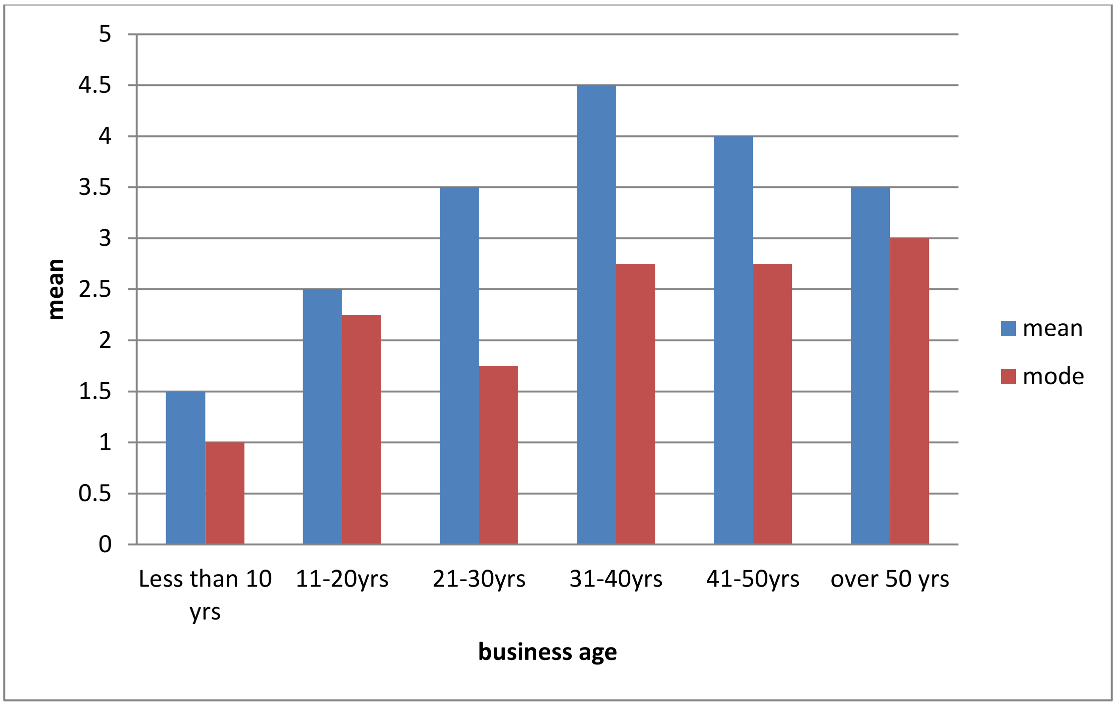


	Construction and material industry	Food, beverage and animal feeds industry	Textiles, apparel, leather and foot ware	Chemical and Pharmaceuticals industry	Automobile and parts industry	Fabricated metals industry	Power generation and electrical/electronics	Packaging, Plastics and stationery
FMC/FMS	1.75	2.25	2	2	2.5	1.5	2.35	2
CIM	1.5	2	1.75	1.75	1.75	1.5	1.75	1.8

Legend.
FMS/FMC – Flexible manufacturing systems/ flexible manufacturing cells
CIM – Computer aided manufacturing

Figure 20 shows that surveyed companies which were less than 10 years invested the least in flexible manufacturing cells/flexible manufacturing systems and computer-integrated manufacturing. Investments by companies in the age band of 31-40yrs were among the highest level. For the other age bands, investments in integrated manufacturing technologies decreased as history of business grew. Companies in the range of 21-30 years and 41 – 50 years were among those who invested almost moderately on integrated manufacturing technologies.

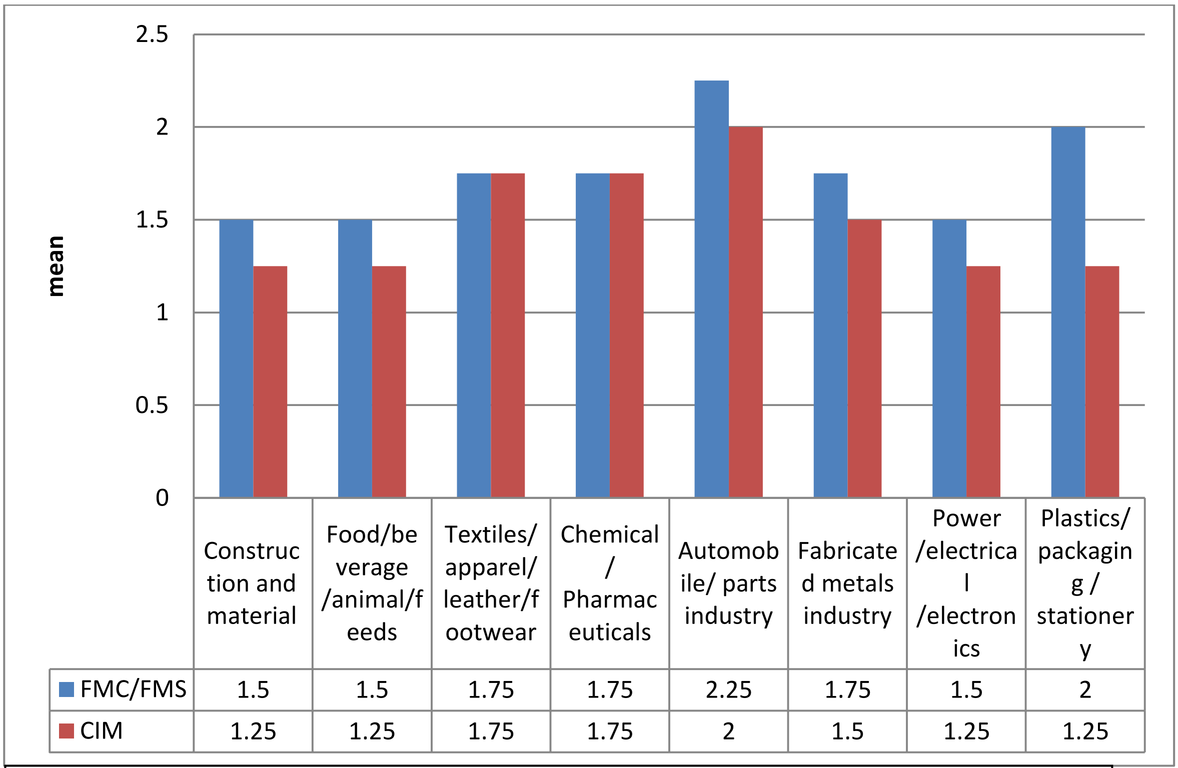
Figure 20: Investment of Integrated Manufacturing Technologies by Age Bands



4.4.5.2 Integration of Integrated Manufacturing Technologies

As the name suggests, one would have thought that integrated manufacturing technologies would be fully or extensively integrated within the company or to include their supply chain. However, the level of integration, as provided by the surveyed companies in Figure 21, is rather low, both at a mean score of 1.75 for flexible manufacturing cells /flexible manufacturing systems, and 1.5 for computer-integrated manufacturing which means that both integrated manufacturing technologies have limited integration. This means that the technology is only limited to the department. Automobile and parts industry registered the highest level of integration for FMC/FMS at a mean score of 2.25 while construction and material industry and food, beverage and animal feed industry registered the lowest at a mean score of 1.5. The highest score for computer-integrated manufacturing (CIM) was automobile and parts industry at a mean score of 2. The rest of the sub-sectors registered low integration ranging from a mean score of 1.75 to a mean score of 1.25.

Figure 21: Integration of Integrated Manufacturing Technologies by Sub-Sectors



Legend.
FMS/FMC – Flexible manufacturing systems/ flexible manufacturing cells
CIM – Computer aided manufacturing

Table 16 shows that more companies had little investment with no integration (33). Only 1 company made substantial investment and extended integration to the suppliers or customers. Five companies made heavy investment and fully integrated flexible manufacturing cells /flexible manufacturing systems .

Table 16: FMC/FMS investment and FMC/FMS integration cross-tabulation

		FMC/FMS Integration					Total
		none	limited	moderate	Fully	Extended	
FMC/FMS Investment	little	33	4	1	0	0	38
	some	6	5	1	0	0	12
	moderate	2	8	4	2	0	16
	substantial	1	5	5	4	1	17
	Heavy	0	2	3	5	0	8
Total		42	24	14	11	1	92

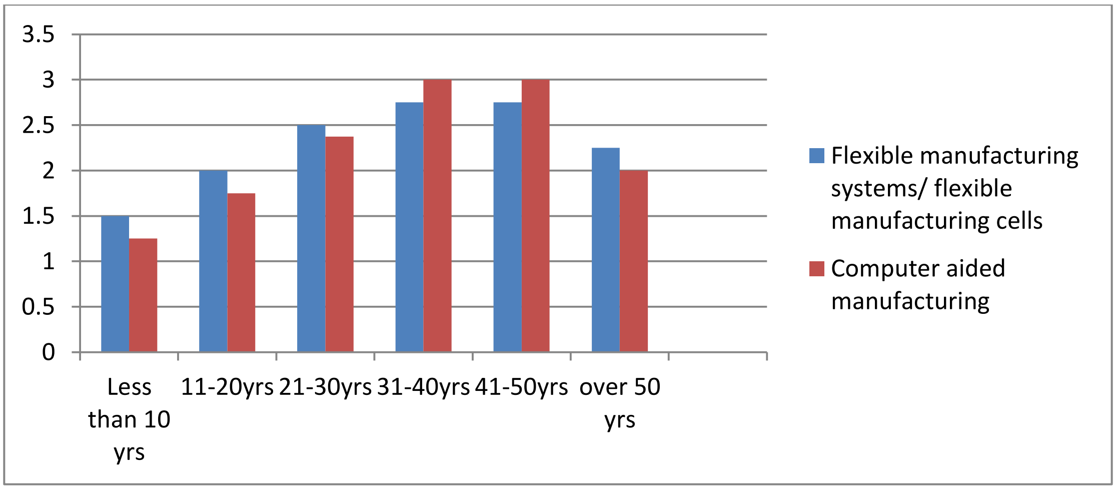
Table 17 shows that few companies made integration in computer-integrated manufacturing. 46 out of a total number of 92 companies surveyed indicated that they made no integration in computer-integrated manufacturing. It was observed that companies that made little investment and did not integrate these technology form the largest group (40), followed by moderate investment with limited integration (8). There were 7 companies which did some investment but made limited integration. 5 companies investment moderate and integrated moderately. Only one company that had heavy investment and extended integration to suppliers or customers in computer-integrated manufacturing.

Table 17: CIM investment and integration cross-tabulation

		CIM Integration					Total
		none	limited	moderate	Fully	Extended	
CIM Investment	little	40	2	2	1	1	46
	some	4	7	1	1	0	13
	moderate	2	8	5	2	1	18
	substantial	0	4	3	2	2	11
	Heavy	0	0	2	1	1	4
Total		46	21	13	7	5	92

Figure 22 shows that the surveyed companies in age bands 31-40 and 41-50 years made more integration in integrated manufacturing technologies than companies in the rest of the age bands. Moreover, interestingly, companies in these two age groups made more integration in CIM than in FMC/FMS which is contrary to the others.

Figure 22: Integration of Integrated Manufacturing Technologies by age band



4.4.6 Generation of AMT index

For the purpose of analysis, the mean scores of AMTs investment and the mean scores of AMT integration of surveyed companies were computed for each of the five domains. These are product design and engineering technology investment mean score (PDETinv) and integration mean score (PDETint), logistics related technology investment mean score (PPTinv) and integration mean score (PPTint), material handling technology investment mean score (MHTinv) and integration mean score (MHTint), assembly and machinery technology investment mean score (AsMTinv) and integration mean score (AsMTint) and integrated manufacturing technology investment mean score (IMTinv) and integration mean score (IMTint).

Below lists the formulae of each investment and integration score for each AMT:-

1. $PDETinv = \frac{1}{4}\ CADinv + CAEinv + GTinv + CAMinv$
2. $PDETint = \frac{1}{4}\ CADint + CAEint + GTinv + CAMint$
3. $PPTinv = \frac{1}{3}\ MRPinv + MRPIIinv + ERPinv$
4. $PPTint = \frac{1}{3}\ MRPint + MRPIIint + ERPint$
5. $MHTinv = \frac{1}{2}\ ASRSinv + AGVinv$
6. $MHTint = \frac{1}{2}\ ASRSint + AGVint$
7. $AsMTinv = \frac{1}{3}\ CAQCinv + ROBOTICSinv + NC/CNC/DCNinv$
8. $AsMTint = \frac{1}{3}\ CAQCint + ROBOTICSint + NC/CNC/DCNint$
9. $IMTinv = \frac{1}{2}\ FMC/FMSinv + CIMinv$
10. $IMTint = \frac{1}{2}\ FMC/FMSint + CIMint$

Table18 shows the summary of AMT score per sub-sector based on the five domains. From the Table, it shows that most investments were made in AsMTs, which were just around the moderate level (mean score 2.43). Production design and engineering technologies ranked second with a mean score of 2.32, followed by production planning technologies (mean score of 1.869). Investment in material handling technologies was the lowest, at the mean score of 1.786. For most sub-sectors, the ranking of the scale of investment in different AMTs varied from sub-sector to sub-sector.

Table 18: AMTs Index per sub-sector

	PDET inv	PDET int	PPT inv	PPT int	MHT inv	MHT int	AsMT inv	AsMT int	IMT inv	IMT int	AMT index
CMI	1.563	1.375	2.133	2.033	2.500	1.225	2.583	1.500	1.625	1.375	**1.791**
FBAFI	2.813	2.188	1.867	1.750	1.600	1.200	2.417	1.583	2.125	2.125	**1.967**
TALFI	2.250	1.875	2.083	1.750	1.800	1.050	1.833	1.833	1.875	1.750	**1.810**
CPI	1.813	1.625	1.533	1.250	2.100	1.375	2.667	2.083	1.875	1.750	**1.807**
API	2.313	1.688	1.600	1.433	1.600	1.300	3.000	2.167	2.125	1.375	**1.860**
FMI	3.250	2.125	1.400	1.500	1.313	1.350	2.750	1.750	1.500	1.625	**1.856**
PGEEI	2.938	1.500	2.400	2.083	1.750	1.575	2.417	2.167	2.050	1.375	**2.025**
PPSI	1.625	1.438	1.933	1.833	1.625	1.200	1.750	1.750	1.900	1.625	**1.668**
Avrg	**2.320**	**1.727**	**1.869**	**1.704**	**1.786**	**1.284**	**2.427**	**1.854**	**1.884**	**1.625**	**1.848**

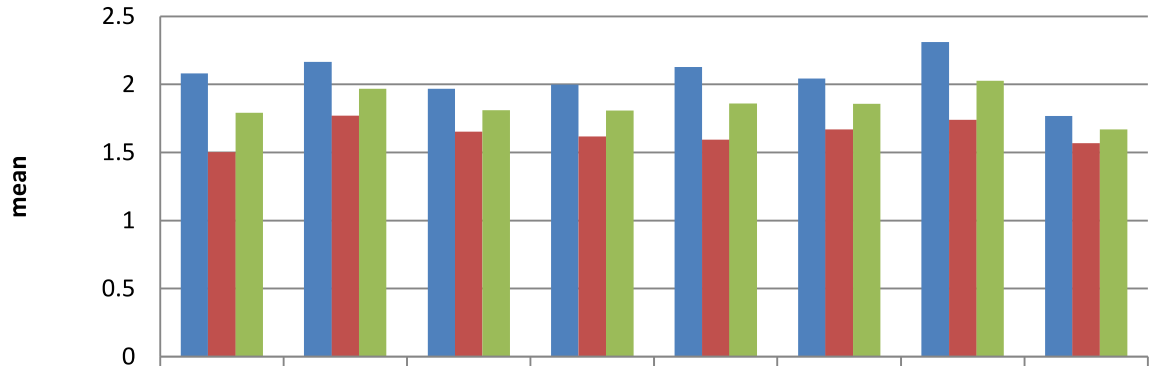
In terms of the sub-sector the level of investment in AMTs showed that power generation, electrical and electronic industry had the highest mean score (2.311) followed by food, beverage and animal feed industry (2.164). Plastic, packaging and stationery had the lowest mean investment scored (1.767). Food, beverage and animal feed industry had the highest mean integration score (1.769) followed by power generation, electrical and electronic industry (1.740). Construction and material industry had the lowest mean integration scored (1.501). The gross mean for invested was 2.0572 and the gross mean for integration was 1.6388.

The score index for AMT for each sub-sector or individual company was calculated as follows:

$$AMTindex = \frac{1}{2}\ AMTinv + AMTint$$

Power generation, electrical and electronic industry had the highest mean AMT index (2.026) followed by food, beverage and animal feed industry (1.967). Plastic, packaging and stationery had the lowest mean AMT index (1.668). It was therefore noted that AMTs adoption in Kenya are still very low (below the mean mark of 3 in a scale of 1-5). Figure 23 shows the AMT score index per sub-sector.

Figure 23: AMT index per Sub-Sector.



	Construction/ material	Food/beverage/animal feed	Textiles/apparel/leather/footwear	Chemical /Pharmaceuticals	Automobile/parts	Fabricated metals	Power generation/electrical appliance	Plastics/packaging/ stationaery
AMTinv	2.081	2.164	1.968	1.997	2.128	2.043	2.311	1.767
AMTint	1.502	1.769	1.652	1.617	1.593	1.670	1.740	1.569
AMTindex	1.792	1.967	1.810	1.807	1.861	1.857	2.026	1.668

4.5 Organizational Structure

Having explored some basic differences in surveyed companies in terms of size and AMTs adoption across the manufacturing sub-sectors, this section focuses on the organizational structure of companies surveyed. Every organization needs a structure in order to operate systematically. The organizational structures must fit into the nature and the maturity of the organization for better performance (Mintzberg, 1979). As identified in the literature organizational structure is basically the formal allocation of work roles and the administrative mechanism to control and integrate work activities (Child & Mansfield, 1972).

By structure the focus in this study is the degree of horizontal differentiation, vertical differentiation, mechanisms of coordination and control, formalization and centralization of decision making power. Literature has also indicated that to achieve greater flexibility of AMT during implementation, changes in organizational structure should be considered(Ghani, 2002; Hajipour *et al*., 2011; Li and Xie, 2012).

This study explored six dimensions of organizational structure orientations identified as; number of sub-units, Levels of authority, Span of control, role programming, communication programming and output programming. Regarding number of sub units, levels of authority, span of control and output programming, information was deduced directly from respondents in section 1 of the instrument. As regards communication programming and role programming the respondents in section 2 of the questionnaire were asked of their perception in regards to the orientations of the dimensions. For each item, respondents were requested to choose a response on a five-point interval scale; anchored at one end with 'not at all' meriting a score of 1, and the other end by 'to a great extent' meriting a score of 5.

4.5.1: Number of Sub-Units

Under the dimension sub-units, which was measured using number of specialized departments in the company, it was found that power generation and electrical and electronics industry had the highest mean sub-units (8) followed by fabricated metal industry (7). Construction/material industry registered the lowest mean (3.5). It was also observed that the importance of sub-units was moderate for small companies as compared to large companies. The data also suggests that the importance of sub-units varied with the age of the company.

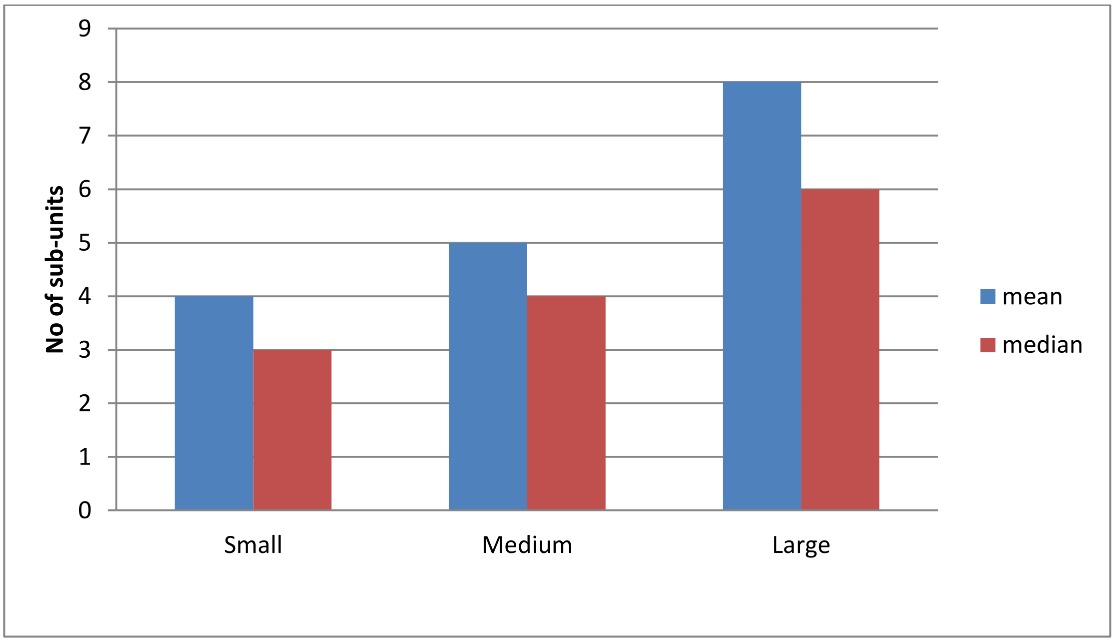
From the data, number of specialized sub-units by company ranged between 3 to 12. Using the five point score scale where 1 is to indicate the lowest organizational index and 5 to indicate the highest organizational index, then a score of 1 was taken for a mean of 3-4sub-units on one end and a score of 5 was taken for a mean of 11-12 on the other end, Table 19 shows the tabulated results in terms of Sub-Sectors.

Table 19: Number of Sub-Units for different AMT manufacturing Sub-Sectors

Sub-sector	Mean	Score value
Construction and material industry	3.5	1
Food, beverage and animal feeds industry	6	2
Textiles, apparel, leather and footwear	5	2
Chemical and Pharmaceuticals industry	4	1
Automobile and parts industry	5	2
Fabricated metals industry	7	3
Power generation and electrical/electronics	8	3
Plastics, packaging and stationery	4	1

The study showed that the number of sub-units depended on the specialization and the size of the company. Companies operating in less specialized products operated more effectively with fewer sub-units. Likewise, companies operating in specialized products had more sub-units. On the other hand small companies had fewer sub-units as compared to larger companies. Virtually all larger companies had research and development and customer/suppliers related departments. The study showed that as the organization grew in size the number of sub-units increased as shown in Figure 24.

Figure 24: Number of Sub-Units by company size



4.5.2 Levels of Authority

In authorizing certain significant activities, particularly in relation to human resources, a manager cannot authorize the activity in relation to his/her direct reports, rather the manager's manager must authorize the activity. The various levels of authority are generally born as a result of the effect of the delegation of the power. According to Mintzberg (1979), the levels of authority are the formally delimited zones of responsibility along the organizational hierarchy. This dimension of organizational structure therefore measures the hierarchical authorities in the production line.

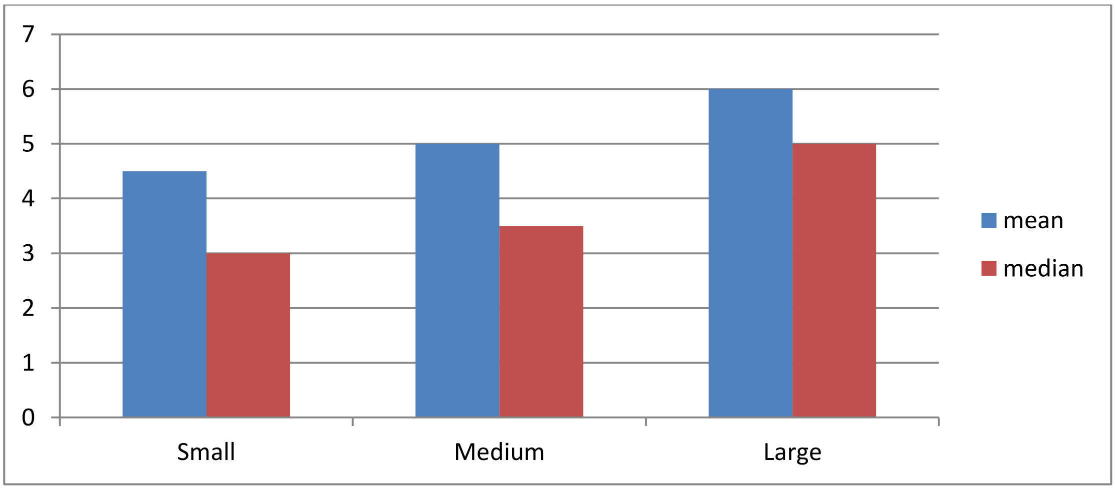
The result of the study showed that, across the eight sub-sectors, the mean number of levels of authority was about 3, which suggested low vertical differentiation. Overall, across the data the lowest registered mean levels of authority was 2 and the highest registered mean levels of authority was 6. By using the lowest and highest number of levels of authority, five point score scale was taken between this two extreme points where 1 indicated a score of 2 on one end and 5 indicated a score of 6 on the other end. Table 20 shows the results by Sub-Sectors.

Table 20: Levels of authority by Sub-Sectors

Sub-sector	Mean	Score value
Construction and material industry	4	3
Food, beverage and animal feeds industry	5	4
Textiles, apparel, leather and footwear	3	2
Chemical and Pharmaceuticals industry	4	3
Automobile and parts industry	5	4
Fabricated metals industry	4	3
Power generation and electrical/electronics	5	4
Plastics, packaging and stationery	3	2

Figure 25 shows that levels of authority increased with size. This is attributed to the fact that as the company grew in size, the division of tasks becomes more complicated and organizations expand their boundaries to allow more levels of authority. For smaller companies tasks are easily coordinated by mutual adjustment but as organizational work becomes more, direct supervision tends to be added and takes over as the primary means of coordination. When tasks get even more complicated, standardization of work processes takes over therefore adding more levels of authority.

Figure 25 : Levels of Authority by Company Size



4.5.3 Span of Control

Span of control is the number of subordinates that a manager or supervisor can directly control (Mintzberg, 1979). This number varies with the type of work: complex, variable work reduces the span of control; whereas routine, fixed work increases it. A manager or supervisor is defined as an incumbent of the organization charged with the responsibility of overseeing and coordinating the work of others in the organization (Child & Mansfield, 1972). Essentially this is the ratio of employees to managers. The span of control of the average manager in an organization determines horizontal differentiation of the organization. Small span of control will result in a taller organizational chart, with more management positions relative to the number of individual contributors. A higher span of control will result in a flatter or wider chart, with fewer management positions relative to the number of individual contributors.

It was assumed in the study that each sub-unit was controlled by one manager/supervisor. In the study the highest mean of number of employees was 284 in power generation electrical/electronics industry and the number of sub-units in this sub-sector was found to be 8. Therefore the largest number of employees controlled by a single manager was calculated as about 35.5. The score scale was based on this figure and scale of 1 was selected as 1 manager for 36 people; scale of 2 as 2 managers for 36 people; scale of 3 as 3 managers for 36 people; scale of 4 as 4 managers for 36 people; and a scale of 5 for 5 manager for 36 people. The results are shown in Table 21 and Figure 27.

Table 21: Span of control by Sub-Sector

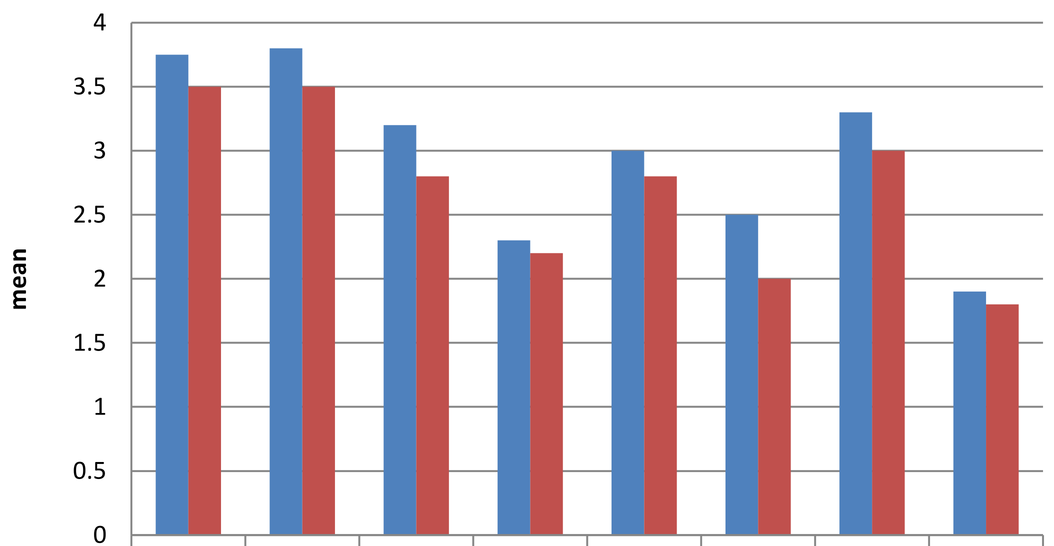
Category	Employees	Sub-units	Span of control	Scale
Construction/ material	92	3.75	25	2
Food/ beverage/animal feeds	215	6	36	1
Textiles/ apparel/ leather/footwear	97	5	19	2
Chemical/Pharmaceuticals	80	4	20	2
Automobile/parts industry	145	5	29	2
Fabricated metals industry	120	7	17	3
Power generation/electrical/electronic	283.75	8	35	1
Plastics, packaging and stationery	59	4	15	3

4.5.4 Role Programming

Role programming herein is the formalization of duties and responsibilities as in sets of job specifications. The mechanistic design of an organizational structure is synonymous with bureaucracy, high formalization, downward communication and little participation by low-level employees in decision-making. The organic design of a of an organizational structure has low formalization, it has lateral, upward and downward communication networks and high participation by low-level employees in decision-making (Mintzberg, 1979).

The extent to which work is formalized to each blue collar employee was tested using the questionnaire in section 2.For each item in the questionnaire, respondents were requested to choose a response on a five-point likert scale; anchored at one end with 'not at all' meriting a score of 1, and the other by ' to a very great extent' meriting a score of 5. The questionnaire was designed in such a manner as to have a score of 5 as the highest index and a score of 1 as the lowest index. From the result, it was observed that the importance of overlapping of jobs in the organization was relatively high for small and medium companies. The results, per sub-sectors, are as shown in Figure 26.

Figure 26: Role Programing by Sub-Sector



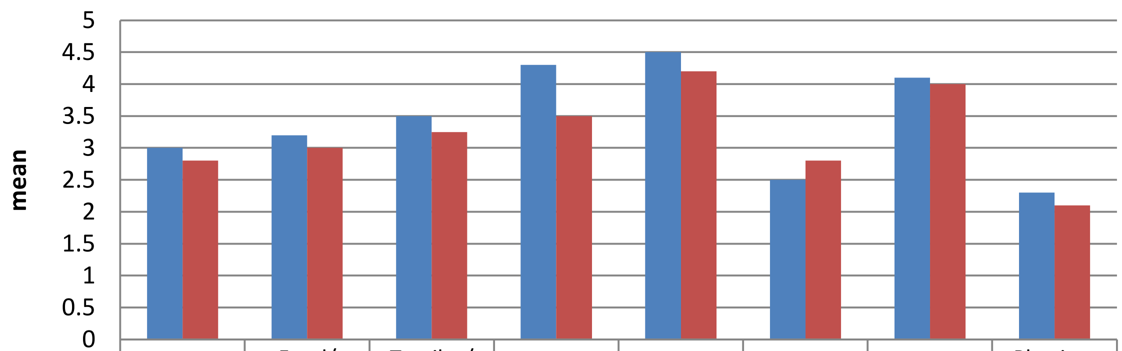
	Construction and material	Food/beverage/animal/feeds	Textiles/apparel/leather/footwear	Chemical/Pharmaceuticals	Automobile/parts industry	Fabricated metals industry	Power/electrical/electronics	Plastic/packaging/ststionery
mean	3.75	3.8	3.2	2.3	3	2.5	3.3	1.9
median	3.5	3.5	2.8	2.2	2.8	2	3	1.8

4.5.5 Communication Programming

Communication programming herein is the formal specification of the structure, content, and timing of communication within the organization. In the surveyed companies, blue collar workers were to rank on the extent to which formal communications are made to them. Mechanistic structure is characterized by downward communication and little participation by low-level employees in decision-making while in the organic design it is characterized by lateral, upward and downward communication networks and high participation by low-level employees in decision-making (Mintzberg, 1979).

For each item in the questionnaire, respondents were requested to choose a response on a five-point likert scale; anchored at one end with 'not at all' meriting a score of 1, and the other end by ' to a very great extent' meriting a score of 5.The questionnaire was designed in such a manner as to have a score of 5 as the highest score and 1 as the lowest score. The results per sub-sectors, Figure 27, reveal that companies in automobile and parts industry had the highest mean score of 4.5. Plastic, packaging and stationery had the lowest mean score of 2.3.

Figure 27: Communication Programming by Sub-Sector



	Constructi on/ material	Food/ beverage/ animal feeds	Textiles/ apparel/ leather/fo otwear	Chemical/ Pharmace uticals	Automobil e/parts industry	Fabricated metals industry	Power/lect rical/electr onic	Plastics, packaging and stationery
mean	3	3.2	3.5	4.3	4.5	2.5	4.1	2.3
median	2.8	3	3.25	3.5	4.2	2.8	4	2.1

4.4.6 Output Programming

Under the quality dimension of output programming, companies were measured on the number of steps through which raw materials pass in the course of becoming the organization's outputs. Information for this dimension was deduced directly from respondents in section 1 of the instrument. The results show that across the eight sub-sectors, the mean number of steps was above 5, which suggested a steady stream of output. Most of the studied companies were either continuous production with little variation in output and rare stops with individuals only used to manage exceptions in the work process or mass production characterized by routines and procedures. There were few small-batch or unit technology companies involved in making simple one-of-a-kind customized products or small quantities of products. In the sampled companies none was involved in fabrication of large equipment in stages or production of technically complex units. Where technically complex units were made, the process only involved assembling of parts that were imported.

The result showed that there was a big variation between the eight sub-sectors due to the nature of products that compete effectively in the market. The highest number of steps recorded from respondents was 12 and the lowest recorded was 3. Based on the highest and lowest value recorded the five point score scale was designed in such a manner as to have 1 indicate a mean of 1-2 steps on one end and 5 to indicate a mean of 11-12 on the other end. On the Sub-Sector basis automobile and parts industry recorded the highest, 10. The lowest number of steps was an average of 4, recorded by textile, apparel, leather and footwear industry and fabricated metal industry. Table 22 shows the results.

Table 22. Output programming by Sub-Sector

Sub-Sector	**Mean no of steps**	**Scale value**
Construction and material industry	4.25	1
Food, beverage and animal feeds industry	5	2
Textiles, apparel, leather and footwear	4	1
Chemical and Pharmaceuticals industry	7	3
Automobile and parts industry	10	4
Fabricated metals industry	4	1
Power generation and electrical/electronics	8	3
Plastics, packaging and stationery	5	2

4.5.7 Generation of Organizational Index

Companies operating in less stable environments operated more effectively if the organizational structure was less formalized, more decentralized and more reliant on mutual adjustment between various departments in the company. Likewise, companies in uncertain environments seemed to be more effective with a greater degree of differentiation between subtasks in the organization and when the differentiated units were heavily integrated with each other. Companies operating in more stable and certain environments functioned more effectively if the organization was more formalized, centralized in the decision-making and less reliant on mutual adjustment between departments. Likewise, these companies had low degree of differentiation of subtasks and integration between units.

Descriptive knowledge of detailed organizational structure dimensions from the surveyed companies can therefore be deduced from the above analysis. Organizational index of each company was calculated as the average measure of dimensions score. For the convenience of comparison and analysis, the following equation gives us the organizational index for each company and also for each sub-sector.

Organizational index (OI) = $(X_{01} + X_{02} + X_{03} + X_{04} + X_{05} + X_{06})/6$ where

X_{01}= Sub-unit score
X_{02}= Levels of authority score
X_{03}= Span of control score
X_{04}= Role programming score
X_{05}= Communication programming score
X_{06} = Out programming score

As shown in Table 23 generated from the above equation, the Sub-Sector with the highest organizational index was the automobile and parts industry with a mean score of 3.25. It was noted from the study that this industry is characterized by Large-batch and mass production technology involving producing large volumes of standardized products. The sub-sector with the lowest organizational index was plastic, packaging and stationery. This was expected as the industry had many part time workers and non-routine jobs. Plastic, packaging and stationery industry was characterized by small-batch and unit technology involving making one-of-a-kind customized products or small quantities of products.

Table 23: Organizational Index by sub-sector.

	Sub-units	Levels of auth	Span cont	Role progr	Comm progr	Output progra	Organ Index
Construction and material	1	3	2	3.75	3	2	2.458
Food/beverage /animal/feeds	2	4	1	3.8	3.2	2	2.667
Textiles/apparel/ leather/footwear	2	2	2	3.2	3.5	1	2.283
Chemical/Pharmaceuticals	1	3	2	2.3	4.3	3	2.600
Automobile/ parts industry	2	4	2	3	4.5	4	3.250
Fabricated metals industry	3	3	3	2.5	2.5	1	2.500
Power /electrical /electronics	3	4	1	3.3	4.1	3	3.067
Plastics/packaging / stationery	1	2	3	1.9	2.3	2	2.033
Average score	1.875	3.125	2.000	2.969	3.425	2.250	

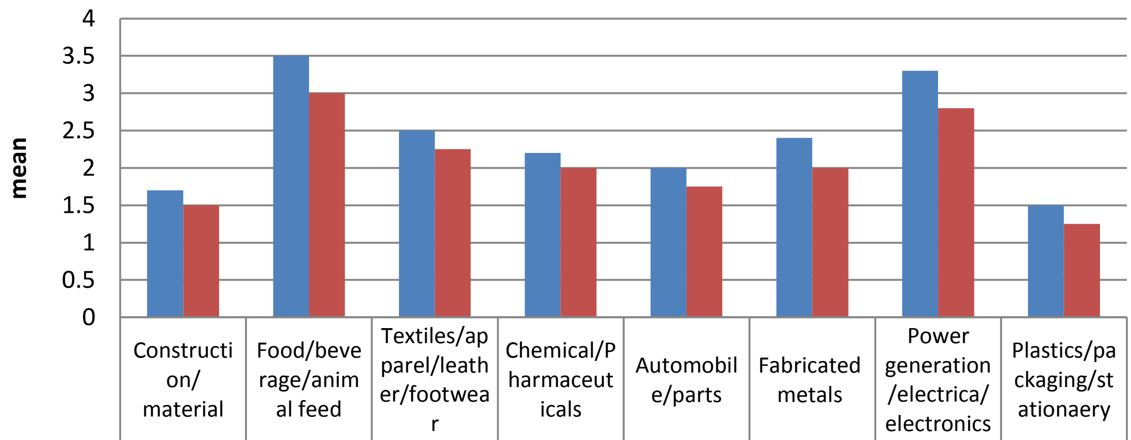
4.6 Human Factors

Having explored the trend in AMT adoption and structural changes of companies across broad manufacturing sub-sectors, this section focuses on the blue collar workers reactions that arise in most periods of technological and structural change. As identified in the literature, five core human factors dimensions were explored namely; job satisfaction, job involvement, organization commitment, psychological barrier and employee empowerment. Regarding this core factors the respondents in section 2 of the questionnaire were asked to rank their feelings on items in the dimensions on this variable. For each dimension, respondents were requested to choose a response on a five-point interval scale; anchored at one end with 'not at all' meriting a score of 1, and the other by 'to a great extent' meriting a score of 5.

4.6 .1 Job Satisfaction

Job satisfaction or employee satisfaction is simply how content an individual is with his or her job. In other words, whether or not they like the job or individual aspects or facets of jobs, such as nature of work or supervision. AMTs requires workers to be equipped with a variety of new skills at various levels. A variety of environmental, structural, technological, individual, and task related factors in a company's operating environment could facilitate or inhibit adoption, implementation and successful management of AMT. In a scale of 1-5 the respondents were asked to rate the extent to which they agreed with 10 statements relating to their organization's Job satisfaction. Figure 28 shows the result from the surveyed companies.

Figure 28: Job Satisfaction by Sub-Sector



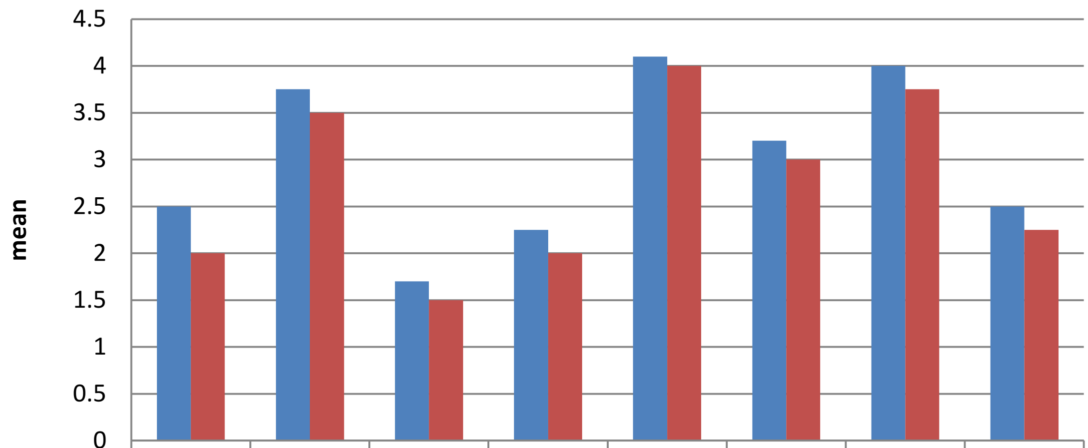
	Construction/ material	Food/beverage/animal feed	Textiles/apparel/leather/footwear	Chemical/Pharmaceuticals	Automobile/parts	Fabricated metals	Power generation /electrica/ electronics	Plastics/packaging/stationaery
mean	1.7	3.5	2.5	2.2	2	2.4	3.3	1.5
median	1.5	3	2.25	2	1.75	2	2.8	1.25

The results showed that food, beverage and animal feed workers were the most satisfied with a mean score of 3.5 followed by power generation, electrical/electronics industry. Plastic, packaging and stationery were the most dissatisfied with a mean score 1.5. It is important to note that plastic, packaging and stationery registered the highest number of part time employees. Employees from medium and large sized companies, compared with those from small sized companies cited job security as a very important contributor to their job satisfaction.

4.6.2 Job Involvement

Job Involvement refers to the psychological and emotional extent to which employees participate in their work. The operating and technical people responsible for running, maintaining, and organizing the new technologies require new skills, attitudes, system procedures and social structures. The use of AMTs increases the demand on workers in decision making. Higher knowledge intensity is required by workers in automation, even low level jobs will require more responsibility for results, more intellectual mastery and abstract skills and more carefully nurtured interdependence. In a scale of 1-5 the respondents were asked to rate the extent to which they agreed with 10 statements relating to their organization's Job involvement. Figure 29 shows the results

Figure 29: Job Involvement by Sub-Sector



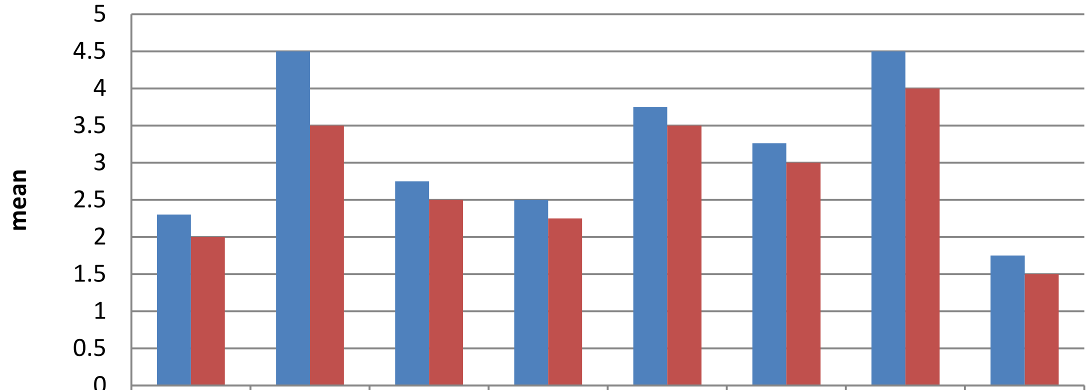
	Construction/ material	Food/beverage/animal feed	Textiles/ apparel/leather/footwear	Chemical /Pharmaceuticals	Automobile/parts	Fabricated metals	Power generation/electrical/electronics	Plastics/packaging /stationary
mean	2.5	3.75	1.7	2.25	4.1	3.2	4	2.5
median	2	3.5	1.5	2	4	3	3.75	2.25

The results revealed that companies from power generation, electrical/electronics industry, automobile and parts industry were the most involved with a mean score of 4. Textile, apparel, leather and footwear industry were the most uninvolved with a mean score of 1.7.Though most respondents rated above a mean score of 2, the findings here indicated that workers autonomy was limited and decision-making was centralized, thus, decreasing the potential for the flexible use of AMT.

4.6.3 Organizational Commitment

Organizational commitment is the individual's psychological attachment to the organization. Reorganization of AMT company consequent to implementation of AMT is usually feared because it means disturbance of the status quo, a threat to people's vested interests in their jobs and an upset to established ways of doing things. The ability of the companies in providing, developing and changing the organizational structure in incorporating the workers new roles and skills required by AMT will enable positive contribution to AMT implementation. Based on a 5 point Likert scale, with 5 as 'to a great extent' and 1 as 'not at all', the respondents were asked to rate the extent to which they agreed with 10 items relating to their organizational commitment. Figure 30 shows the results.

Figure 30: Organizational Commitment by Sub-Sector



	Construction/ material	Food/beverage/animal feed	Textiles/ apparel/leather/footwear	Chemical /Pharmaceuticals	Automobile/parts	Fabricated metals	Power generation/electrical/electronics	Plastics/packaging /stationery
mean	2.3	4.5	2.75	2.5	3.75	3.26	4.5	1.75
median	2	3.5	2.5	2.25	3.5	3	4	1.5

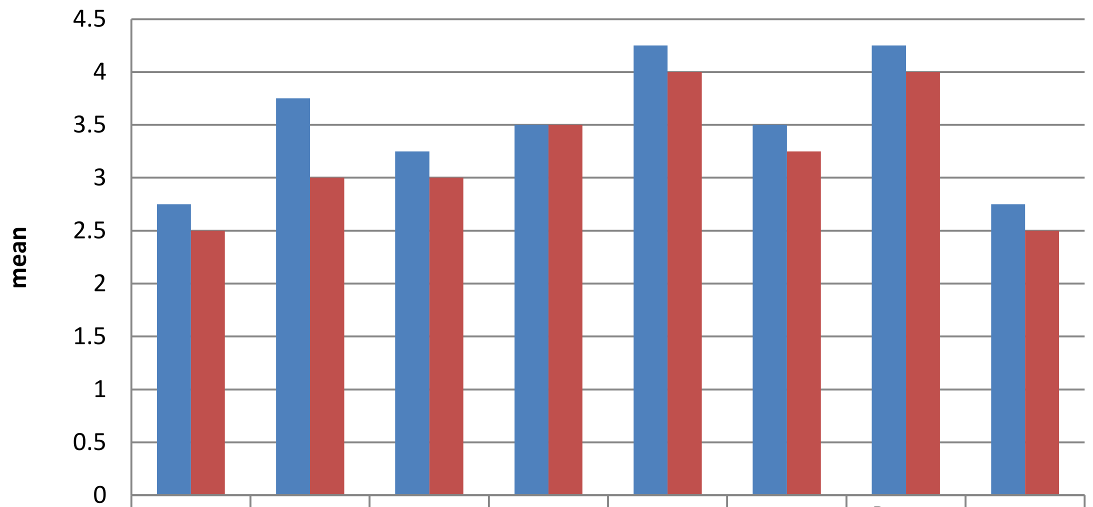
From the data, it was observed that among the companies surveyed power generation, electrical/electronics industry and food, beverage, and animal feed industry recorded the highest mean of organizational commitment at a mean of 4.5. Construction and material industry as well as plastic, packaging and stationery recorded the low means of 2.3 and 1.5 respectively.

Companies with higher basic skill levels were able to exploit much of the innate flexibility in AMT and most of this companies registered a high mean in their commitment. Most small companies with lack of suitable skills at a number of levels showed low absolute rate of take-up of technology and therefore registered low mean.

4.6.4 Psychological Barriers

New technology creates phobia among operators. The anxiety and emotional fear towards new technology lead to induced stress among operators, which is caused by anxiety and tension associated with technological change. Based on a 5 point Likert scale, with 1indicating'to a great extent' and 5indicating 'not at all', the respondents were asked to rate the extent to which they agreed with 10 statements relating to their psychological barriers. Figure 31 below shows the results.

Figure 31: Psychological Barriers by Sub-Sector



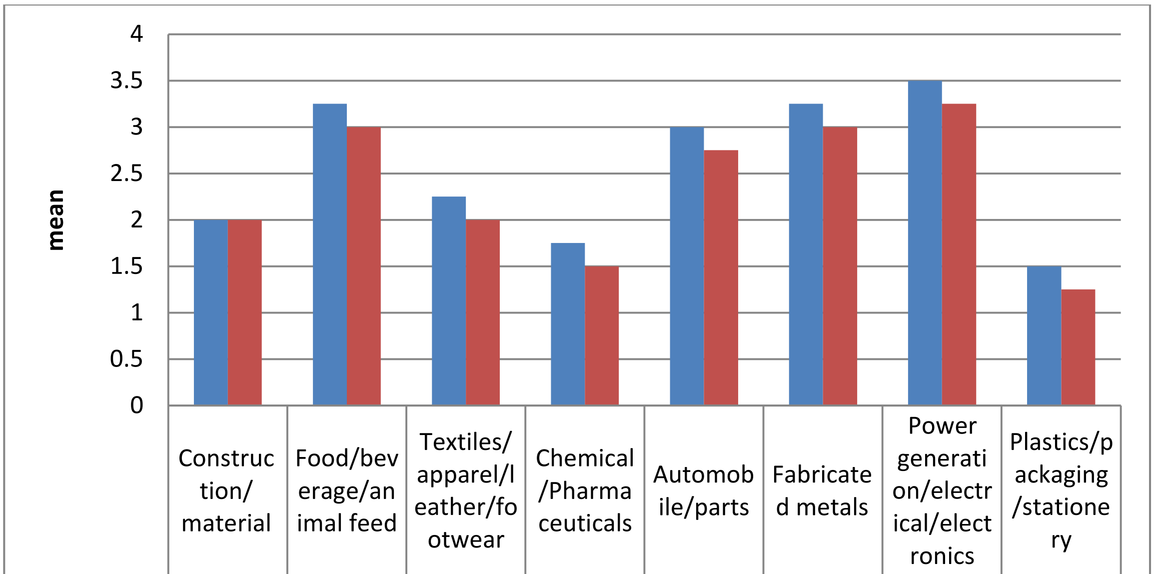
	Construction/ material	Food/beverage/animal feed	Textiles/apparel/leather/foot ware	Chemical/Pharmaceuticals	Automobile/parts	Fabricated metals	Power generation/electrical/electronics	Plastics/packaging/stationery
mean	2.75	3.75	3.25	3.5	4.25	3.5	4.25	2.75
median	2.5	3	3	3.5	4	3.25	4	2.5

The results show that most of the surveyed companies generally think that implementation efforts fail because of under-estimation of the scope or importance of preparation of employees. The study showed that power generation, electrical and electronics industry as well as automobile and parts industry suffered less by scoring a mean of 4.25. Construction and material industry as well as plastic, packaging and stationery suffered the most with a mean score of 2.75.

4.6.5 Employee Empowerment

Employee empowerment is giving employees a certain degree of autonomy and responsibility for decision-making regarding their specific organizational tasks. It allows decisions to be made at the lower levels of an organization where employees have a unique view of the issues and problems facing the organization at a certain level. Based on a 5 point Likert scale, with 5 as ‘to a great extent’ and 1 as ‘not at all’, the respondents were asked to rate the extent to which they agreed with 10 statements relating to employee empowerment. Figure 32 shows the results.

Figure 32: Employee Empowerment by Sub-Sector



	Construction/ material	Food/beverage/animal feed	Textiles/ apparel/leather/footwear	Chemical /Pharmaceuticals	Automobile/parts	Fabricated metals	Power generation/electrical/electronics	Plastics/packaging /stationery
mean	2	3.25	2.25	1.75	3	3.25	3.5	1.5
median	2	3	2	1.5	2.75	3	3.25	1.25

The study revealed that companies from power generation, electrical/electronics industry were the highest with a mean score of 3.5. Plastic, packaging and stationery industry scored the lowest with a mean score of 1.5. Though most respondents rated a mean score of 2 and above, the findings here indicated that workers empowerment was minimal. Lack of flexible, multi-skilled, knowledgeable workforce was cited as the major factor. It is worth noting that the increase in task complexity linked to AMT requires employees to expand their scope of attention and process significantly more information. Their technical knowledge must therefore extend well beyond their own functions to encompass aspects of adjacent.

4.6.6: Generation of Human Factor Index Score

From the above analysis there exists a descriptive detailed knowledge of human factors variable from the surveyed companies. Human factor index (HFI)of each company/sub-sector was calculated as the average measure of dimensions score. For the convenience of comparison and analysis, the following equation gives the human factor index for each company/sub-sector.

Human Factor index (HFI) = $(X_{01} + X_{02} + X_{03} + X_{04} + X_{05})/5$where

X_{01}= Job satisfaction score
X_{02}= Job involvement score
X_{03}= Organizational commitment score
X_{04}= Psychological barrier score
X_{05}= Employee empowerment score

From the above equation Table 24 is generated for each Sub-Sector.

Table 24: Human factor index score by Sub-Sector

	Job satisfaction	Job involvement	Organization commitment	Psychological barriers	Employee empowerment	HF Index score
CMI	1.7	2.5	2.3	2.75	2	**2.25**
FBAFI	3.5	4	4.5	3.75	3.25	**3.80**
TALFI	2.5	1.7	2.75	3.25	2.25	**2.49**
CPI	2.2	2.25	2.5	3.5	1.75	**2.44**
API	2	4.1	3.75	4.25	3	**3.42**
FMI	2.4	3.2	3.26	3.5	3.25	**3.12**
PGEEI	3.3	4	4.5	4.25	3.5	**3.91**
PPSI	1.5	2.5	1.75	2.75	1.5	**2.00**
Average	**2.39**	**3.03**	**3.16**	**3.50**	**2.56**	

Legend.
PGEEI - Power generation, electrical/electronic
FBAI –Food, beverage and animal feed
PPSI - Plastic, packaging and stationery
TALFI- Textile, apparel, leather and footwear
CPI- Chemical and pharmaceutical
CMI – Construction and material
API- Automobile and parts
FMI- Fabricated metal industry

The results show that power generation, electrical and electronics industry registered the highest score at a mean of 3.91, followed by food, beverage and animal feed industry at a mean of 3.80. The lowest mean score recorded was in plastic, packaging and stationery industry with a mean score of 2.00, which may be attributed to the number of unskilled workforce in this industry. Most blue collar workers in plastic, packaging and stationery industry were certificate holders or just secondary level education graduates.

4.7 Test of Hypothesis and Fit

So far the characteristics of the sampled companies and their practices in regards to their AMT adoption, their organizational structure, company size and human factors have been described. This section provides answers to the research question set forth to undertake this study:-to what extent do AMTs influence organizational structure and do company size and human factors significantly affect the relationship between AMT adoption and organizational structure? To answer this question, statistical procedures were used to test the four hypotheses developed from the literature.

The AMT adoption was operationalized in terms of AMT investment and AMT integration while organizational structure was operationalized in terms of sub-units, levels of authority, span of control, role programming, output programming and communication programming. Company size was operationalized using workforce number and capital invested. Human factors were operationalized in terms of job satisfaction, organizational involvement, organizational commitment, psychological barriers and employee empowerment.

Several constructs of each dimension were measured in order to capture a wide range of information regarding the dimension on the surveyed companies. However, it was not feasible to examine each one of them as too many explanatory variables would reduce the degree of freedom, which will then result in less favorable test results. Statistical tests were therefore carried out using the mean values of each variable for each of the 92 companies. Preliminary tests were done to check if the data was normally distributed in respect of each variable. Table 25 shows the results of the test of distribution of the data on the four variables.

Table 25: Results of test of distribution of the data

	No	Minimum	Maximum	Mean	Std. Deviation	Skewness		Kurtosis	
		Score	Score	Score	Score	score	Std. Error	score	Std. Error
CSI	92	1.50	5.00	3.3478	1.10627	-.221	.251	-1.065	.498
AMTI	92	1.75	2.04	1.8596	.08963	.769	.251	-.694	.498
OI	92	1.67	3.50	2.7699	.54343	-.765	.251	-.364	.498
HFI	92	2.20	4.00	3.2087	.57257	-.165	.251	-1.360	.498

Legend.
CSI – Company Size Index
AMTI – Advanced Manufacturing Technology Index
OI – Organizational Index
CSI – Human Factor Index

Table 25 shows that Organizational Index (OI), Company Size Index(CSI) and Human Factor Index (HFI), were negatively skewed but the magnitude of the coefficients were less than 1(0.221, 0.765 and 0.165) an indication of a measure of normality. The

Advanced Manufacturing Technology Index (AMTI) was positively skewed but again the magnitude of the coefficients was less than 1 (0.769) an indication of a measure of normality. The range of AMTI was between 1.75 and 2.04 while OI was between 1.67 to 3.50. Human factor ranged between 2.20 to 4.00 while CSI had the highest range of between 1.50 to 5.00.

Based on the above analysis the data can be used to make meaningful inferences. Hypotheses testing was performed by testing the level of agreement between the variables. The testing of the hypotheses was conducted by examining bivariate, stepwise and multivariate correlations. The aim of the hypotheses testing of the study was to test the level of agreement between the variables. The 2 polar points used in this study was1 and 5, with 1 being the lowest index and 5 being the highest index.

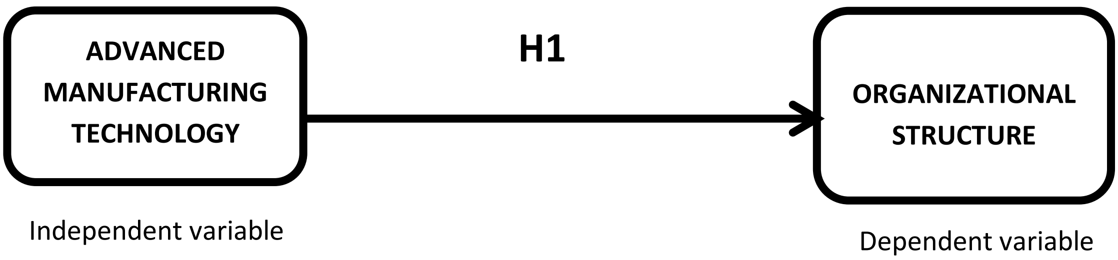
4.7.1 Relationship between AMT Adoption and Organizational Structure

Objective one of the study sought to establish the relationship between AMT adoption and organizational structure. To achieve this objective, the following hypothesis was formulated based on the literature review and conceptual framework.

H1 There is a positive relationship between Advanced Manufacturing Technology adoption and organizational structure.

The relationship between AMT adoption and organizational structure is illustrated in Figure 33.

Figure 33: The relationship between AMT adoption and organizational structure



This hypothesis was tested using simple bivariate regression analysis of AMT adoption index on organizational structure index. The results are shown in Table 26.

Table 26: Model summary, ANOVA and coefficients of linear regression of AMT adoption on organizational structure

Model summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.779[a]	.607	.602	.34274

a. Predictors: (Constant), AMTI

ANOVA

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	16.301	1	16.301	138.763	.000[b]
	Residual	10.573	90	.117		
	Total	26.873	91			

a. Dependent Variable: OI

b. Predictors: (Constant), AMTI

Coefficients

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	-5.550	.746		-7.438	.000
	AMTI	4.722	.401	.779	11.780	.000

Dependent Variable: OI

In the table the *R* value, representing the simple correlation, is 0.779 which indicates a high degree of correlation. The R^2 value, indicating how much of the total variation in the dependent variable can be explained by the independent variable, is 60.7%. This is an indication of a good goodness of fit of the model. This is supported by the test of significance represented by F-ratio at 138.763, $p<0.05$depicting that the relationship is statistically significant at 95% confidence level (P-value <0.05)

Coefficients in Table 26 provide the necessary information to predict Organizational Index from AMT Index, as well as determine whether AMT adoption contributes significantly to the model. As shown in the table Unstandardized Coefficients "B"= 4.722, $p<0.05$ indicating that for every unit change in AMTI, there is 4.722 change in OI. The regression equation can be fitted as follows:

$OI_{11} = -5.550 + 4.722(AMTI) + \varepsilon_{11}$

OI = Organizational index,
AMTI = Advanced manufacturing technology index
ε_{11} = Error term

Since the lower polar point is 1 and the upper polar point is 5for all indices, the negative constant (-5.55)in the above equation sets the range for AMT index as 1.39 to 2.23. AMTI measured from 1 to 5, 1 indicated early simple stage of adoption (technical simplicity) and 5 indicated complex stage of adoption (technical complexity). Thus when complexity increases beyond the range (value of AMTI above 2.23) the equation does not give meaningful results. Equally when technical simplicity is below 1.39 the equation does not give meaningful results either. From the above equation it can be concluded then that AMT adoption contributes significantly to the model at early stages of adoption. In particular, a rise in AMT index at this stage is associated with a rise in organizational index. This indicates that as investment and integration of AMTs increase organizational characteristics tends to increase towards polar point 5.

Although all the surveyed companies showed some internal specializations, the typically changeful nature of AMT adoption limited the scope of the relationship. The study indicated that there is no significant proof of the positive relationship between AMT adoption and organizational structure at higher values of AMT adoption. However, the positive association between AMT adoption and Organizational structure could only be supported at low values of AMT adoption (1.39 -2.23). In this connection it can be argued that it is not only important to take into account the level of AMT adoption but also to consider other contingencies that might accompany AMT adoption.

In summary the benefits of AMT implementation can be realized by investing only a few AMTs at a time and as a result companies can gradually integrate these technologies into the production process to get the most benefit from it. Thus AMT adoption positively influences organizational structure characteristics more significantly at early stages of adoption. At higher AMT adoption the equation does not properly explain the relationship. Therefore the hypothesis that there is a positive relationship between AMT adoption and organizational structure was supported only at early stages of AMT adoption.

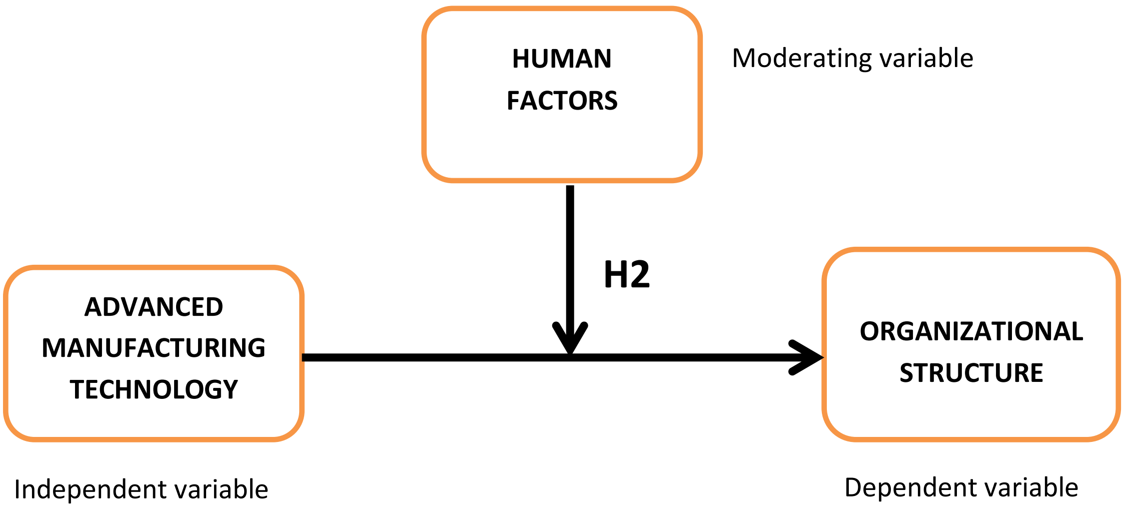
4.7.2 Moderating Effect of Human Factors on the Relationship between AMT Adoption and Organizational Structure

Objective two of the study sought to establish the effect of human factors on the relationship between AMT adoption and organizational structure. To achieve this objective, the following hypothesis was formulated based on the literature review and conceptual framework.

H2 The relationship between Advanced Manufacturing Technology and Organizational structure depends on human factors.

The moderation effect of human factors on the relationship between AMT adoption and organizational structure is illustrated in Figure 34.

Figure 34: The moderation effect of human factors on the relationship between AMT adoption and organizational structure



This hypothesis was tested using stepwise forward regression analysis. The relevant analytical results are shown in Table 27.

Table 27: Stepwise regression of AMT adoption, human factors and the interaction term (AMT*HFI) on organizational structure

Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.779[a]	0.607	0.602	0.34274
2	.863[b]	0.744	0.739	0.27776
3	.900[c]	0.811	0.804	0.24037

a. Predictors: (Constant), AMTI
b. Predictors: (Constant), AMTI, HFI
c. Predictors: (Constant), AMTI, HFI, AMTI*HFI

ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	16.301	1	16.301	138.763	.000[b]
	Residual	10.573	90	0.117		
	Total	26.873	91			
2	Regression	20.007	2	10.003	129.658	.000[c]
	Residual	6.867	89	0.077		
	Total	26.873	91			
3	Regression	21.789	3	7.263	125.704	.000[d]
	Residual	5.084	88	0.058		
	Total	26.873	91			

a. Dependent Variable: OI
b. Predictors: (Constant), AMTI
c. Predictors: (Constant), AMTI, HFI
d. Predictors: (Constant), AMTI, HFI, AMTI*HFI

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	-5.55	0.746		-7.438	0
	AMTI	4.722	0.401	0.779	11.78	0
2	(Constant)	-3.599	0.667		-5.396	0
	AMTI	2.888	0.419	0.476	6.894	0
	HFI	0.455	0.066	0.479	6.931	0
3	(Constant)	15.985	3.573		4.473	0
	AMTI	-7.769	1.953	-1.281	-3.978	0
	HFI	-4.986	0.981	-5.253	-5.081	0
	AMTI*HFI	2.946	0.531	6.981	5.554	0

a. Dependent Variable: OI

In the first model, advanced manufacturing technology index (AMTI) was regressed on organizational index (OI). In the second model AMTI and HFI (main effects) were regressed on OI. In the third model AMTI, HFI and the interaction term (AMT*HFI) were regressed on OI. To check for the moderation effect the significance of the independent variable and the moderator variable was not particularly relevant but moderation was assumed to take place if the interaction term (AMTI*HFI) was significant.

Table 27 shows that when human factor was added the model explained 74.4% (model 2) of variation of organizational index compared to 60.7% (model 1) explained without human factor. This shows a 22.5% increase in the R^2 indicating the significance of human factor in the model (F-ratio is 129.658 with p-value <0.05). When the two-way interaction term is considered in the regression the effectiveness of the model is further improved. The result shows that with the interaction term (AMT*HFI) the model explained 81.1% of variation in organizational index (R^2 =0.811 in model 3) compared with 74.4% without the interaction term (R^2 = 0.744 in model 2). The result reveals that R^2 increased by 9%, from 0.744 to 0.811, when the interaction term was added. The result indicates a statistically significant relationship between OI and AMTI, HFI and AMTI*HFI (F=125.704 with $p< 0.05$).

Table 27 suggests that interaction between AMT adoption and Human factor is significantly correlated with organizational structure. Coefficients of the explanatory variables changed to negative with -7.769 for AMTI and -4.986 for HFI all with p-value < 0.05 when the interaction term was added. However coefficient of the interaction term was positive at 2.946 with p-value of < 0.05 and the constant for the model was at 15.985 with p-value of < 0.05. The three model regression equations can be fitted as follows:

$OI_{21} = -5.55 + 4.722(AMTI) + \varepsilon_{21}$ model 1

$OI_{22} = -3.599 + 2.888(AMTI) + 0.455(HFI) + \varepsilon_{22}$ model 2

$OI_{23} = 15.985 – 7.769(AMTI) - 0.4986(HFI) + 2.946(AMTI*HFI) + \varepsilon_{23}$ model 3

OI = Organizational index,
AMTI = Advanced manufacturing technology index
HFI =Human factor index
AMTI*HFI = AMT and HFI Interaction term
$\varepsilon_{21},\varepsilon_{22},\varepsilon_{23}$ = Error terms

Since 5 is the upper limit and 1 is the lower limit for all indices, then when HFI is fixed at 1 and for OI to vary from 1 to 5, AMTI must vary from 2.1to 3. Similarly, as shown in the equations on page 96, when HFI is fixed at 5, then for OI to vary from 1 to 5, AMTI must vary from 1.65 to 1.95. Therefore at the introduction of HFI as a moderating variable AMTI then varied from 1.65 to 3, an improvement from 1.39 to 2.23 obtained without the interaction term.

The equation in model 3 indicated improvement in the range of fit in the relationship between AMT adoption and organizational structure, indicating a linear dependence of organizational structure characteristic on the interaction of AMT adoption and human factors. This implied that for every unit change in the interaction term, organizational structure characteristic increased by 2.96 when all other terms were held constant. Changes in human factor positively and significantly affected AMT adoption and organizational structure relationship as the direction of the relationship was positive. This meant that the hypothesis that the relationship between Advanced Manufacturing Technology and Organizational structure depended on human factors was supported.

In summary, the significance of human factor in the relationship between organizational structure and AMT adoption showed that as use of AMTs increased the demand on workers in terms of decision-making and therefore higher knowledge intensity was required by workers during AMT implementation. Therefore structural adjustments to increase the dimensions of structure must be carefully nurtured. No matter how investment and integration of AMTs is in a company, fear of work overload caused by reduction of cycle time can hinder these structural adjustments. Consequently, catering for employees` job satisfaction and intrinsic motivations by creating opportunities for employee involvement can be considered a viable method to integrate the goals of employees' with the company's.

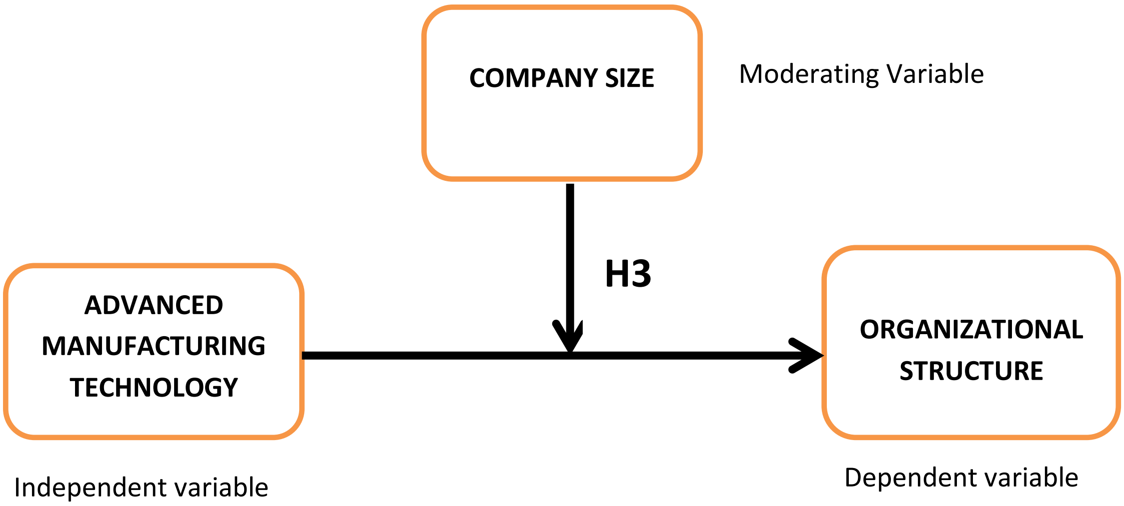
4.7.3 Moderating Effect of Company Size on the Relationship between AMT Adoption and Organizational Structure

Objective three of the study sought to establish the effect of company size on the relationship between AMT adoption and organizational structure. To achieve this objective, the following hypothesis was formulated based on the literature review and conceptual framework.

H3 The relationship between Advanced Manufacturing Technology and Organizational structure depends on company size.

The moderation effect of Company size on the relationship between AMT adoption and organizational structure is illustrated in Figure 35.

Figure 35: The moderation effect of company size on the relationship between AMT adoption and organizational structure



This hypothesis was tested using stepwise forward regression analysis. In the first model, advanced manufacturing technology index was regressed on organizational index. In the second model advanced manufacturing technology index and company size (main effects) was regressed on organizational structure. In the third model, advanced manufacturing technology, company size index and interaction between the two (AMT*CSI) was regressed on organizational structure index. To check for the moderation effect the significance of the independent variable and the moderator variable was not particularly relevant but moderation was assumed to take place if the interaction term (AMTI*CSI) was significant.

Table 28 shows that when company size index was added to the main relation the goodness of fit of the model improved from 60.7% (model 1) to 84.6% (model 2). This is a 39.4% increase indicating the importance of the Company size in the model. This is further supported by F-ratio that was at 243.635 with p-value < 0.05. When two-way interaction term (AMTI*CSI) was considered the goodness of fit was further improved. The result showed that model 3 explained 85.3% of variation in organizational structure index (R^2 =0.853).The results also revealed that R^2 increased by 0.83% from 0.846 to 0.853 when the interaction variable was added. The result showed a statistically significant relationship between OI and AMTI, CSI and AMTI*CSI (F=169.924with p< 0.05).

Table 28: Stepwise regression of AMT adoption, company size and the interaction term (AMTI*CSI) on organizational structure

Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.779[a]	0.607	0.602	0.34274
2	.920[b]	0.846	0.842	0.21595
3	.923[c]	0.853	0.848	0.21203

a. Predictors: (Constant), AMTI

b. Predictors: (Constant), AMTI, CSI

c. Predictors: (Constant), AMTI, CSI, AMTI*CSI

ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	16.301	1	16.301	138.763	.000[b]
	Residual	10.573	90	0.117		
	Total	26.873	91			
2	Regression	22.723	2	11.362	243.635	.000[c]
	Residual	4.15	89	0.047		
	Total	26.873	91			
3	Regression	22.917	3	7.639	169.924	.000[d]
	Residual	3.956	88	0.045		
	Total	26.873	91			

a. Dependent Variable: OI

b. Predictors: (Constant), AMTI

c. Predictors: (Constant), AMTI, CSI

d. Predictors: (Constant), AMTI, CSI, AMTI*CSI

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	-5.55	0.746		-7.438	0
	AMTI	4.722	0.401	0.779	11.78	0
2	(Constant)	-2.524	0.536		-4.707	0
	AMTI	2.559	0.313	0.422	8.186	0
	CSI	0.297	0.025	0.605	11.735	0
3	(Constant)	0.974	1.763		0.553	0.582
	AMTI	0.652	0.967	0.108	0.674	0.502
	CSI	-0.568	0.417	-1.156	-1.362	0.177
	AMTI*CSI	0.468	0.225	1.965	2.079	0.041

a. Dependent Variable: OI

Table 28 suggests that interaction between AMT index and company size index was significantly related with organizational structure index. Coefficients of the explanatory variables were 0.652 with p-value at 0.502 for AMTI and -0.568 with p-value at 0.177 for CSI. Coefficient for the interaction term was positive at 0.468 with p-value at 0.041. The constant of the model was 0.974 at p-value of 0.582. From these results only the interactive term was significant at 95% level of confidence. The regression equations for the models can therefore be fitted as follows:

$OI_{31} = -5.55 + 4.722(AMTI) + \varepsilon_{31}$ model 1

$OI_{32} = -2.524 + 2.559(AMTI) + 0.297(CSI) + \varepsilon_{32}$ model 2

$OI_{33} = 0.468(AMTI*CSI) + \varepsilon_{33}$ model 3

OI	= Organizational index,
AMTI	= Advanced manufacturing technology index
CSI	=Company size index
AMTI*CSI	= AMT and CSI Interaction term
$\varepsilon_{31}, \varepsilon_{32}, \varepsilon_{33}$	= Error terms

Model 3 equation indicated that a unit change in the interactive value caused 0.468 change in the organizational index. Since the upper limit for OI is 5 and the lower limit is 1, then the lowest possible value for the interactive term is 2.137 and the highest possible value of interactive value is 10.683. This indicates that as OI stretched from 1 to 5 the interactive term stretched from 2.137 to 10.683.

The results of the empirical analyses confirmed therefore that the availability of monetary assets and the technical skills of blue-collar workers are indispensably significant in determining the level of AMT implementation. This implied that skill demand of AMT was a formidable challenge for smaller manufacturing companies to acquire and retain. Larger companies are likely to have the skills and human resources it takes to understand, implement, and manage such technologies.

Company size therefore moderates the relation between AMT adoption and organizational structure indicating that there is a linear dependence of OI from AMTI*CSI. This implies that changes in company size positively and significantly affect AMTI and OI relationship as the direction of the relation is positive. This meant that the hypothesis that the relationship between Advanced Manufacturing Technology and Organizational structure depended on company size was supported.

4.7.4 Relationship between AMT Adoption, Organizational Structure, Human Factors and Company Size.

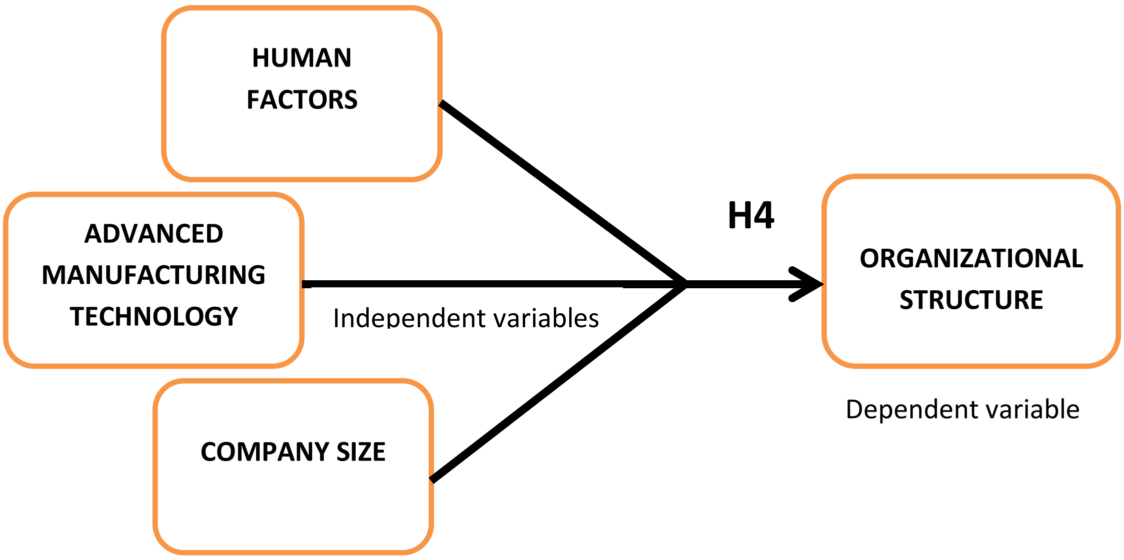
Objective four of the study sought to establish whether the joint effect of AMT, Human Factors and Company size on Organizational Structure is different from the individual effects.

To achieve this objective, the following hypothesis was formulated based on the literature review and conceptual framework.

H4 The combined effect of Advanced Manufacturing Technology, Human factors and Company size on organizational structure is different from the individual effects.

The combined effect of Company size, AMT adoption and Human factors on the organizational structure is illustrated in Figure 36.

Figure 36: The combined effect of company size, AMT adoption and Human factors on organizational structure



The testing of the combined effect of AMT adoption, human factors and company size was done by examining the significance of each term in regression of AMT index, human factor index and company size index on organizational structure index.

Multivariate regression of AMT index, human factor index and company size index (individual effects) separately and the combination of AMT index +human factor index + Company size index (combined effects) on organizational index was conducted. The results are shown in Table 29.

The result showed that the goodness of fit of AMT adoption regressed on organizational structure was 60.7%, human factors regressed on organizational structure was 60.8% and company size regressed on organizational structure was 72.9%. For the combined effect of the three predictor variables regressed on organizational structure the goodness-off it (R Square) was 87.1%. An analysis of Variance showed that for the combined effect, F statistic was 197.876 with p-value of < 0.05 compared to F statistic of 138.763 with p-value at < 0.05 for AMT only; F statistic of 139.605 with p-value of < 0.05 for human factors only and F statistic of 242.449 with p-value at < 0.05 for company size only. The results showed that all regressions were satisfying and effective. Coefficients of the explanatory variables for the combined effect were as follows: 2.045with p-value < 0.05 for AMTI; 0.221with p-value < 0.05 for human factors and 0.245with p-value < 0.05 for company size. The constant of the regression being -2.104.

The regression equations can be fitted as follows:

$OI_{41} = -5.55+4.722(AMTI) + \varepsilon_{41}$ for model 1
$OI_{42} = 0.855+ 0.74(HFI) + \varepsilon_{42}$ for model 2
$OI_{43} = 1.826+ 0.419(CSI) + \varepsilon_{43}$ for model 3
$OI_{44} = -2.104+2.045(AMTI) + 0.221(HFI) + 0.245(CSI) + \varepsilon_{44}$ for model 4

OI = Organizational index,
AMTI = Advanced manufacturing technology index
HFI = Human factor index
CSI = Company size index
$E_{41}, \varepsilon_{42}, \varepsilon_{43}$ = Error terms

The equations showed that the constants of HFI and CSI were low compared with AMTI in all the models. This indicated that AMTI acted as the main predictor of the relation. For individual effects OI was found to be more positively related with human factor index (constant = 0.74) than company size index (constant = 0.419). The combined effects results showed that all other terms held constant, company size affected the organizational structure more than human factors (a unit change in HFI caused 0.221 change in OI and a unit change in CSI caused 0.245 change in OI).

Table 29: Multivariate linear regression of AMT adoption, human factors and company size on organizational structure

Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.779[a]	.607	.602	.34274
2	.780[a]	.608	.604	.34211
3	.854[a]	.729	.726	.28431
4	.933[c]	.871	.866	.19856

a. Predictors: (Constant), AMTIc. Predictors: (Constant), CSI
b. Predictors: (Constant), HFId. Predictors: (Constant), AMTI, HFI, CSI,

ANOVA

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	16.301	1	16.301	138.763	.000[b]
	Residual	10.573	90	0.117		
	Total	26.873	91			
2	Regression	16.34	2	16.34	139.605	.000[b]
	Residual	10.534	90	0.117		
	Total	26.873	91			
3	Regression	19.598	2	19.598	242.449	.000[b]
	Residual	7.275	90	0.081		
	Total	26.873	91			
4	Regression	23.404	4	7.801	197.876	.000[d]
	Residual	3.469	88	0.039		
	Total	26.873	91			

a. Dependent Variable: OId. Predictors: (Constant),, CSI
b. Predictors: (Constant), AMTIe. Predictors: (Constant), AMTI, HFI, CSI
c. Predictors: (Constant), HFI

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	-5.55	0.746		-7.438	.000
	AMTI	4.722	0.401	0.779	11.78	.000
2	(Constant)	0.855	0.204		4.191	.000
	HFI	0.74	0.063	0.78	11.815	.000
3	(Constant)	1.826	0.095		19.23	.000
	CSI	0.419	0.027	0.854	15.571	.000
4	(Constant)	-2.104	.503		-4.179	.000
	AMTI	2.045	.313	.337	6.535	.000
	HFI	.221	.053	.233	4.156	.000
	CSI	.245	.026	.499	9.283	.000

a. Dependent Variable: OI

Model 1 : linear regression on organizational structure index with AMT index
Model 2 : linear regression on organizational structure index with Human factor
Model 3 : linear regression on organizational structure index with company size
Model 4 : linear regression on organizational structure index with AMT, Human factor and company size

It can be concluded from Table 29that the degree of fit was highest when all the three variables were combined (R^2 = 0.871) compared to the individual effect (R^2 = 0.607 for AMTI alone, 0.608 for HFI alone and 0.729 for CSI alone). The regression equations revealed that organizational index was positively related to AMT index, human factor index and company size index (positive constants in all the models). The F-ratio was above 138.763 for all models and p-value < 0.05 for all the models indicating that all variables were statistically significant.

However a change in one unit of AMTI in model 1 caused a change of 4.722 in OI but a change in one unit of AMTI in model 4 caused a change of 2.045 in OI. A change of one unit of HFI in model 2 caused a change of 0.74 in OI but a change of one unit of HFI caused a change of 0.221 in model 4. Similarly a change of one unit of CSI in model 3 caused a change of 0.419 but a change of one unit of CSI in model 4 caused a change of 0.245 in OI. This meant that the hypothesis that the combined effect of Advanced Manufacturing Technology, Human factors and Company size on organizational structure was different from the individual effects was supported.

4.8. Summary of the Chapter

This chapter has provided the background information of the surveyed companies in terms of their demographic characteristics, company size, AMT adoption, organizational structure, human factors and finally the perceived relationship between the four variables. Through sub-sectors and regression analysis approach, the behavior of AMT companies in Kenya in relationship to AMT adoption has been examined. In particular, it was found find that organizational structure index of these companies tended to increase towards polar point 5 as AMT index increased at early stages of adoption. Organizational structure index increased with company size index and human factor index.

Broadly, the respondent companies were classified into eight sub-sectors based on manufactured products. The majority of the respondents were from Food, beverage and animal feeds industry, which accounted for 31.5%, followed by the Construction and material industry (14.1%), Chemical and Pharmaceuticals industry (12.0%), Plastics, packaging and stationery (12.0%) and Power generation and electrical/electronics (10.9%). Other respondents represented a small fraction like Fabricated metals industry (7.6%), Textiles, apparel, leather and footwear (6.5%) and Automobile and parts industry

(5.4%). The median company age was around 30 years old. The result showed that across all of the eight manufacturing sub-sectors, the core stocks of companies were well established. The majority of the companies had existed in the manufacturing scene for a period of between 31 to 50 years. Most companies operated at a single site and the numbers of small companies were the majority.

Company size was measured using workforce number and capital invested. On workforce number the survey showed that the largest number of employees by sub-sector was at a mean of 284 and the lowest at a mean of 59. The mean size of companies surveyed was around 50 employees and it was no surprise that the top management level were in-charge of their manufacturing functions and involved in decision-making on manufacturing issues. On capital invested the survey showed that fabricated metal industry, construction and material industry and chemical and pharmaceutical industry was leading with a mean score of 4.0. The lowest mean score on capital invested was plastic, packaging and stationery industry with a mean score of 2. This measure of company size was anchored on the two polar point continuum of small to large. The term smaller and larger company purely describing the side of the continuum.

Analyses of the AMTs adoption of the companies surveyed was based on the level of investment in the technology and its level of integration. The study investigated 14 types of AMTs which are commonly used by manufacturing companies. These technologies were grouped, based on their functionalities, into 5 domains namely: Product design and engineering technologies (PDETs), Production planning technologies (PPTs), Material handling technologies (MHTs), Assembly and machinery technologies (AsMTs) and integrated manufacturing technologies (IMTs). In terms of the level of AMT adoption, the study showed that many companies were at early stages of adoption. On a scale of 1 – 5, Power generation, electrical and electronic industry had the highest mean AMT index (2.026) followed by food, beverage and animal feed industry (1.967). Plastic, packaging and stationery had the lowest mean AMT index, at 1.668.

Organizational structure characteristic level was measured through number of sub-units, levels of authority, span of control, role programming, communication programming and output programming. The measure of each of the organizational structure dimension was determined by measuring the dimension on two polar point of 5 and 1. The measuring instrument was arranged such as to show 1 as the lowest level and 5 as the highest level.

The organizational structure index was calculated as the mean score from the six dimensions. In terms of sub-sectors the results showed that automobile and parts industry had the highest mean index score of 3.250 and plastic, packaging and stationery industry had the lowest mean score of 2.033. It was also noted that plastic, packaging and stationery industry had the largest number of part-time workers.

Human factors were explored using five human factor dimensions identified in the literature as job satisfaction, job involvement, organization commitment, psychological barriers and employee empowerment. The result showed that power generation, electrical and electronics industry had the highest mean index score of 3.91, followed by food, beverage and animal feed industry at a mean of 3.80. The lowest mean index score was plastic, packaging and stationery industry with at 2.00, which may have been attributed to the number of unskilled workforce in this industry. The study showed that most blue collar workers in plastic, packaging and stationery industry were certificate holders or secondary school graduates.

When the relationship between organization structure and AMT adoption was examined, it was found that a linear positive relation ($OI = -5.550 + 4.722(AMTI) + \varepsilon_{11}$) at early stages of adoption. However, the positive association between AMT adoption and organizational structure could only be supported at low values of AMT adoption (1.39 - 2.23).The study indicated that there was no significant proof of the positive relationship between AMT adoption and organizational structure at higher values of AMT adoption. In this connection it can be argued that it is not only important to take into account the level of AMT adoption but also to consider other contingencies that might accompany AMT adoption. Therefore the hypothesis that there is a positive relationship between AMT adoption and organizational structure was supported only at early stages of AMT adoption.

On regressing stepwise AMT adoption and human factors on organizational structure it sustained the notion that employee behavior has an influence on AMT adoption and organizational structure. The results showed that there existed a linear relationship between AMT adoption, human factors, the moderating term (AMTI*HFI) and organizational structure ($OI = 15.985 – 7.769(AMTI) - 0.4986(HFI) + 2.946(AMTI*HFI) + \varepsilon_{23}$. The results indicated the relationship between AMT adoption and organizational structure depended on the interaction term (AMTI*HFI). This meant that that HFI statistically moderated the relationship and the hypothesis that the relationship between Advanced Manufacturing Technology and Organizational structure depends on human factors was supported.

The testing of the relationship between AMT adoption, company size and organization structure showed a positive linear relationship between organizational structure and the interaction term (AMTI*CSI)($OI = 0.468(AMTI*CSI) + \varepsilon_{33}$). The equations indicated that CSI statistically moderated the relation between AMT adoption and organizational structure indicating a positive linear dependence of OI from AMTI*CSI. This implied that CSI positively moderated the relationship between AMT adoption and organizational structure. This meant that the hypothesis that the relationship between Advanced Manufacturing Technology and organizational structure depended on company size was supported.

The combined effect of the three predictor variables was examined by the significance of each term in regression of AMT index, human factor index and company size index on organizational structure index. It was concluded that the degree of fit was highest when all the three variables were combined ($R^2 = .871$) compared to the individual effect ($R^2 = .607$ for AMTI alone, 0.608 for HFI alone and 0.729 for CSI alone). This meant that the hypothesis that the combined effect of Advanced Manufacturing Technology, Human factors and Company size on organizational structure was different from the individual effects was supported.

Advanced manufacturing technologies can provide the manufacturing companies in Kenya with the tools and techniques to meet the customers' changing needs, increase flexibility and competitiveness in the region. However, the manufacturing companies in Kenya must meet the demands of AMTs in providing organizational structural adjustments and develop the much needed skills of their workforce. In Kenya, investments and integration of AMTs are low implying that manufacturing companies must plan to gain the strategic benefits of the technology. Companies that are applying advanced technologies need to improve their competitive position by changing the nature of tasks, interconnections and nature of information flows, the skills required, the roles played, the styles of management and coordination.

CHAPTER FIVE: DISCUSSION OF FINDINGS

5.1 Introduction

The previous chapter presented the descriptive analysis and statistical results based on the data collected from the study. This chapter will discuss the findings of the practice of the sampled companies in comparison with the current literature in Organization Theory and Production/Manufacturing Management. The Chapter begins with a brief recap of surveyed companies' profiles followed by discussion of the findings. The discussion of the findings consists of four major parts in line with the four objectives of the study. The first part is focused on the findings of the surveyed companies on the relationship between AMT adoption and organizational structure. The second part focuses on the moderation effect of human factors on the relationship between AMT adoption and organizational structure. Third part will focus on the moderation effect of company size on the relationship between AMT adoption and organizational structure. The fourth part focuses on the joint effects of AMT adoption, human factors and company size on organizational structure. The chapter summary section concludes the chapter with the major findings of the chapter.

5.2 Surveyed Companies' Profiles

The survey was conducted via questionnaires that were sent to all the183 identified MT manufacturing companies in Kenya. 92 companies, representing a response rate of 50 %,responded positively and data from these companies was used in the analysis. Section 1 of the questionnaire was directed to top managers or production managers with knowledge of AMTs. Section 2 of the questionnaire was self-administered to the blue collar workers working with AMT machines. All respondents in both sections had been in their respective position for an average of 9 years thus enhancing the reliability and the creditability of the data collected.

In section 1 of the instrument 43% of the respondents were from top management, 40% were from persons directly responsible for manufacturing or operations or production issues of their companies and 17% were persons holding non-manufacturing-related positions but involved in some sort of decision making at the strategic level for the manufacturing function. For section 2 of the instrument, 5 respondents were sampled from each company and an average for each unit of analysis was thereafter calculated.

63% of respondents in section 2 were machine operators, 23% were machine maintenance personnel and 14%were shop stewards.

Samples were taken from eight manufacturing sub-sectors which produce discrete products, covering the whole range of the industry. 31.5% of respondents were from Food, beverage and animal feeds industry; 14.1% from Construction and material industry; 12.0% from Chemical and Pharmaceuticals industry; 12.0% from Plastics, packaging and stationery industry; 10.9% from Power generation and electrical and electronic industry; 7.6% from Fabricated metals industry; 6.5% from Textiles, apparel, leather and footwear and 5.4% from Automobile and parts industry. This was deemed representative of the current industry distributions of the listed AMT manufacturing companies in Kenya (KAM, 2014).

Most of the companies surveyed were involved in providing products that compete in the region and therefore providing a great opportunity for investment capacity in the new manufacturing technologies. All the surveyed companies had investment in at least two and at most nine of the 14 types of AMTs. The measurement for AMT adoption was derived from two perspectives; its level of investment and the extensiveness of integration. In general the company surveyed showed that the level of AMT adoption in Kenya is very low with investments levels at a mean of 2.057 and integration levels at a mean of 1.639 in a scale of 1-5. It is therefore obvious that the level of AMTs adoption is at a very early stage. However the findings of the study showed that levels on integrations grew with levels of investments in a company.

Fourteen types of AMTs were investigated drawn from 5 domains based on their respective functions. The five domains are Product design and engineering technologies (PDETs), Production planning technologies (PPTs), Material handling technologies (MHTs), Assembly and machinery technologies (AsMTs) and integrated manufacturing technologies (IMTs). The findings of the study showed that no particular industry could claim to be dominant in all the AMTs. As the largest group of surveyed companies, food, beverage and animal feed industry had the highest level of investment and integration in IMTs but the lowest level of integration in MHTs. Power generation, electrical/electronics, the largest sub-sector in size, had the highest level of investment and integration in PPTs while plastics, packaging and stationery, the smallest sub-sector in size, had the lowest level of investment and integration in AsMTs. Fabricated metal industry had the highest investment in PDETs but Food, beverage and animal feeds had the highest integration in the same AMT. Again construction and material industry had the highest investment in MHT but Power generation, electrical and electronics led in integrating the same AMT. Automobile parts industry had the highest level of investment and integration of AsMTs.

Investments in PPT, for the surveyed companies, were still at an early stage of the material requirements planning tool, since result showed that most companies invested in MRP the most and ERP the least. However, it was noted that the younger a company was the less it invested in MRP. The survey also showed that investment in PPT largely depended on the size of a company. According to the study, the level of integration in PPT increased with the age of the technology. Since MRP was the earliest version of PPT and had been applied for the longest time, the level of integration of MRP was the highest in the surveyed companies. Similarly, as the latest version of PPT, ERP was integrated the least. Compared with companies from other industries, Power generation, electrical/electronic companies tended to invest more in PPT. Companies older than 50 years tended to invest and integrate less PPT than younger companies. Companies with high PPT investment and integration were found to use more flexible structures.

Material handling technology was the least invested and integrated technology in this study. This technology was used by manufacturing companies to facilitate the handling of material in manufacturing operations. From any point of view, MHT got the least attention. Companies barely invested and integrated MHT in their companies no matter which industry they belong to and how old their businesses were. However, the investment and integration of MHT was noticed to be highly related with company size. It was perhaps that companies were using MHT to deal with their vast material handling to support their mass production facilities. Unfortunately, the investment and integration in MHT was not significantly related with any particular organization structure dimension.

Assembly and machining technologies (AsMT) were mostly widely applied for frequently repetitive functions. NC/CNC/DNC was the most widely applied AsMT. In particular, it was mostly applied in medium sized companies. Moreover, investment in robotics and NC/CNC/DNC technologies increased with age bands. The automobile and parts industry tended to have higher investment and integration in AsMT. The level increased with company size. The study discovered that the investment and integration of AsMT was significantly related with human factors. For companies that had quality products, where precision and accuracy were important, AsMT was used to achieve their objectives. Also, it was found that AsMT was positively related with organizational structure in a significant way.

Integrated manufacturing technologies (IMT) did not differ much across sub-sectors. However, large companies tended to have higher investment in IMT due to their strong financial strength. In addition, except for the oldest and youngest age bands, investment of FMC/FMS and CIM, decreased as their age band grew. The older a company was, the less it invested in IMT. Integration of IMT was at low levels for both FMC/FMS and CIM and it did not differ much for each sub-sector. IMT was second least invested and integrated among the five major AMT types. Different sub-sectors had indifferent levels of investment in IMT. The level increased with the company size. The investment and integration of IMT was seen to be positively associated with organizational structure. The study agreed with Pong and Burcher (2009) findings that IMT is positively associated with the dimensions of human factor.

The study showed that smaller companies used an average of 3 different AMTs while larger plants used an average of 6 different AMTs. From this finding, it can be argued that the superior performance of larger companies were partly due to the increased use of AMTs. Even though Pong and Burcher, (2009) found that size has indirect effect on AMT adoption, this study found out that size significantly moderated or enhanced the effect of AMT adoption on Organizational structure. Surprisingly integration of ERP and investment of GT did not grow with size as hypothesized. ERP integration seemed to be more in the middle industry. This finding may be explained by the fact that this technology was newer in the said domains and absorption levels were still low. Olhager and Prajogo (2012) found that ERP was used by 74.2% of all manufacturing companies in Australia and by 85% of the larger companies. Thus, the finding concerning ERP was in contrast. The study showed that CAD use grew faster than other dimensions with increase in company size. This may be due to the generally capital intensive nature of AMTs companies. Rahman and Bennett (2009) reported that FMS was not found in small companies but was found only in very large companies. This may explain the stronger relationship between expensive AMTs, IMT, AsMTs, MHTs and size in the study.

5.3 Relationship between AMT Adoption and Organizational Structure

The first objective of the study was to establish the relationship between AMTs adoption and organizational Structure. The hypothesis tested was that, as AMT adoption increases the organizational structure index also increases. The extensiveness of AMT usage in companies surveyed was measured using the level of investment and the level of integration. Pong and Butcher (2009) used similar measurements of AMT usage in their study on the fit between AMT and Manufacturing strategy. Organizational structure index was explored through six dimensions incorporated from various sources(Sun *et al*., 2007, Ghani *et al*., 2002; Blau *et al*., 1976; Woodward, 1965). The six dimensions include; number of sub-units, Levels of authority, Span of control, role programming, communication programming and output programming.

The surveyed population consisted of manufacturing companies whose major products were classified in eight industries. These industries include companies in food, beverage and animal feeds industry, construction and material industry, chemical and pharmaceuticals industry, plastics, packaging and stationery industry, power generation and electrical/electronic industry, fabricated metals industry, textiles, apparel, leather and footwear industry and automobile and parts industry. When empirically tested, the research findings present the interrelationship between these two variables. Five dominant findings emerged from the study.

First, the findings showed the presence of a positive relationship between AMT adoption and organizational structure (OI = -5.550 +4.722(AMTI). However since OI and AMTI were measured from 1 to 5, and considering the above equation, the value for AMTI could only range from 1.39 to 2.23.Therefore the significance of the relationship is varied only at early stages of AMT adoption. At early stages of adoption the study showed that as investments and integration of PDET, PPT, MHT, AsMT and IMT increased the organizational structural measures (sub-units, levels of authorities, span of control, role programming, output programming and communication programming) also increased. This indicates that as investment and integration of AMTs increased from 1.39

to 2.23 organizational structure characteristic increased from polar point1 to polar point 5. Woodward(1965) demonstrated that there was a positive interaction between technology and organizational structure which influenced performance. She found that a linear relationship existed between technology and structural measures such as the number of hierarchical levels, span of control and personnel ratios. Several other studies have shown that manufacturing technology has an influence over structure (Blau *et al*., 1976; Marsh & Mannari, 1981; Parthasarthy and Sethi, 1992; Ghani *et al*., 2002; Hajipour *et al*., 2011; Li and Xie, 2012). However the current study shows that AMT adoption contributes significantly to the organizational structure of a company only at early stages of AMT adoption.

Second, this study found that a company's capacity to assimilate technology depended on its organizational capabilities. Current study encapsulates the need for companies to increase their organizational capabilities during investment and integration of AMTs. Lim *et al*.(2010) found that the ability of the companies to create specialized sub-units and thus integrating work activities, lead to increased levels of AMT adoption. Based on the results obtained, the study shows that some efforts have been made in the areas of role programming and communication programming but training of workers to increase their ability to run multiple machines is not in the priority line of many surveyed companies. Developing better role and communication programming by incorporating the workers new roles and skills required by AMT will enable positive integration of AMTs. However, most small companies need to build their organizational capabilities to derive the full potential of AMTs. Under the existing condition AMT will not work well, thus, organization-driven changes should be initiated.

Third, this study revealed that most of the organizational structural adjustments are evolutionary (reactive), rather than being revolutionary (proactive). In many industrial companies surveyed the match between needed structure and AMT adoption took some time to materialize after implementation This finding is supported by Ghani (2002) who found that AMT adoption had no effect on the organizational structure that is mostly reactive in nature (less proactive), but has significant effect on the organizational structure that is proactive. Similarly Li and Xie (2012) found that manufacturing companies which were successful in AMT implementation had opted in advance for structural adjustments.

Fourth, the results showed that the level of AMT adoption in Kenya is low at a mean of 1.85 with investments levels at a mean of 2.057 and integration levels at a mean of 1.639 on a scale of 1-5. All the surveyed companies were found to have a measure of investment in at least 2 and at most 9 of the 14 types of AMTs investigated. Yussuf *et al*., (2008) found adoption level for Malysian SMEs at moderate levels taken in comparison to the present study to mean an average of 2.5 (mid value on the scale). This means that AMT adoption level in Kenya is way below the Malysian level. It has been argued that investments in AMTs provide productivity benefits derived from the incorporation of routine tasks into an AMT's hardware and software, which lowers direct labor costs, rework costs, and work-in-process inventories and increases machine utilization ((Sun *et al*., 2007, and Ghani *et al*., 2002). Similarly integration of AMTs shortens lead times, encourages design for manufacturability, and makes feasible the production of small batches of customized goods (Yussuf *et al*., (2008). With globalization and free trade agreements, manufacturing companies in Kenya needs to increase levels of AMTs adoption to survive the global competition.

Based on the five sub-groupings (Product Design and Engineering Technologies (PDETs); Production Planning Technologies (PPTs); Material Handling Technologies (MHTs); Assembly and Machinery Technologies (AsMTs) and Integrated Manufacturing Technologies (IMTs)), the results showed that most investments were made in AsMTs, which were just around the moderate level (mean score 2.43). Production design and engineering technologies ranked second with a mean score of 2.32, followed by production planning technologies (mean score of 1.869). Investments in material handling technologies were the lowest, at the mean score of 1.786. Companies can use AMT to enhance manufacturing capabilities and achieve the intended competitive advantage (Rahman and Bennett, 2009). However, the selection of the levels of investment and integration in AMT are often according to the nature and needs of the business (Song *et al*., 2007). This study has shown that mass production defines most features of large surveyed companies and therefore as expected AsMTs had the highest score in AMT adoption.

Fifth, the study showed that the level of organizational structure characteristic was moderate at a mean of 2.61 in a scale of 1-5 and varied with the type of industry. There was generally a high degree of consistency on all the six dimensions of Organizational index in each of the companies studied. The study showed that a company which had a greater number of levels of authority also tended to be higher on all other dimensions.

The study found that the Sub-Sector with the highest organizational index was the automobile and parts industry with a mean score of 3.25. It was noted from the study that the automobile and parts industry was characterized by large-batch and mass production technology involving producing large volumes of standardized products. The sub-sector with the lowest organizational index, 2.033, was plastic, packaging and stationery industry. Plastic, packaging and stationery industry had many part time workers and non-routine jobs and was characterized by small-batch and unit technology involving making one-of-a-kind customized products or small quantities of products. Woodward (1965) found that a number of organizational characteristics varied significantly among the firms she studied and classified the firms as single unit and small batches, large-batch manufacturing and continuous-process manufacturing.

5.4 Influence of Human Factors on the Relationship between AMT adoption and Organizational Structure

The second objective of the study was to determine the effect of Human Factors on the relationship between AMT adoption and organizational structure. The hypothesis tested was that human factors moderate the relationship between AMT adoption and organizational structure. The hypothesis tested the effect of human factors on the relationship between AMT adoption and organizational structure. The human factors were operationalized in terms of job satisfaction, job involvement, organization commitment, psychological barriers and employee empowerment. The results of the test of hypothesis revealed four dominant findings.

First, human factors moderate the relationship between AMT adoption and organizational structure. There was linear dependence of organizational structure index on the interaction index (AMTI*HFI) as supported by the regression equation; $OI = 15.985 – 7.769(AMTI) - 0.4986(HFI) + 2.946(AMTI*HFI) + \varepsilon_{23}$. Based on the above equation, on a scale of 1 to 5 for all indices, the introduction of HFI as a moderating variable varied AMTI from 1.65 to 3. This is an improvement from 1.39 to 2.23 realized before HFI was added (pg 113). This implied that as AMT adoption increased better skilled and motivated workers became essential. Human factors positively and significantly affected AMT adoption and organizational structure relationship. This is supported by Davids & Martin (1992) who found that blue collar workers' resistance to technological change lead to work slowdowns, poor employee morale and high maintenance cost. This finding is also in agreement with Yussuff *et al*. (2008) who found that the most automated companies had decentralized decision-making processes and had the largest number of specialists. The results from the current study herewith mean that the hypothesis that the relationship between Advanced Manufacturing Technology and Organizational structure depends on human factors is supported.

Second, there exist a positive relationship between Human factors, AMT adoption and organizational structure. The regression equation; $OI = -3.599 + 2.888\ (AMTI) + 0.455(HFI)+\varepsilon_{22}$, indicates the presence of this relationship. Elasticity of the dependent variable OI increased with the elasticity of HFI. In a scale of 1 to 5 the study showed that Power generation, electrical and electronics industry which had the highest score in AMT adoption index (2.025), second highest score in organizational structure index (3.067)had also the highest score in human factors index (3.91). On the other hand plastic, packaging and stationary industry which had the lowest score in AMT adoption index (1.668) and organizational structure index (2.033)had also the lowest score in human factors index (2.00). This finding was supported by several studies that suggested that technology implementation was more likely to be successful when the technology, organization and people issues were designed to complement and integrate with each other (Preece, 1995; King & Anderson, 1995, Ghani, 2002).

Third, the study showed that the level of human factors was above average at a mean of 2.93 on a scale of 1-5 and varied with the type of industry. The results showed that power generation, electrical and electronic industry registered the highest score, mean of 3.91, followed by food, beverage and animal feed industry at a mean of 3.80. The lowest score recorded was in plastic, packaging and stationery industry with a mean score of 2.00, which was attributed to the number of unskilled workforce in this industry. Across the industries, most respondents had a rated mean score of above 2, though lack of flexible, multi-skilled and knowledgeable workforce was evidence. The increase in task complexity linked to AMT required employees to expand their scope of attention and process significantly more information. Companies with higher basic skill levels were able to exploit much of the innate flexibility in AMT and most of this companies registered a high mean in human factors. Most small companies lacked suitable skills at a number of and therefore registered low human factor mean.

Skilled labor is an indispensable precondition for diffusion of AMTs. The survey revealed that in small and medium companies the ratio of trained production engineers to blue collar workers was at an average of one to twenty. In contrast, Japan, where more than two thirds of the CNC machines were mainly in small and medium sized companies, more than 40% of the work force was made up of college-educated engineers, and all had been trained in the use of CNC machines (Song *et al.*, (2007). According to Song *et al*. (2007) training to upgrade skill was often done annually in Japan, thus it can be deduced that the inefficiency of labor is part of the reason that manufacturing companies in Kenya have not yet been able to diffuse the AMT technology so effectively.

Fourth, lack of suitable skills slowed the absolute rate of take-up of technology. In a scale of 1 to 5 the study showed that Power generation, electrical and electronics industry which had the highest score in AMT adoption index (2.025) had also the highest score in human factors index (3.91). On the other hand Plastic, packaging and stationary industry which had the lowest score in AMT adoption index (1.668) had also the lowest score in human factors index (2.00). The results means that lack of suitable skills will not only slow the absolute rate of take-up of technology, but will also limit the range of applications which could be made because of a lack of trained manpower to support the development of sophisticated manufacturing options. Similarly, Dawal *et al*,.(2014) found that the efficient use of new technologies required motivated skilled workforce, especially in an increasingly interconnected application.

5.5 Influence of Company size on the Relationship between AMT adoption, and Organizational Structure

The third objective of the study was to determine the effect of company size on the relationship between AMT adoption and organizational structure. Evidence in the literature showed that conventional technology use increased with company size, measured as the logarithm of workforce number(Kimberly, 1976; Yasai-Ardekani, 1989). The current study operationalized company size further to include AMT capital invested. The logic behind the two measures was that as the up-take of AMT increased a section of production work was done by the machines thus reducing the workforce. This measure of company size was anchored on the two polar point continuum of smaller (index 1)to larger (index 5). The term smaller and larger company purely describing the side of the continuum.

With the above measure of company size the hypothesis tested was that the relationship between AMT adoption and organizational structure depends on company size. The average employment across the sub-sector was found to be around140 but the median was at around 50. This was an indication of the presence of some very large companies which were pulling the whole sub-sector average up. The result of the test of hypothesis revealed four dominant findings.

First, company size positively moderated the relationship between AMT adoption and Organizational structure. Forward stepwise regression of the main effects (AMTI and CSI) and the interaction term (AMTI*CSI)on organizational structure revealed that the only the interactive term was significant at 95% level of confidence. The regression equation reduced to $OI = 0.468(AMTI*CSI) + \varepsilon_{33}$.The equation indicated that CSI statistically moderate the relationship between AMT adoption and organizational structure indicating a linear dependence of OI on AMTI*CSI. This implied that changes in company size index positively and significantly affected the relationship between AMTI and OI. This means that the hypothesis that the relationship between Advanced Manufacturing Technology and Organizational structure depends on company size was supported. This is supported by Yusuff *et al*. (2008) who found that the broader product line in large companies contributed to better use of AMTs. The current finding means that large companies have greater values of organizational structure characteristics perhaps due to larger companies' command of resources which give them access to skilled operators and professionals.

Second, it was found that there exist a positive linear relationship between organizational structure, AMT adoption and company size ($OI = -2.524 + 2.559(AMTI) + 0.297(CSI) + \varepsilon_{32}$).The study revealed that the introduction of capital invested as a dimension of size linearized the relation of AMT adoption and company size. This is supported by the scatter diagram in Appendix 7. In previous empirical studies where company size was only measured in terms of workforce number, literature shows that conventional technology use increased with company size logarithmically (Noe *et al.*, 2008;Yasai-Ardekani, 1989).

Third, the results of the empirical analyses confirmed that the availability of monetary assets was indispensably significant in determining the fate of AMT implementation. Other studies have shown that companies, with less capital invested, were found to have limited AMT adoption probably because of their fragile financial resources which lead to reluctance to invest in AMTs (Ettlie, 1990, Voss, 1988; Scott and Davis; 2007).Likewise, Pearson and Grandon (2004) found that availability of monetary assets is indispensably significant to managers and owners and such subjects often determine the fate of AMT implementation, particularly in smaller manufacturing companies. Companies with ability for higher capital investments were found to use AMTs to make manufacturing easier, more accurate, flexible, sophisticated, faster and cheaper.

Fourth, the study showed company size varied with the type of industry. For all Companies surveyed average company size was at a mean of 2.7 on a scale of 1-5. The results showed that investment in AMT largely depended on the size of a company. Large companies tended to have higher investment in AMT perhaps due to their strong financial strength. The results showed that power generation, electrical and electronic industry was leading with a mean score of 4.0 followed by food, beverage and animal feeds industry with a mean score of 3.5. The lowest score was registered by plastic, packaging and stationery industry with a mean score of 1.5. It is important to note that this industry registered the highest number, about 50%, of part-time employees.

As regards capital invested, the results showed that fabricated metal industry, Construction and material industry and chemical and pharmaceutical industry lead with a mean score of 4.0. The lowest was plastic, packaging and stationery industry with a mean score of 2. In terms of workforce number, it was observed that companies in the power generation, electrical/electronic industry were the largest with mean and median at 284 and 130 employees respectively. Companies in the plastics, packaging and stationery had score with a mean of 59 and a median of 45 full time equivalent employees respectively. It was observed that the skill demand of AMT is a formidable challenge for smaller manufacturing companies to acquire and retain. The strongest determinants of the level of AMT adoption are by far the technical skills of blue-collar workers. In support of this finding Meredith (1987) noted that large companies are able to afford the often extreme expense of these computerized manufacturing technologies and the cost of the failure should the investment fail. Similarly Noe *et al*., (2008) noted that large companies are likely to have the skills and human resources it takes to understand, implement and manage manufacturing technologies.

5.6 Influence of Advanced Manufacturing Technology adoption, Human Factor and Company Size on Organizational Structure

The fourth objective of the study was to establish whether the joint effect of AMT adoption, Human Factors and Company size on Organizational Structure is different from the individual effect. The hypothesis tested was that the joint effect of AMT adoption + human factors+ company size on organizational index is different from individual effect. When empirically tested, the research findings present the interrelationships among the variables. The result of the test of hypothesis revealed five dominant findings.

First, the study showed that the joint effect of AMT adoption, Human factors and Company Size on Organizational structure (OI = -2.104+2.045(AMTI) + 0.245(FSI) + 0.221(HFI))was different from the effects of AMT adoption on organizational structure (OI =-5.550 +4.722(AMTI)). Results of two-way ANOVA for testing Hypothesis 4showed that at 95% confidence level the goodness of fit was 87.1% (Table 28) while AMT adoption alone showed 60.7% (Table 25) goodness of fit. The study showed that AMT influence on the organizational structure is better explained when human and company size variables were introduced. It can be concluded that an organization must be designed with a proper mix of technology, structure and human behavior.

Second, the study showed that the joint effect of AMT adoption, Human factors and Company Size on Organizational structure (OI = -2.104+2.045(AMTI) + 0.245(FSI) + 0.221(HFI))was different from the effects of Human factors on organizational structure (OI = 0.855 +0.740(HFI)). Statistical analysis showed that at 95% confidence level the goodness of fit of the joint model was 87.1% (Table 28) while Human Factors alone (Table 28) showed 60.8% goodness of fit. The adoption of new technology or the penetration of a new market warrants unstable environment which in turn merits an organizational restructuring . This finding is supported Lim, Griffiths and Sambrook (2010) that concluded that organizational structure development should be dependent on the company's capabilities and manufacturing technologies, behavior of workers as constrained by the power distribution between them.

Third, the study showed that the joint effect of AMT adoption, Human factors and Company Size on Organizational structure (OI = -2.104+2.045(AMTI) + 0.245(FSI) + 0.221(HFI))was different from the effects of Company Size on organizational structure (OI =1.826 +0.419(CSI)). The results indicates that when determining the most effective structure and design for an organization, the number of people that belong to the organization has a major impact on which structure works best. In support of this finding Mirmahdi (2012) found that typical structure of a small business is flat since there are a limited number of people who are responsible for many tasks. The typical structure of a large organization is tall, with several vertical levels, or management layers, which represent a more complex structure. Statistical analysis showed that at 95% confidence level the goodness of fit of the joint model was 87.1% (Table 29) while company size alone (Table 29) showed 72.9% goodness of fit. Predictions and statistical inferences made based on the fitted model showed that the effect of company size on organizational structure was different from the joint effects of AMT adoption, human factors and company size.

Fourth, there was a weak positive relation between human factors and Organizational structure (OI = 0.855 + 0.74(HFI)). The sub-sector that recorded the highest score in human factor was the sub-sector that recorded the second highest score in Organizational index. Power generation, electrical/electronics industry had the highest score in human factors (3.91) and second highest score in organizational structure (3.067). In contrast Plastic, packaging and stationary industry had the lowest score in human factors (2.00) and also the lowest score in organizational structure (2.033).

In support of this finding Hajipour *et al*. (2011) found that reorganization of AMT Company is usually feared because it means disturbance of the status quo, a threat to people's vested interests in their jobs and an upset to established ways of doing things.

This then explains why industries with low human factor index are reluctant in reorganizing their structure. The structure of a company is more difficult to alter since change involves redefining jobs, changing the reporting relationships, and even eliminating some units. For these reasons many of the surveyed companies have deferred the needed reorganization, resulting in loss of effectiveness and an increase in cost of manufacturing. Li *et al* (2012) argued that organizational structure is an indispensable means and the wrong structure will seriously impair business performance and may even destroy it. Though most companies cited their organizational structure as moderately independent, the findings here indicated that workers autonomy was limited and decision-making was centralized, thus, decreasing the potential for the flexible use of AMT.

Fifth, it was found that company size had a weak positive relation with Organizational structure (OI = 1.826 +0.419(CSI)). Compared to influence of AMT adoption, company size indicated a mild positive relation with organizational structure. This indicated that as investment and integration of AMTs increased organizational structure tended to move towards the organic polar point but also as company size increased the organizational structure tended to move towards the mechanistic polar point. It was found that as the size increased there was a tendency to move towards organic structure for specialized AMT departments while at the same time moving towards mechanistic in the other departments. This explains the weak positive relation during adoption. The results indicated that once the AMT adoption period was over or nears the end organizational structure tends to slide back to mechanistic. This may be because of what some authors have observed that investments in AMT will pay off only when complementary variables such as infrastructure and strategy fit the investments in technology (Kimberly, 1986; Ward *et al*., 1994) .

5.7 Summary of the chapter

This study aimed at finding out the relationship between Organizational structure and AMT adoption and if this relationship depended on human factors and company size. Thus, this study was undertaken in order to answer the research question in regards to what extent do AMTs adoption influence the organizational structure of a company and do human factors and company size significantly affect the AMT-Organizational structure relationship?

In regard to the first issue of the research question, the study confirmed that all the surveyed dimensions of the organizational structure increased with an increase in the level of AMTs adoption. However the study showed that the relationship between AMT adoption and organizational structure was only varied at early stages of AMT adoption and that at later stages other contingencies were required to validate the relationship. The study also partly confirmed conclusions derived from the literature that there is a link between AMT implementation and organizational structure (Ghani *et al*., 2002; Hajipour *et al*., 2011, Mirmahdi, 2012). The finding confirmed that companies that use most or all AMTs to achieve their competitive advantage, have a high organizational structure index.

On the second issue of the research question, regarding human factors, the study found that the operating and technical people responsible for running, maintaining, and organizing the new technologies require new skills. The study found that the goodness of fit in the model with human factor was 74.4% while the model without human factors was 60.7%. Hajipour *et al*. (2011) contends that reorganization of AMT Company is usually feared because it means disturbance of the status quo, a threat to people's vested interests in their jobs and an upset to established ways of doing things. This then explains why companies with low human factor index were reluctant in reorganizing their structure. Thus, this study found that human factors significantly moderate the relationship between AMT adoption and organizational structure relationship.

On the third issue in the research question, regarding company size, it was noted from the study that size was an enabler variable in the use of AMT. The study showed that smaller companies used an average of 3 different AMTs while larger plants used an average of 6 different AMTs. Given this finding, it can be argued that the superior performance of larger companies were partly due to the increased use of AMTs. Even though Pong and Burcher, (2009) found that size has indirect effect on AMT adoption, this study found that size significantly moderated the relationship between organizational structure and AMT adoption.

On the fourth issue in the research question, regarding joint effect of the predictor variables, it was noted that the joint effect of AMT adoption, human factors and company size was different from their individual effects. Statistical analysis showed that at 95% confidence level the goodness of fit of the joint model was 87.1%; while AMT alone, Human Factors alone and company size alone showed 60.7%, 60.8 and 72.9% respectively. It can therefore be concluded that organizational structure development should be dependent on the company's capabilities and manufacturing technologies and behavior of workers as constrained by the power distribution between them.

CHAPTER SIX: SUMMARY, CONCLUSION AND IMPLICATIONS

6.1 Introduction

In the last chapter, research findings were presented and their significance and their association assessed with the current literature. In this chapter, the summary, conclusions and implications of the research will be highlighted. The chapter is organized into five sections. The first section provides a summary of findings about research issues and the research problem. The second section highlights the implications for theory, which look at the contribution of the research to knowledge in its immediate discipline or field and the wider body of knowledge, implications for Manufacturing Companies and Practitioners, which generally involves top management team and the implications of the research for policy and practice, which generally involves government bodies and other professional bodies dealing with manufacturing sectors. Third section deals with limitations of the study while the fourth section deals with the conclusions of the study and last section that concludes the final chapter of the thesis will deal with suggestions for further research.

6.2 Summary of Findings

Studies on AMTs have shown that companies with a particular organizational capabilities will invest in specific kind of AMT to achieve their intended manufacturing performance (Yusuff *et al.*, 2008; Spanos and Voudouris, 2009; Boothy, 2010). However, the association of the various AMTs adoption to the company's organizational structure, human factors and company size was unclear. Thus, this study was undertaken in order to substantiate the nature of the relationship between AMTs adoption and organizational structure of a company and whether human factors and company size significantly affect this relationship.

As regards AMT adoption, the results showed that the level of AMT adoption in Kenya was low at a mean of 1.85 with investments level at a mean of 2.057 and integration level at a mean of 1.639 on a scale of 1-5. All the surveyed companies were found to have a measure of investment in at least 2 and at most 9 of the 14 types of AMTs investigated. The results showed that most investments were made in AsMTs, which were just around the moderate level (mean score 2.43). Investments in MHTs were the lowest, at the mean score of 1.786. The level of organizational structure characteristic was found to be moderate at a mean of 2.61 in a scale of 1-5 and varied with the type of industry. There was generally a high degree of consistency on all the six dimensions of Organizational index in each of the companies studied. The industry with the highest organizational index was the automobile and parts industry with a mean score of 3.25 and the industry with the lowest organizational index, 2.033, was plastic, packaging and stationery industry.

Regarding human factors, the study showed that the level was above average at a mean of 2.93 on a scale of 1-5 and varied with the type of industry. Power generation, electrical and electronic industry registered the highest human factors score, mean of 3.91. The lowest human factor score recorded was in plastic, packaging and stationery industry with a mean score of 2.00, which was attributed to the number of unskilled workforce in this industry. In regard to company size the measure varied with the type of industry and averaged at a mean of 2.7 on a scale of 1-5. Investment in AMT largely depended on the size of a company. Power generation, electrical and electronic industry was leading with a mean score of 4.0 and the lowest score was registered by plastic, packaging and stationery industry with a mean score of 1.5.

In regard to the first issue of the research question organizational structure characteristics were found to be associated with different levels of investment and integration of AMTs. The study confirmed that all the surveyed dimensions of the organizational structure increased with level of AMTs adoption. Conclusion derived from literature that there is a positive relationship between AMT adoption and organizational structure was partly confirmed. The study found the relationship to be linear only at early stages of AMT adoption. The finding showed that companies that adopt most of AMTs operate at optimal value of organizational structure index. Thus organizational structure index was higher when AMT adoption was higher. The study found that the surveyed companies did not integrate fully their invested AMTs particularly assembly and machining technologies (AsMT).

The second research question was with regard to the influence of human factors on the relationship between AMT adoption and organizational structure. The hypothesis sought to test whether human factors moderated the relationship between AMT adoption and organizational structure. When empirically tested, the research findings confirmed that there was a linear dependence of organizational index from the interaction index

(AMTI*HFI). The result presented herewith meant that the hypothesis, that the relationship between Advanced Manufacturing Technology and Organizational structure is moderated by human factors was supported.

The third issue in the research question was in regard to the influence of company size on the relationship between AMT adoption and organizational structure. Evidence in the literature showed that conventional technology use increases with company size, measured as the logarithm of workforce number(Kimberly, 1976; Yasai-Ardekani, 1989). In the current study company size was operationalized further in terms of workforce number and capital invested. With these measure of company size the hypothesis to be tested was that the relationship between AMT adoption and organizational structure is moderated by company size.

When empirically tested, the research findings indicated that there is a linear dependence of organizational index from the interaction term (AMTI*CSI). This implied that changes in company size index positively and significantly affected the relationship between AMT adoption and organizational structure. This meant that the hypothesis, that the relationship between Advanced Manufacturing Technology and Organizational structure is moderated by company size, was supported. This finding meant that company size enhanced the effective use of AMT perhaps due to larger companies' command of resources which gave them access to skilled operators and professionals who could get more out of these technologies. Further, the broader product line in large companies contributed to better use of AMTs.

The fourth issue regarded the joint effect of AMT adoption, human factors and company size on organizational structure. The hypothesis tested was that the joint effect of AMT adoption + human factors+ company size on organizational index was different from individual effect. When empirically tested, the research findings showed that the joint effect of AMT adoption, Human factors and Company Size on Organizational structure was different from the individual effects of AMT adoption, human factors and company size on organizational structure. The goodness-of fit for the combined effect was87.1%compared with 60.7% for AMT alone, 60.8% for human factors alone and 72.9% for Company size. Table 30 shows summary of tests of hypotheses and result.

Table 30: Summary of tests of hypotheses and results

OBJECTIVE	HYPOTHESIS	RESULTS	REMARKS
1 To establish the relationship between AMTs and Organizational Structure.	**H1:** There is a positive relationship between Advanced Manufacturing Technology and organizational structure	OI=f (AMTI) Bivariate regression $OI_{11} = -5.550 + 4.722(AMTI) + \varepsilon$ $F=138.763$; $P<0.05$, $R=0.779$, $R^2=0.607$ **Results:** AMT adoption contribute positively to the organizational structure of a company at early stages of AMT adoption.	PARTLY SUPPORTED
2 To determine the effect of Human Factors on the relationship between AMT adoption and Organizational Structure	**H2:** The relation between Advanced Manufacturing Technology and Organizational structure depends on Human factors.	OI=f (AMTI,HFI,AMTI*HFI) Stepwise regression $OI_{21}= -5.55 + 4.722(AMTI) + \varepsilon$ *($F=138.763$; $P<0.05$, $R=0.779$, $R^2=0.607$)* $OI_{22}=3.599+2.888(AMTI)+0.455(HFI)+\varepsilon$ *($F=129.658$; $P<0.05$, $R=0.863$, $R^2=0.744$)* $OI_{23}=15.985–7.769(AMTI)-0.4986(HFI)+2.946(AMTI*HFI)+\varepsilon$ *($F=125.704$; $P<0.05$, $R=0.900$, $R^2=0.811$)* **Results:** The relationship between AMT adoption and organizational structure depends on human factors.	SUPPORTED
3. To determine the effect of Company Size on the relationship between AMT adoption and Organizational Structure	**H3:** The relation between Advanced Manufacturing Technology and Organizational structure depends on Company size.	OI=f (AMTI,CSI,AMTI*CSI) Stepwise regression $OI_{31}=-5.55+4.722(AMTI)+\varepsilon$ *($F=138.763$; $P<0.05$, $R=0.779$, $R^2=0.607$)* $OI_{32}=-2.524+2.559(AMTI)+0.297(CSI)+\varepsilon$ *($F=243.763$; $P<0.05$, $R=0.920$, $R^2=0.846$)* $OI_{33} = 0.468(AMTI*CSI) + \varepsilon$ *($F=169.924$; $P<0.05$, $R=0.923$, $R^2=0.853$)* **Results:** The relationship between AMT adoption and organizational structure depends on company size.	SUPPORTED
4. To establish the joint effect of AMTs, Human and Company factors on Organizational Structure	**H4:** The combined effect of Advanced Manufacturing Technology, Human factors and Company size on organizational structure is different from the individual effects.	OI=f (AMTI,HFI,CSI) Multivariate regression $OI_{41} = -5.55+4.722(AMTI)+\varepsilon$ *($F=138.763$; $P<0.05$, $R=0.779$, $R^2=0.607$)* $OI_{42} = 0.855 + 0.74(HFI) + \varepsilon$ *($F=139.605$; $P<0.05$, $R=0.780$, $R^2=0.608$)* $OI_{43}= 1.826+0.419(CSI) + \varepsilon$ *($F=242.449$; $P<0.05$, $R=0.854$, $R^2=0.729$)* $OI_{44}=-2.104+2.045(AMTI)+0.221(HFI)+0.245(CSI)+\varepsilon$ *($F=197.876$; $P<0.05$, $R=0.933$, $R^2=0.871$)* **Results:** The joint effect of AMT adoption, Human factors and Company Size on Organizational structure is different from their individual effects.	SUPPORTED

6.3 Implications of the Study

6.3.1 Implications for Theory

On the empirical front, the wider contribution of this study to the theory is in twofold. First, it adds to the accumulating conceptual and empirical work on the relationship between AMT adoption and organizational structure. This study confirmed that there is a relationship between AMT adoption and organizational structure, that is, companies investing and integrating most of the AMTs will have higher structural dimensions (sub-units, levels of authority, span of control, role programming, communication programming and output programming) during the early adoption period. Thus adding to the body of knowledge that reiterate that manufacturing technology has an influence over structure.

The AMT is often measured using the extent of use, or the level of investment (Rahman and Bennett, 2009). The current study used the measurement of AMT derived from its level of investment and its integration. The mean score of each of the five categories of AMTs is derived by taking the average of its investment score and integration score. This measurement was used due to the fact that all AMT can be integrated or linked to each other to facilitate enterprise-wide integration (Cook and Cook, 1994; Wainwright and Waring, 2004). Thus, providing an extensive measurement option for AMT adoption.

Company size on the other hand is often measured as the logarithm of workforce number(Kimberly, 1976; Yasai-Ardekani, 1989). The current study used the measurement of company size derived from its workforce number and capital invested (Rosnal *et al*., 2003). The mean score in a company was derived by taking the average score. The logic behind the two measurements being that AMT has the power to democratize manufacturing industries, starting at the lower end of the value chain and increasingly moving toward complex decision-making roles. Thus the study provided an alternative balanced measurement for company size and thus adding to the body of knowledge by providing extensive measurement option for company size.

The study also found that the human factors and company size significantly affect the relationship between AMT adoption and organizational structure. Companies that invested in their employees and built their capital were found to be more likely to invest and integrate more AMTs such as CAE,CAD,AGVs and ASRS. Thus, this study provided a better understanding of the AMT diffusion in the manufacturing companies in Kenya that produce discrete products, and permits therefore better comparison with the literature currently dominated by developed countries.

Secondly, the study has made contribution to the contingency theory. The management principles to be applied to any situation depend on complex variety of critical environmental and internal contingencies. Historically contingency theory has sought to formulate broad generalizations about the formal structures that are typically associated with or best fit the use of different technologies. Organizational theory asserts that the structure of a company hinges on four main contingencies: technology, size, environment and strategy. The current study showed that the relationship between AMT adoption and organizational structure depended on human factors. This study concluded that there is no doubt that the strength of fit between AMT adoption and organizational structure depends on human factors. Thus adding to the body of knowledge on contingency theory.

From a statistical point of view, correlated variables are always found in data collected from sampling survey, which will inevitably involve collinearity problems when conducting linear regression. The absence of this is reflected in the study, shown as high goodness of fit (R-square and Adjusted R-Square higher than 0.6). Therefore, the study suggests that perspectives of fit via non-parametric methods are the most appropriate techniques in such research topics. In particular the study also showed that fit as moderation is the best approach in the production management area in order to provide reliable and sensible results.

6.3.2 Implications for Manufacturing Companies and Practitioners

This section considers the implications of the research findings to manufacturing companies or more specifically to the managers of these companies. The most important implication of these result, is that AMT investment in manufacturing facilities is well worth pursuing. This is contrary to the conclusions reached by Demeter (2003) and Dean and Snell (1996) that AMTs have little impact on performance.

The general finding of the study is that the majority (60%) of the companies that made adjustments in their organizational structure prior to its AMT implementation achieved a high adoption level of AMT. This finding support assertion by Parthasarthy and Sethi (1992) asserted that superior performance could result when there is a fit between manufacturing technology and the structure of organization. It thus becomes clear to the top management team and indeed all those involved in the strategic decisions of the manufacturing company, that the successful implementation of AMT requires a consideration of the link between the levels of AMTs adoption and the company's organizational structure. Only by acknowledging and understanding this link can managers hope to reap the full benefits of the new technologies. Moreover, by understanding the link between organizational structure and AMTs, managers are better able to plan for the deployment of workers and implementation process. Once the company has decided on the levels of investment and integration of AMTs the managers will be able to identify the appropriate organizational structure in order to achieve the intended performance.

Advanced manufacturing technology offers enormous potential to increase both effectiveness of the manufacturing effort. It is capable of influencing organizational capabilities across manufacturing industries and allows companies to compete on a higher level of customer requirements. This finding support assertion by Das and Narasimhan (2001) that AMT investment and integration needs to fit with the company's organizational structure in order to be effective and capable of achieving the intended objectives. In short, the message to all manufacturing companies is that AMT adoption must match organizational structural elements for better performance.

6.3.3 Implications for Policy Makers

This section highlights the implications of the research for policy makers such as the Ministry of industrialization, the Ministry of Finance, the National Council for Science and Technology, the National Industrial Development Commission, the Kenya National Chamber of Commerce and Industry, the Kenya Association of Manufacturers. Given the positive impact on organizational structure by successful investment and integration of AMT in medium companies, Government agencies and other funding bodies, should continue, and where possible, expand the financial support offered to small companies who wish to pursue investment in AMTs. Government agencies should seriously look into the possibility of creating more funding opportunities or financial assistance to enhance the company's manufacturing capabilities, especially the medium sized companies.

This research has highlighted the importance of human factors and higher company’s capabilities in managing and planning the manufacturing processes. Advanced Manufacturing Technologies requires workers to be equipped with a variety of new skills at various levels. The operating and technical people responsible for running, maintaining, and organizing the new technologies require new skills, attitudes, system procedures and social structures. Higher knowledge intensity is required by workers in automation. The AMT jobs will require more responsibility for results, more intellectual mastery and abstract skills and more carefully nurtured interdependence (Cagliano, 2000). The current trend in sophisticated automation in manufacturing technology calls upon policy makers in tertiary education to relook at the manufacturing engineering curriculum to accommodate the current technological trend in the industry.

The manufacturing sector in Kenya has contracted sharply over the past few decades. In the global market place, manufacturing companies will only succeed if they can remain competitive. This thesis has shown that successful investment in AMTs, can allow companies to succeed and remain competitive in a global market and thus encouraging investment in AMTs is a means by which the Kenyan government can protect the capacity and employment levels within manufacturing sector. Government agencies can thus enhance the importance of the role of the manufacturing sector in the Kenyan economy by actively encouraging companies to switch to the more high-technology enterprises by investing in more AMTs. It is indeed true for high-cost economies like the UK, that the activities that are likely to thrive are those that are complex and high-value adding(DTI report, 2007).

6.4 Limitations of the study

The study focused on AMT diffusion in AMT manufacturing companies in Kenya that produce discrete products. The study looked at how a company chooses to change its organizational structure during AMT investing and integration period and the fit between the two variables. Organizational structural changes during AMT investing and integration period, is then examined, allowing for human factors and company size to moderate it. This research, like any other has a number of limitations.

First is with regard to generalizability. This study focused on AMT manufacturing companies that produce discrete products. This is because these sub-sectors are those that have been acknowledged to use AMTs. Moreover, they employ similar discrete manufacturing processes to manufacture products. Hence, given this limited choice of industry, the findings are generalizable only to this industry.

Second is with regards to cross-sectional design. This study investigated the state of fit between AMT adoption and organizational structure. The study relied on cross-sectional data to examine the relationship of AMT adoption and organizational structure. Although the cross sectional nature of this study is not a serious limitation, it does not permit the study to highlight the causal directions between the variables. Furthermore, it does not permit the examination of influence of AMT adoption on organizational structure over time.

Thirdly, the study did not consider the learning effect arising from the duration the company has implemented the piece of AMT. In this case, all the companies were treated the same, no matter how long the piece of the technology had been in use. It is acknowledged that these limitations exist in the study. However, they do not detract from the significance of the findings, indeed they can provide sound platforms for future research.

6.5 Conclusion of the Study

In conclusion, this study has fulfilled its goal and expectations initially set for the study. Despite the limitations encountered in the study, significant contribution has been made to the field of organizational theory and production management in regard to AMT implementation. Contingency theory was used to study fit between AMT adoption and organizational structure and the effects of human factors and company size on the relationship between AMT adoption and organization structure.

On the relationship between AMT adoption and organizational structure, the study has provided the empirical evidence crucially required to substantiate the anecdotal accounts on the nature of the relationship. The study confirmed that the type of organizational structure in companies is associated with the level of AMT investment and integration. It is thus possible to conclude that a company that is investing and integrating AMTs should adopt higher dimensions of organizational structure in order to significantly achieve a higher performance. The results obtained indicated that at early stages of AMT adoption there was a clear positive relationship between AMT adoption and organizational structure. However, at high AMT adoption level the relationship was not clear perhaps due to reactive structural adjustments levels witnessed in most companies. In conclusion the findings of this research have reiterated the importance and the need for proactive planning to facilitate changes in the organizational structure in order to get productivity gains.

On the effects of human factors on the relationship between AMT adoption and organizational structure, the study found that human factors positively moderate the relationship between AMT adoption and organizational structure. Accommodating employees motivational needs is always difficult to implement and it is more difficult for organizations that have been designed to be rigid for a particular technology. The study has shown that the traditional organizational structure will increasingly become obsolete. Thus concluding that planned human factors effectiveness system will facilitate a better synthesis between AMT adoption and organizational structure

Company size was found to positively influence the relationship between AMT adoption and organizational structure. It was noted that size was an enabler variable in the use of AMT and small manufacturers were found to lag behind larger manufacturers in implementing new technologies, perhaps due to larger companies' command of resources which gave them access to advanced manufacturing technologies. The study also revealed that it is essential for a company to match its technology investment and integration with its company size in order to achieve the intended manufacturing performance. The study revealed that the introduction of capital invested as a dimension of size linearized the relation of relationship of AMT adoption and organizational structure. It can therefore be concluded that size enhances the effective use of AMTs.

The study showed that the joint effect of AMT adoption, human factors and company size on organizational structure was different from the individual effects of AMT adoption, human factors and company size on organizational structure. The study confirmed that AMT influence on the organizational structure is better explained when human and company size variables were introduced. Organizational structure development should be dependent on the company's capabilities and manufacturing technologies and behavior of workers. The study therefore produced a unifying model which cumulated human factors and company size in relationship between AMT adoption and organizational structure. It can be concluded that an organization must be designed with a proper mix of technology, structure, size and human factors.

6.6 Suggestions for Further Research

An important avenue for further research would be to replicate and extend this research design to include performance. The underlying premise under investigation in this study was the notion that the better the fit between an organizational structure and AMT the superior the performance. Alignment or lack thereof, between organizational structure and AMT adoption was hypothesized to be a determinant of manufacturing performance. The objectivity of the data can be enhanced by using financial information that can be captured in the company's financial reports to include performance.

In addition, as the study relied on cross-sectional data to examine the fit in the relationship between AMT adoption and organizational structure, it was not possible to highlight the causal directions between the variables. Furthermore, it does not permit the examination of the relationship over time. Given that companies rarely adopt all AMTs simultaneously and the performance impact of AMT adoption may vary significantly over time an evolutionary perspective that examines how companies adopt and utilize AMTs over time would be needful. In this regards, a longitudinal study of research would enrich the research findings.

The way information is gathered determines how the findings are interpreted and the conclusions that can be drawn from research depend heavily on the particular research methods employed (Furlong, Lovelace, Lovelace, 2000). Different types of research method draw different types of conclusions for the studies. The findings of this study were derived merely from the information gathered from the survey using a questionnaire. Thus it is proposed that future research may use a mixture of qualitative and quantitative studies, which involve both case studies and survey. The series of case studies will provide additional information in understanding the relationship and the degree to which the AMT adoption and organizational structure reflect on the manufacturing performance. This method should give a thorough insight and better understanding in exploring the issues.

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APPENDICES
APPENDIX 1

QUESTIONNAIRE SECTION 1

This section of the questionnaire is designed to collect data from production managers of Advanced Manufacturing Technology (AMT) Companies in Kenya to establish the influence of AMT adoption, Human factors and company size on organizational structure in Manufacturing Companies in Kenya. The data shall be used for academic purposes only, and will be treated with strict confidence. Your participation in facilitating the study is highly appreciated. All information in this questionnaire will remain absolutely confidential and will be seen only by academic researchers involved in this study.

PART A: GENERAL INFORMATION

1. Name of your Company ………………………………………………..…………

2. Year of establishment?...

3. Name of your job title? ……………………………………………………..………..

4. Years of holding the position in the company? ……………………………………..

5 How long have you worked in this Company? …………………………………. years

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

i.	Chemical and Pharmaceuticals industry	
ii.	Automobile and parts industry	
iii.	Construction and material industry	
iv.	Fabricated metals industry	
v.	Food, beverage and animal feeds industry	
vi.	Textiles, apparel, leather and footwear industry	
vii.	Plastics, packaging and stationery industry	
viii.	Power generation and electrical appliance industry	
ix.	Others(specify)	

PART B: COMPANY SIZE

7 How many permanent workers do this company have on average per month for the last one year…… [ ]

8 How many part-time workers do this company have on average per month for the last one year…… [ ]

9 Which category of capital investment does your company fall in (Tick as appropriate)

Below Kshs. 5M	Kshs. 5 M – 50M	Kshs. 50M-500M	Kshs. 500M-5B	Kshs. Over 5B

PART C: ADVANCED MANUFACTURING TECHNOLOGY

10 Indicate the amount 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

	Manufacturing technologies	1	2	3	4	5	N/A
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.						
5	Material requirement planning (MRP) - to plan production and raw materials requirements by working backward from the sales forecast.						
6	Manufacturing resources planning (MRPII) - Extension of MRP. Planning of manufacturing resources, i.e. manufacturing, marketing, finance and engineering, based on one integrated system.						
7	Enterprise resources planning (ERP) - extension of MRPII. Integrates business processes by using a centralized database. More functions such as reporting, decision making etc						
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						
10	Computer-aided quality control system (CAQCS)-to carry out inspection and testing on final products or incoming or in process materials.						
11	Robotics - a reprogrammable, multifunctional machine to perform repetitive tasks such as pick-and-place						
12	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).						
13	Flexible manufacturing cells/systems (FMC/FMS) - a group of NC/CNC automated workstations interconnected by a material handling system.						
14	Computer-integrated manufacturing (ClM) - integrate CAD, CAM, and FMS, i.e. from design to distribution.						

11 Indicate the extent of integration of the technologies implemented in your organization. (Tick as appropriate)

5= Extended integration	*4=Full integration*	*3=moderate integration*	*2=limited integration*	*1= no integration*
The technology is integrated within the organization and extended to external organizations like suppliers and customers.	The technology is integrated with other systems from other departments within the organization (i.e other than those in production)	The technology is integrated within production and operations functions or production design and production planning	The technology is integrated within production or operations functions or production design or production planning or to logistics	The technology is controlled by a dedicated software/system not linked to other application system within the production/operation s department
Example: CAD is link to customer system, or to suppliers inventory system	Example; CAD is linked to marketing or finance/HR department	Example: CAD links to materials and planning, or design and production functions.	Example: CAD links to materials, or planning, or warehousing, or logistic functions.	Example: CAD only for engineering drawing not connected to any otherpart of production

	Manufacturing technologies	1	2	3	4	5	N/A
1	Computer-aided design (CAD)						
2	Computer-aided engineering (CAE)						
3	Group technology (GT)						
4	Computer-aided manufacturing (CAM)						
5	Material requirement planning (MRP)						
6	Manufacturing resources planning (MRPII)						
7	Enterprise resources planning (ERP)						
8	Automated storage and or retrieval systems (ASRS)						
9	Automated guided vehicles (AGV)						
10	Computer-aided quality control system (CAQCS)						
11	Robotics						
12	Numerical control machines (NC/CNC/IDNC)						
13	Flexible manufacturing cells/systems (FMC/FMS)						
14	Computer-integrated manufacturing (ClM)						

PART D: ORGANIZATIONAL STRUCTURE

12 Indicate the products in your company and the number of processes needed from raw material to the finished product. (Indicate appropriately)

	Product	No. of processes
i.		
ii.		
iii.		
iv.		
v.		
vi.		
vii.		
viii.		
	Average	

13 How many sub-units/departments do you have in this company? (Tick as appropriate)

14 How many levels of authority do you have in this company? (Tick as appropriate)

2	3	4	5	ABOVE 5

Any other remarks

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QUESTIONNAIRE SECTION 2

This section of the questionnaire is designed to collect data from blue collar employees of Advanced Manufacturing Technology (AMT) Companies in Kenya to establish the influence of AMT, Human factors and company size on organizational structure in manufacturing industry in Kenya. The data shall be used for academic purposes only, and will be treated with strict confidence. Your participation in facilitating the study is highly appreciated. All information in this questionnaire will remain absolutely confidential and will be seen only by academic researchers involved in this study.

PART A: GENERAL INFORMATION

1 Name of your Company…………………………………………………………………

2 What is your job title? ………………………………………………………………..

3 How long have you worked in this Company? ___________________________years

PART B: ORGANIZATIONAL STRUCTURE

4 *Communication programming*

To what extent do you agree with the following statements? *Use the scale where 5= very great extent, 4=great extent, 3=moderate extent, 2=small extent, 1= not at all*

	Statement	1	2	3	4	5
i.	Good employee suggestions are acknowledged by providing incentives or other meaningful recognition					
ii.	I often communicate/share information about my programme with staff of other departments					
iii.	Changes with respect to new technology equipment are communicated timely and effectively to all affected personnel.					
iv.	Communication channels exist for employees to effectively communicate up, down and across within the company.					
v.	Employees can access strategic information to do work easily					
vi.	Management sufficiently consults me regarding my work					
vii.	Employees understand the top managements' goals of the organization					
x	Realistic mechanisms are in place for employees to provide recommendations for improvement					
xi	In this organization, my ideas are frequently passed on to top-management					

5 *Role Programming*

To what extent do you agree with the following statements? *Use the scale where 5= very great extent, 4=great extent, 3=moderate extent, 2=small extent, 1= not at all*

	Statement	1	2	3	4	5
i.	My work primarily involves the performance of variety of tasks with well established procedures.					
ii.	There are well-defined standards of practices involving my work.					
iii.	There are specific routine related steps, processes and methods in my work.					
iv.	In my work I have freedom to select the method applicable in any given situation					
v.	My work does not require extended periods of sustained concentration resulting in high levels of stress or fatigue.					
vi.	My work requires considerable judgment and personal initiative to interpret objectives and work assignments.					
vii.	My work is not governed by tough directives from the supervisor					
viii.	My work requires the application of specialized processes or methods					
ix.	My work requires independent judgment in meeting target set by management.					

PART C: HUMAN FACTORS

6 *Job Satisfaction*

To what extent do you agree with the following statements? *Use the scale where 5= very great extent, 4=great extent, 3=moderate extent, 2=small extent, 1= not at all*

	Statement	1	2	3	4	5
i	I am highly satisfied with my job					
ii	I have very few grievances in my work					
iii	My organization puts a lot of emphasize on cost control					
iv	My job is highly meaningful					
v	My relationship with my supervisor is great					
vi	My job gives me sense of accomplishment					
vii	My work gives me pleasure					
viii	My opportunity for advancement is very good in this organization					
ix	My job has great impact on the success of the organization					
x	Those who do well on the job stand a fair chance of being promoted					

7 *Organizational Commitment*
To what extent do you agree with the following statements? *Use the scale where*
5= very great extent, 4=great extent, 3=moderate extent, 2=small extent, 1= not at all

	Statement	1	2	3	4	5
i	I like working for my organization					
ii	I look forward to coming to work					
iii	I have a strong desire to stay to maintain my work in the organization					
iv	I will stay overtime to finish my work					
v	We talk well about our organization					
vi	This organization gives me a strong sense of meaning					
vii	Staff have individual attachment to this organization					
viii	Staff have close cooperation with the managers					
ix	Staff don't intend to leave the organization in the future					
x	Employees perceive current and future opportunity as adequate					

8 *Involvement in Job*
To what extent do you agree with the following statements? *Use the scale where*
5= very great extent, 4=great extent, 3=moderate extent, 2=small extent, 1= not at all

	Statement	1	2	3	4	5
i.	Employees are involved in decision making process					
ii.	There is enhanced employee participation in decision making					
iii.	Employees influence organizational decisions					
iv.	My opinion is asked before changes are made in the organization					
v.	My opinion counts in the work group decision making					
vi.	Employee have influence over what happens in their dept/work group/team					
vii.	Decision making has greatly contributed to the employees' level of empowerment					
viii.	Our environment is such that employees can quickly take a decisions and take action					
ix	I have enough opportunities to contribute to decisions that affect me					
x	My manager values the work I do					

9 *Employee empowerment*
To what extent do you agree with the following statements? *Use the scale where*
5= very great extent, 4=great extent, 3=moderate extent, 2=small extent, 1= not at all

	Statement	1	2	3	4	5
i.	If staff have a problem they can speak directly to management					
ii.	Management is happy when employees do their work well					

iii.	Our organization invests in supporting staff initiatives and projects					
iv.	Resources are evenly distributed according to needs of departments					
v.	There is emphasis on empowerment and growth					
vi.	Help is available from the organization when staff have a problem					
vii.	The organization shows great concern on employees' work and well being					
viii.	Management is satisfied with employees' work					
ix.	The organization really cares about my well-being					
x	My opinion is asked before changes are made in the way I work.					

10 *Employee Psychological barriers*

To what extent do you agree with the following statements? *Use the scale where 1= very great extent, 2=great extent, 3=moderate extent, 4=small extent, 5= not at all*

	Statement	1	2	3	4	5
i.	In the next 12 months I expect my job to be made redundant					
ii.	The adoption of AMTs has made my work difficult					
iii.	The adoption of AMTs has affected my job description					
iv.	In my workplace, machines/equipment are not in a good state of repair.					
v.	It is likely that my job could be eliminated within the next year?					
vi.	The reason why AMT implementation was brought was to replace jobs like mine					
vii.	I am concerned that, within the next five years, my employer may replace me with a machine					
viii.	I am concerned that, within the next five years, my employer may replace me with another worker who is more skilled than me					
ix.	I am concerned that advances in technology may mean that my job will be replaced by a machine or a robot					
x.	On my job, I have very little freedom to decide how I do my work.					

11 Any other remarks

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APPENDIX 2: LIST OF AMT COMPANIES IN KENYA AND THEIR PRODUCTS

NO.	NAME OF COMPANY	PRODUCTS	TOWN
A	**Chemical and pharmaceuticals industries**		
1.	Basco Paints Limited	Paints, thinners, adhesives	Nairobi
2.	Beta HealthCare	Pharmaceuticals	Nairobi
3.	Blue Ring Products Limited	Cleansing detergent	Nairobi
4.	Bobmil Industries Limited	PU foam and polyethylene	Mombasa
5.	British American Tobacco Kenya Limited	Tobacco	Nairobi
6.	Chloride Exide Kenya Limited	Battery	Nairobi
7.	Crown-Berger (K) Limited	Paints, thinners, adhesives	Nairobi
8.	Dawa Limited	pharmaceuticals	Nairobi
9.	East Africa Botanicals Limited	Chemicals	Nairobi
10.	Eastern Chemical Industries Limited	Pharmaceuticals	Mombasa
11.	Elys Chemical Industries	Pharmaceuticals	Nairobi
12.	Eveready East Africa Limited	Dry cell battery	Nakuru
13.	Inkuador Aroma Body Products	Aromatic, natural skin and hair products	Nairobi
14.	JET Chemicals (Kenya) Limited	Cleaning products	Nairobi
15.	KAPI Limited	Pyrethrum based Insecticides	Nakuru
16.	Kenya Fluorspar Company Limited (KFC)	Fluorspar	Kerio Valley
17.	Lacheka Lubricants Limited	Lubricants	Bandari Road, Nairobi
18.	Magadi Soda Company	Soda Ash	Magadi
19.	Napsbury Product	Household cleaning products	Nairobi
20.	Orbit Chemical Industries Limited	Industrial Chemicals, Fertilizers, Soaps	Mombasa Road, Nairobi
21.	Rotam Sub-Saharan Africa	Agrochemicals and Veterinary Products	Nairobi
22.	Soilex Prosolve Limited	Detergents and cleaning solutions	Industrial Area, Nairobi
23.	Stalite Systems Co.Limited	Cleaning detergents	Ruaraka
24.	Sudi Chemical Industries Limited	Drilling Chemicals, Aerosol Fillings	Industrial Area, Nairobi
25.	Sweetie Cosmetic 95	Skin and beauty products	Nairobi
26.	Tiger Brands (k)Limited	Chemicals and adhesives	Enterprise Road, Nairobi
27.	Tripac Chemical Industries Limited	Chemical Products	Industrial Area, Nairobi
28.	Universal Ponds Kenya Limited	Baking powder	Industrial area Nairobi
B	**Textiles, apparel, leather and footwear industries**		
29.	African Cotton Industries Limited	Cotton, ear buds, toiletries	Nairobi, Mombasa
30.	Bata Shoe company Limited	Foot wear	Limuru
31.	Bogani Industries Limited	Fabrics	Ruiru
32.	Chandaria Industries Limited	Toilet and napkin tissue paper	Nairobi
33.	Chemplus Holdings Limited	Dana toothpaste and toothbrush	Nairobi
34.	Colgate-Palmolive(East Africa) Limited	Toothpaste, soaps	Nairobi

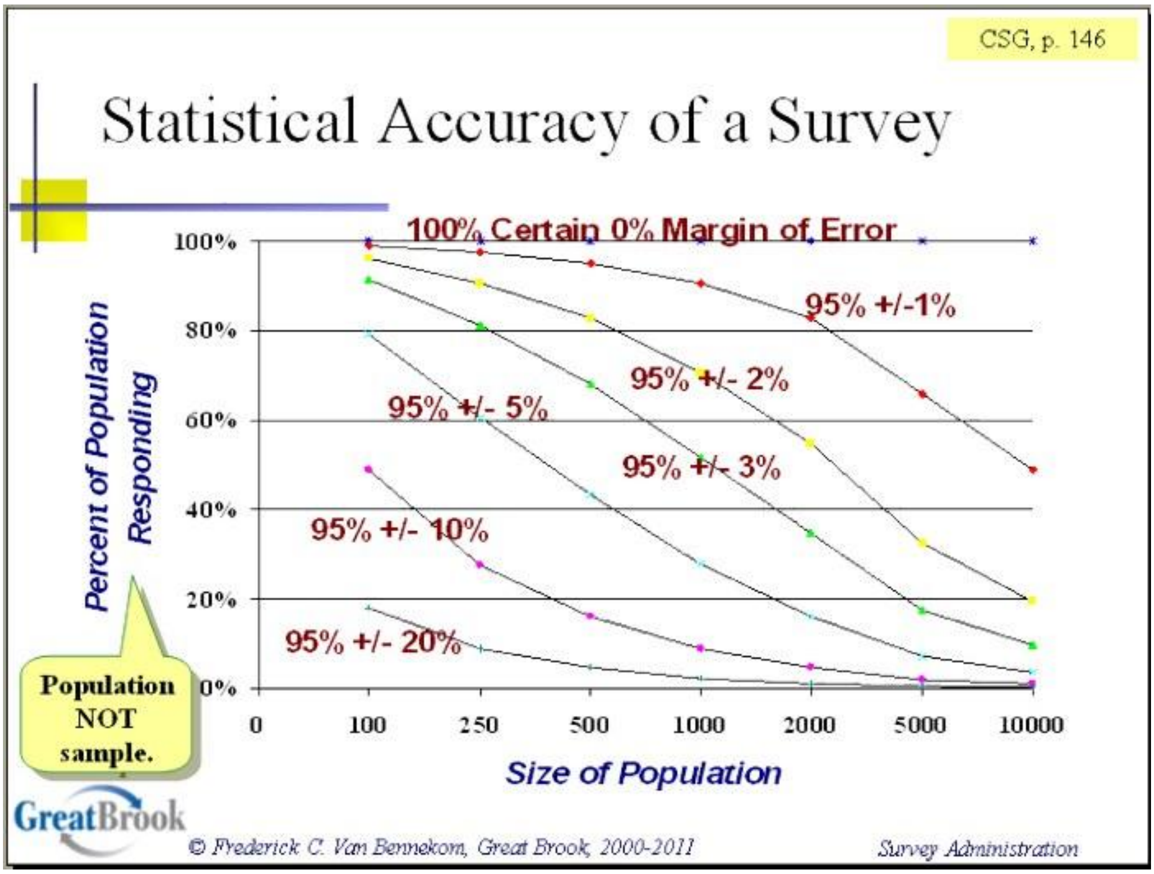
35.	J.D Sharma & Sons	Outer knitwear sweater	Nairobi
36.	Ken Knit (Kenya) Limited	Textile manufacturers	Eldoret
37.	Kenwear Garment Manufacturers	Textiles	Thika
38.	Kim-Fay East Africa Limited	Personal care	Mombasa Rd, Nairobi
39.	PZ Cussons East Africa Limited.	Soaps, toiletries, and household products	Ruaraka
40.	Spinners and Spinners Limited	Textile eg pillows	Ruiru
41.	Thika Cloth Mills Limited	Textiles	Thika
C	**Power generation and electrical/Electronics industries**		
42.	East African Cables Limited.	Cables	Nairobi
43.	Kenya Electricity Generating Company Limited.	Electricity	Nairobi
44.	Solarworks East Africa	Solar energy	Nairobi
45.	Solimpexs Africa Limited	Solar water heating products	Nairobi
46	Orpower 4, lnc	Electricity	Naivasha
47	Kenya Solar	Solar energy	Nairobi
48	Cuma Refrigeration East Africa Limited	Refrigerators	Nairobi
49	Kenwestfal Works Limited	Cables	Nairobi
50	Power Technics Limited	Electronics	Nairobi
51	Socabelec East Africa Limited	**Electronics**	Mombasa
52	Sollatek Electronics Kenya Limited	Solar panels	Nairobi
53	Modulec Engineering Systems Limited	ICT cabinets	Nairobi
54	PCTL Automation	Low voltages Electronics	Nairobi
55	Eveready (EA) Limited	Dry cells	Nakuru
D	**Automobile and parts industries**		
56.	General Motors Kenya Limited	Motor vehicle assembly	Nairobi
57.	Cooper Motor Corporation	Automotive	Nairobi
58.	Kenya Grange Vehicle Industries Limited	Vehicle Parts	Nairobi
59.	Kenya Vehicle Manufacturers	Semi-trailers	Thika
E	**Fabricated metals industry**		
60	Africa Kaluworks (Aluware) Division K	Aluminum cookware	Nairobi
61	Apex Steel Limited	Steel	Nairobi
62	Associated Steel Limited (ASL) – HFD	Stainless steel	Nairobi
63	Doshi Enterprise	Steel Tube and pipe manufacturers	Nairobi
64	Enkomak Bakery Machinery Company	Bakery machines	Nairobi
65	Galsheet Kenya Limited	Iron Roofing Sheets	Nairobi
66	Hebatullah Bros Limited	Aluminum and steel fabrication	Nairobi
67	Kiesta Industrial Technical Services Limited	Metallic Machine Parts	Ngong Road, Nairobi
68	Kitchen King Limited	Aluminum products & kitchenware	Mombasa
69	New World Stainless Steel Limited	Stainless Steel	Lusaka Road, Nairobi
70	Numerical Machining Complex	Parts for manufacturing and Industries	Nairobi
71	Stainless Steel Products Limited	Stainless Steel Products	Lusaka Road, Nairobi

72	Steel Structures Limited	Steel Products	Nairobi
73	Steelmakers Limited	Hot rolled steel products	Nairobi
74	Superfit Steel Construction Limited	Steel Structure Parts,	Industrial Area, Nairobi
75	Tuff steel	Steel	Nairobi
76	Welrods Limited	Welding Rods, Industrial Gases	Industrial Area, Nairobi
F	**Food, beverage and animal feeds industries**		
77	Alpha Dairy Products Limited	Ice cream products	Nairobi
78	Alpha Fine Foods Limited	Meat products	Nairobi
79	Bdelo Limited	Maize tortillas	Nairobi
80	BIDCO Oil Refineries Limited	Edible oil, cooking fat, margarine	Thika
81	Britannia allied Industries Limited	Biscuits	Nairobi
82	Brookside Dairy Limited	Dairy products	Ruiru
83	Buzeki Milk company	Dairy product, Molo milk	Molo
84	C&R Food Industries Limited	Snacks such crisps, cakes and cookies	Nairobi
85	Cadburys Kenya Limited	Beverages	Nairobi
86	Coca-Cola Company	Beverages	Nairobi
87	Cosmos Limited	Pet care products, animal health products	Nairobi
88	Deepa Industries Limited	Species under the name ‘tropical heat’	Nairobi
89	Del Monte Kenya Limited	Beverages(juice)and food(pineapples)	Thika
90	Delamere Dairies	Dairy products	Naivasha
91	East African Breweries Limited	Alcoholic beverages	Nairobi
92	Eastern Produce Kenya Limited	Tea	Nandi Hills
93	Excel Chemical Limited	Beverages	Nairobi
94	Farmers Choice Limited	Meat product	Nairobi
95	House of Manji	Baked Products	Nairobi
96	Jetlak Foods Limited	Canned Foods	Thika
97	Kakuzi Limited	coffee, tea, passion fruit, avocados, citrus, pineapples	Thika
98	Kamili Packers Limited	Food industry in flour, grains, rice and spices	Nairobi
99	Kapa Oil Refineries Limited	Edible oil and fats, Detergent powder, baking powder and laundry soap	Nairobi
100	Kenafric Industries	Confectionery, Food, Footwear, and Stationery products	Nairobi
101	Kenblest Limited	Bread	Thika
102	Kenya Nut Company	Nuts	Nairobi
103	Kenya Tea Packers Limited (KETEPA)	Tea, Tea Packaging	Kericho
104	Kevian Kenya Limited	Juice, Water	Nairobi
105	Kuguru Foods Company Limited	Beverages and Food Products	Nairobi
106	Macadamia Nuts Limited	Nuts	Nairobi
107	Manji Food Limited	Biscuits	Industrial Area, Nairobi
108	Melvin Marsh International	Tea	Enterprise Road, Nairobi
109	Miritini Kenya Limited	Tetra pack juices, PET fruit juice drinks, fruit squash ,drinking water	Nairobi
110	Mjengo Limited	Daawat Rice. Nuvita Biscuits	Thika
111	Mumias Sugar Company	Sugar	Mumias

112	Nestle Foods Kenya	Food Products	Nairobi
113	New KCC	Dairy products	Nairobi
114	New Kenya Cooperative Creameries	Dairy products e.g. milk, yoghurt, ghee, cheese	Nairobi
115	Njoro Canning Factory Limited	Canning vegetables, frozen food etc	Nakuru
116	Patco Industries Limited	Confectionery	Industrial Area, Nairobi
117	Pembe Flour Millers	Flour and feed millers	Industrial Area, Nairobi
118	Petmix Feed	Animal feeds	Nairobi
119	Pwani Oil Products Limited	Edibles Fats and Oils	Mombasa
120	Sasini Tea	Tea, Coffee	Nairobi
121	Sony Sugar	Sugar	Nyanza
122	TruFoods Limited	Jams, Sauces	Nairobi
123	Tuzo Milk Company	Dairy Products	Industrial Area, Nairobi
124	Unga Farm Care (EA) Limited	Farm Feeds	Nakuru
125	Unga Group Limited	Fluor, Maize meal, Cereals	Industrial Area, Nairobi
126	Unilever Kenya Limited	Food, Home and Personal Care Products	Nairobi
127	Unilever Tea Kenya	Tea	Kericho
128	United Millers Limited	Wheat flours, Bakery products, Vegetable cooking Oils and Soaps	Kisumu
129	Williamson Tea	Tea	Kericho
130	Wines of the World Limited	Alcoholic Beverages	Kileleshwa, Nairobi
G	**Construction and material industries**		
132	Athi River Mining Limited	Cement	Nairobi
133	Bamburi cement	Cement	Nairobi, Mombasa
134	Bilco Engineering	Spun concrete, pipes precast concrete	Nairobi
135	Cabro East Africa	Wood products	Nairobi
136	Carton Manufacturers Limited	Corrugated paperboard and boxes	Nairobi
137	Country Mattresses Limited	Polyurethane mattress	Nairobi
138	East African Packing Limited	Corrugated paperboard and boxes	Nairobi
139	East African Portland Cement	Cement	Nairobi
140	Fairdeal Upvc, Aluminum and Glass Limited	Upvc, aluminum and glass	Mombasa
141	Foam Mattress Limited	Polyurethane mattress	Kisumu
142	Hydraulic Hose & Pipe Manufacturers Limited	Pipes and hoses	Nairobi
143	Interior Designs Co Limited	High class furniture	Nairobi
144	Kenya Ceramic Project	Ceramic water filters	Kiminini
145	Kenya Litho Limited	Corrugated paperboard and boxes	Nairobi
146	Kenya Tanning Extract Company	Leather, Skins, Tanneries	Thika
147	Manzil Glass	Glass	Thika
148	Maweni Limestone Limited	Cement	Mombasa
149	Olympia Capital Holdings	vinyl floor tiles; vinyl sheeting; rubber tiles; building material	Nairobi
150	Polythene Industries Limited	Polythene Products	Nairobi
151	Rea Vipingo Company	Sisal	Nairobi

152	Rupa Cotton Mills EPZ Limited	Cotton Material	Athi River
153	Safepak Limited	Polyethylene terephthalate (PET)products	Nairobi
154	Slumberland Kenya Limited	Beds, Mattresses	Industrial Area, Nairobi
155	Super Foam Limited	Polyurethane mattress	Ruiru
156	TARPO Industries Limited	Tents	Enterprise Rd, Nairobi
157	Unified Bag Converters Limited	Corrugated paperboard and boxes	Nairobi
158	Warren Concrete Limited	Precast Concrete Products	Ruaraka, Nairobi
H	**Plastics, packaging and stationery industries**		
159	All Pack (K) Limited	Corrugated paperboard and boxes	Nairobi
160	Metal Crown Limited	Metal, Plastic Packing, cans	Industrial Area, Nairobi
161	Mombasa Canvas Limited	Canvas and Canvas Products	Mombasa
162	Nairobi Bottlers Limited	Bottling	Nairobi
163	Nampack Limited	Metal Packaging	Thika
164	Platinum Packaging Limited	Flexible Packaging	Nairobi
165	Sanpac Africa Limited	Rigid Plastic Packaging	Nairobi
166	Shade Systems(E.A)Limited	Tents, Shades, Umbrellas etc	Museum Hill, Nairobi
167	Shrink Pack Limited	Packing materials	Nairobi
168	Statpack Industries Limited	Packaging Materials	,Nairobi
169	Packaging Industries Limited	Corrugated Cartons, Single Faced Kraft, Paper sacks	Lungalunga Road, Nairobi
170	Paper Bags Limited	Corrugated paperboard and boxes	Industrial Area, Nairobi
171	Paper Converters Limited	Corrugated paperboard and boxes	Nairobi
172	Unified Bag Converters Limited	Corrugated paperboard and boxes	Nairobi
173	Acme Containers Limited	Plastic crates, drums and jerry cans	Limuru
174	Arrow Rubber Stamp Company Limited.	Rubber stamps	Nairobi
175	Blowplast Limited	Plastic	Nairobi
176	Kenpoly Manufacturers Limited	Plastic based domestic-wares	Nairobi
177	Stamet Products (K) Limited	Stationery Products	Nairobi
178	Top tank	Plastic water storage	Nairobi
179	Economic Industries	Stationary products	Nairobi
180	Flexoworld Limited	Digital plates for polyethene	Nairobi
181	General Plastics Limited	Rigid plastic packing manufacturers	Nairobi
182	HACO Industries	Ball Point pens	Nairobi
183	Harsho Packing Company Limited	Plastic paper and woven bags	Nairobi

Appendix 3: Statistical determination of sample size



APPENDIX 4: LIST OF AMTs AND THEIR DESCRIPTION

	AMT	DESCRIPTION
1	**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).
2	**Computer-aided engineering (CAE)**	CAE software assists the engineer while examining and testing design from a structural or engineering point of view. This package is very similar to CAD software (Hunt (1987).
3	**Group technology (GT)**	GT assists in designing and testing a product, from a structural or engineering point, controlling of manufacturing machinery, and also for part classifications and coding systems (Kotha and Swamidass (2000)
4	**Computer-aided manufacturing (CAM)**	This is a digital computer used for automation of electromechanical processes e.g. control of machinery on factory assembly lines. They are designed for multiple input and output arrangements, extended temperature range and resistance to vibration computer-aided manufacturing (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 (Pong and Burcher, 2009). It encompasses the software to control manufacturing machinery. It produces the information required to determine the process of manufacture. For example, if the product is to be processed on a CNC, CAM will determine the movements of the tooling, cutting speeds, etc.
5	**Manufacturing Resource Planning (MRP, MRPII)**	The application of computer aided systems in the planning and control of contract filling and manufacture as regards disposal and organization, including determination and management of material needs, dates, and capacities; that is, the administration of bills of materials, operations scheduling, materials, and time as well as the recording of operating data, the planning of production and/or the management of customer orders (Pong and Burcher, 2009).It controls the entire manufacturing system from order entry through scheduling, inventory control, finance, accounting, accounts payable and so on (Kotha and Swamidass, 2000). Material Requirement Planning (MRP) - used to determine and manage material needs, dates, and capacities by using bills of materials, operations scheduling, materials, and time as well as the recording of operating data. A useful tool for the planning of production and/or the management of customer orders (Spanos and Voudouris, 2009). When MRP is extended to other areas of the business to include the other various resources, it is called Manufacturing Resource Planning (MRP II) - planning of all the resources of a manufacturing company, i.e. manufacturing, marketing, finance and engineering. It is based on one integrated system containing a database which is accessed and used by the whole company according to individual functional requirements (Kotha and Swamidass, 2000)).
6	**Enterprise Resource Planning (ERP)**	ERP is an extension of MRP II. ERP integrates business processes by using a centralized database. It contains modules to allow efficient reporting and decision making throughout the company, process data interactively and to be available in real time, and it also allows easier global integration (Kotha and Swamidass, 2000)).
7	**Automated material handling (AMH)-Automated storage and or**	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

	retrieval system (ASRS)	(AGV) (Kotha and Swamidass, 2000)).
8	**Automated Guided Vehicles (AGV)**	Transport automation is in most cases undertaken by driverless transport systems, such as automated guided vehicles (AGVs) or rail-guided vehicles, also by suspended conveyors and roller conveyers or conveyor belts. AGVs are small independently powered vehicles which move materials to and from value adding operations. They are usually guided by cables buried in the floor of the operation and receive instructions from a central computer. Variations on this arrangement include AGVs which have their own on-board computers or optical guidance systems (Spanos and Voudouris, 2009).
9	**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)).
10	**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.
11	**Computer Numerically Controlled machines (CNC) or numerical controlled machines (NC)**	Machining tool which is directly linked to a computer that controls it. The information can either be stored on disk computer (CNC), or in a form of a punched paper tape (NC). This information controls the movements of its tools and the speed of the machine throughout the processing operation. The set of coded instructions and the computers attached to the machine have taken the place of the operator who would previously have controlled the machine by hand. Today, CNC controls are mostly applied for turning machines, boring and milling machines, horizontal boring machines, and machining centres. Other machining work holds a share of over 20% in NC/CNC machines, the principal share being held by grinding and erosion machines; but CNC controls exist for almost types of machining (Kotha and Swamidass, 2000)
12	**Flexible manufacturing cells (FMC) or systems (FMS)**	Consists of two or more NC/CNC machines which are interconnected by handling devices (such as robots) and transport system. A FMS can work on more than one different work piece simultaneously. It allows varying machining operations on different work pieces to be performed within a given area (Pong and Burcher, 2009).The NC workstations perform 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 operated under the guidance of a central computer system. FMC - capable of single path acceptance of raw materials and single path delivery of a finished product; FMS-capable of multiple paths. May also be comprised of 2 or more FMCs linked in series or parallel.
13	**Computer Integrated Manufacturing (CIM)**	Incorporate CAD, CAM and also the control of FMS. It integrates all elements in the manufacturing process from product design to distribution (CAD/CAM, CNC, robots, AGV, production planning, logistics). It links beyond company departments by integrating computer systems, thus islands of computer application in the companies are integrated (Rosnah *et al*., 2003). A variety of single elements are designed in a specific way to link already installed systems. With CIM, an uninterrupted digital information flow is created between all computer assisted technical and administrative departments of a plant; avoiding multi-programming and multi-keeping of the same data in the memories of the computer systems in different departments (Hunt (1987).

Appendix 5: linear regression on organizational structure against human factors

Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.780[a]	.608	.604	.34211

a. Predictors: (Constant), HFI

Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.780[a]	.608	.604	.34211

a. Predictors: (Constant), HFI

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	.855	.204		4.191	.000
	HFI	.740	.063	.780	11.815	.000

a. Dependent Variable: OI

Appendix 6: linear regression on organizational structure against company sizes

Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.854[a]	.729	.726	.28431

a. Predictors: (Constant), CSI

ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	19.598	1	19.598	242.449	.000[b]
	Residual	7.275	90	.081		
	Total	26.873	91			

a. Dependent Variable: OI

b. Predictors: (Constant), CSI

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	1.826	.095		19.230	.000
	CSI	.419	.027	.854	15.571	.000

a. Dependent Variable: OI

Appendix 7: scatter diagram for regression on organizational structure against Advanced Manufacturing Technology and company size