Advanced Manufacturing Technology and Technical Labour in Manufacturing Companies in Kenya

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Abstract**—***Over the past few decades, manufacturing has evolved from a more labor-intensive set of mechanical processes to a sophisticated set of information based technology. With the existence of various advanced manufacturing technologies (AMTs), more and more functions or jobs in the production line are being performed by these machines instead of human labour. This study was undertaken in order to establish the relationship between AMT adoption and technical labour characteristics. The AMT adoption was measured in terms of its investment and integration, while Technical labour (TL) was measured in terms of job satisfaction, organizational involvement, organizational commitment, psychological barriers and employee empowerment. Data from 92 manufacturing companies in Kenya showed that as adoption of AMTs increased, the aforementioned characteristics of technical labour increased. On a scale of 1-5 the study showed that Power generation, electrical and electronics industry had the highest index score in AMT adoption (2.025) and in technical labour (3.91). On the other hand Plastic, packaging and stationary industry had the lowest score index in AMT adoption (1.668) and in technical labour (2.00). Primary finding showed the existence of a positive relationship between the two variables (AMT =1.542 +0.99(TL). It was concluded that the role of current technical labour is bound to diminish and other suitable informational based skills in manufacturing processes will be required as the rate of take-up of technology increases. In line with Vision 2030 the study encapsulates the need for policy makers to align manufacturing engineering training to current technological trend in the industry.*

Keywords: Advanced manufacturing technology, Adoption, Technical labour

I INTRODUCTION

MANUFACTURING processes, equipment and systems used in design and production are undergoing dramatic changes in response to new customer needs, competitive challenges and emerging technologies [1]. Historically, manufacturing has changed from a highly labor-intensive set of mechanical processes to an increasingly sophisticated set of information technology intensive processes. This technological revolution is fast replacing human beings with machines in virtually every sector of manufacturing industry [2]. In developed countries, millions of technical workers have been permanently eliminated from the economic process, and whole work categories and job assignments have shrunk, been restructured or disappeared [3]. Developing countries, like Kenya, are likely to face increasing technological unemployment as transnational companies adopt state-of-the-art high-tech production facilities, letting go millions of low skilled labourers who can no longer compete with the cost efficiency, quality control and speed of delivery achieved by automated manufacturing.

Reference [4] stated that fear of work overload caused by reduction of cycle time is a factor of concern among blue collar workers. Reference [5] found that new technology creates phobia among operators and the anxiety towards the new technology lead to emotional fear among AMT workers. Reference [3], 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. Reference [16] emphasized that irrespective of the manufacturing technology type, a company needs to be as least mechanistic as possible to be effective.

Advanced Manufacturing Technology requires informational based skilled workers who should be provided with more autonomy in dealing with issues such as AMT plans and problem solving [3]. Reference [3] found that providing workers with opportunities to improve their intrinsic skills by means of employee empowerment practices aligned the goals of employees' with the company's.

II ADVANCED MANUFACTURING TECHNOLOGY

Different studies have adopted wider definitions of AMTs. Reference [6] 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 [7]. Reference [8] used the term AMT to describe a variety of technologies that utilize computers to control, track or monitor manufacturing activities, either directly or indirectly. Reference [9] regards AMTs as a wide variety of modern computer based technologies in the manufacturing environment. From these studies, it can be summarized that, AMT suggests both soft and hard technologies which are being employed to enhance manufacturing competencies. This study adopts the narrower form of AMT as the use of innovative technology to improve production processes or products and it is this concept that is further explored within this study.

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 [2], which is in line with the focus of this study. This study adopts a similar list as that put forward by reference [9]. However, the management practice element Just-in-Time (JIT), is excluded as the researcher considers it not a technology, but instead more of a practice. The study therefore investigated fourteen AMTs namely; Computer aided design (CAD), Computer aided engineering (CAE), Group technology (GT), Computer aided manufacturing (CAM), Manufacturing Resource Planning (MRP), Material requirement Planning (MRP II), Enterprise Resource Planning (ERP), Automated Guided Vehicle (AGV), Automated Storage and Retrieval System (ASRS), Numerical controlled machines (NC/CNC/DNC), Computer Aided Quality Control System (CAQCS), Robotics, Flexible Manufacturing Systems/Flexible Manufacturing Cells (FMS/FMC) and Computer integrated Manufacturing (CIM).

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III TECHNICAL LABOUR

Advanced Manufacturing Technologies requires workers that are equipped with variety of computational skills at various levels of production. Technical labour, refers to the operating and technical workers responsible for running and maintaining production machines and processes. The increasing automation of production processes has left thousands of blue collar workers jobless [2]. As the new generation of AMTs, armed with greater intelligence and flexibility, make their way to the market, automakers are far more likely to substitute them for workers because they are more cost effective. In view of this, every major manufacturing activity, human labour will steadily be replaced by these AMT machines. Today, millions of working men and women around the world find themselves trapped between economic eras and increasingly marginalized by the introduction of these labour saving technologies [1].

Production processes technological change affects and demand changes in design and manufacturing activities. Consequently jobs/tasks of employees have to be redesigned. Employees, particularly operators, resist technological change fearing that new technology would reduce or eliminate the need for their particular skills. Reference [10] best articulated technologies as having potential to deskill the worker, to isolate him/her from the means of production and to diminish the worker's power and influence.

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 [11]. 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 and computer knowledgeable workforce.

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 [2]. Manufacturing companies in Kenya face many uncertainties when they venture into global market since most technological development happens in developed countries. These uncertainties may be attributed to low level of skilled labour and training mechanisms that are not congruent with the changing manufacturing technology.

IV MANUFACTURING COMPANIES IN KENYA

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. 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 [14]. Even though large proportion of industrial output is directed towards satisfying basic needs, Kenya is currently the most important source of foreign direct investment **[**FDI] in Uganda and Rwanda. The region, particularly Uganda, is the most important export destination for Kenyan products [15].

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. Eight sub-sectors were acknowledged, in this study, to employ AMTs and they included; 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, automobile and parts industry. This is deemed representative of the current manufacturing companies in Kenya.

The role of the manufacturing sector in Vision 2030 is to create employment and wealth [17]. To steer industrial growth, skills development for the technical human resource has been identified as a specific goal for the manufacturing sector [17]. However the rapid elimination of work opportunities resulting from technical innovation and corporate globalization is causing men and women everywhere to be worried about their future. The young are beginning to vent their frustration and rage in increasingly antisocial behaviour. Older workers, caught between a prosperous past and a bleak future, seem resigned, feeling increasingly trapped by social forces over which they have little or no control. This study investigated the current state of AMT adoption in the manufacturing sector in Kenya and its relationship with current technical labour in the industry.

V MATERIALS AND METHODS

Preliminary study showed that, by end of 2014, there were about 183 companies using a form of AMT [14,17]. These companies manufacture a variety of products for domestic consumption and for export. Letters were written to all the 183 identified companies and either delivered or posted. As the AMT plants were located at different places, geographically ranging from 5 to 700 km, data collection process took nearly 7 months. Data was collected using a questionnaire adapted from [9], [16] and the researcher. The questionnaire solicited information on the two variables of the study; technical labour characteristics and AMT adoption. Specifically, the questionnaire used was divided into two sections. The first section sought to collect technical information from production/plant managers. The second section was self-administered to at least five blue collar employees and the researcher took more respondents where previous respondents were unable to answer the questions appropriately. This second section sought to collect work related information and an average for each was thereafter calculated. Table 1 shows how the two variables were operationalized.

Table 1: Operationalization of variables

ariable	dimension	Definition	Indicators
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
	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
Technical Labour	Job satisfaction	how contented an individual is with his or her job	The extent of worker feelings of contentment with his/her job. Five-Point Likert scale
	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 scale
	Organizational commitment	individual's psychological attachment to the organization.	Ranking on the extent of a worker attachment to the organization. Five-Point Likert scale
	Employee empowerment	degree of autonomy / responsibility a worker has in decision-making r	The degree of autonomy /responsibility a worker has in decision-making regarding his/her work. Five-Point Likert scale
	Psychological barriers	mind-associated problems a worker has with job security / job displacement	The extent of a worker's feelings of job security due to technological change. Five-Point Likert Type Scale

The study grouped the identified 14 AMTs in 5 domains based on their functionality. 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 CAD, CAE, GT and CAM, PPTs included MRP, MRP II and ERP, MHTs included AGV and ASRS, AsMTs include NC/CNC/DNC, CAQCS and Robotics and IMTs included FMS/FMC and CIM.

The aggregate scores for AMTs adoption of surveyed companies generated ten scores as shown below:-

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. $IMTint = \frac{1}{2}[FMC/FMSint + CIMint]$ where *inv* indicates investment *int* indicates integration

The mean score of AMT for each sub-sector or individual company was calculated as follows;

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

Technical labour index for each company/sub-sector was generated from the following equation.

Technical Labour index (TLI) = $(X_{01} + X_{02} + X_{03} + X_{04} + X_{05})/5$ 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

To determine the relationships between AMT adoption and technical labour a bivariate regression analysis was performed. 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.

VI RESPONDENTS' PROFILE

Out of the population of 183, 101 companies responded positively. Data from these companies were collected for analysis. Out of the 101 respondents 9 were either inconsistent and or incomplete and so were rejected in the analysis. The analysis was therefore based on 92 companies representing all the sub- sectors as summarized in Table 2.

Table 2: AMT sub-sector companies distribution

Category	Respondents	Population	%t
Construction and material	13	27	48.15
Food, beverage and animal feeds	29	55	52.73
Textiles, apparel, leather and footwear	6	13	46.15
Chemical and Pharmaceuticals	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

The majority of the respondents in section 1 of 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).

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.

VII RESULTS AND INTERPRETATIONS

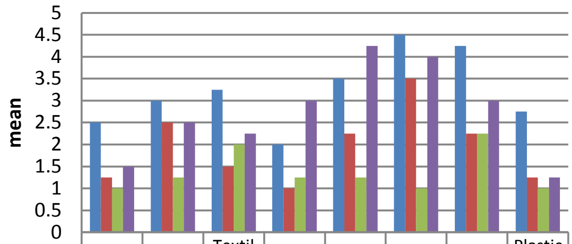
The surveyed population consisted of AMT companies whose major products were classified in the identified eight sub-sectors. Given the need for a broad analysis, the need to keep the eight sub-sectors homogeneous (from a manufacturing/ production perspective) and the acknowledged diverse adoption of AMTs among the sub-sectors, the results are presented by sub-sector.

A Product Design and Engineering Technologies

Figure 1 shows the mean scores of companies which made actual investments in each product design and engineering technologies (PDET). It shows that the most common PDET among the companies surveyed was CAD, which received above moderate investments with a mean score of 3.25; followed by CAM, with mean score of 2.75. The results show that the least invested was GT with mean score of 1.25. The fabricated metal industry relies on CAD the most, followed by the automobile and parts industry. Similarly, CAE is 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 while packaging and stationery registered the lowest mean score (1.25).

Overall, the results show that the levels of integration in PDETs are limited, since none of the scores is over 2.5 (half way). In terms of the individual PDET, almost 90 percent of the respondents invested moderately in CAD, however the majority had their CAD either stand alone, no integration or only integrated within the department

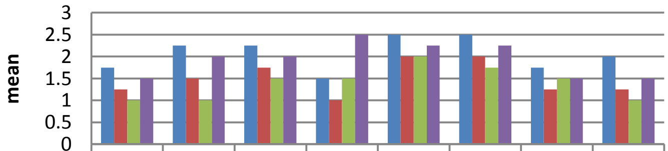
Fig 1: Investments of product PDETs by Sub-Sector



	Construction/ material	Food/ beverage/animal feeds	Textiles/ apparel/ leather/footware	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

Figure 2 compares integration mean score of PDETs with Sub-Sectors. The results show that Automobile and parts industry had the highest mean score of 2.1875 followed by fabricated metal industry that had a mean score of 2.125. Construction and material industry had the least score of 1.375

Fig **2:** Integration of PDETs by Sub-Sector

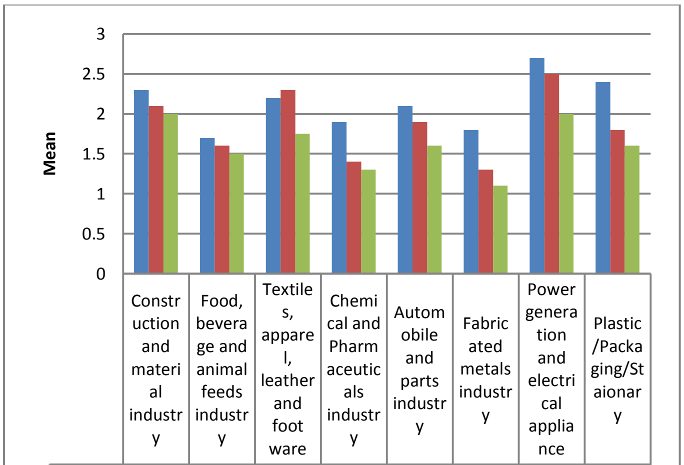


	Construction and material	Food/beverage /animal/ feeds	Textiles/ apparel/ leather/ foot ware	Chemical/ Pharmaceuticals	Automobile/ parts industry	Fabricated metals industry	Power /electrical /electronics	Plastics/ packaging / stationery
CAD	1.75	2.25	2.25	1.5	2.5	2.5	1.75	2
CAE	1.25	1.5	1.75	1	2	2	1.25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

B Production Planning Technologies

As shown in Figure 3, the ranking of investments in the three technologies in this domain, from highest to lowest are MRP, MRPII and ERP. The results show that indeed companies are still very much at the early version of production planning technologies

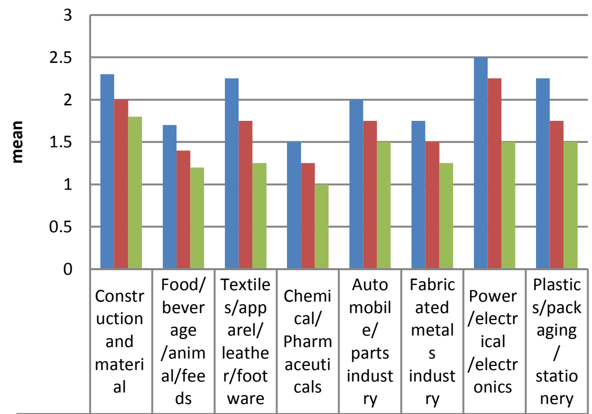
Fig 3 Investment in PPTs by Sub-Sectors



	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

Generally, the level of integration for PPTs companies surveyed was limited, with a mean score of 2, showing that integration is only within the department. As shown in Figure 4, power generation/electrical/electronic industry had slightly more integration as compared to other manufacturing industry, with MRP and MRPII above 2. Chemical and pharmaceutical industry had the least integration, with a mean score of 1.25.

Fig 4: Integration of PPTs by Sub-Sector

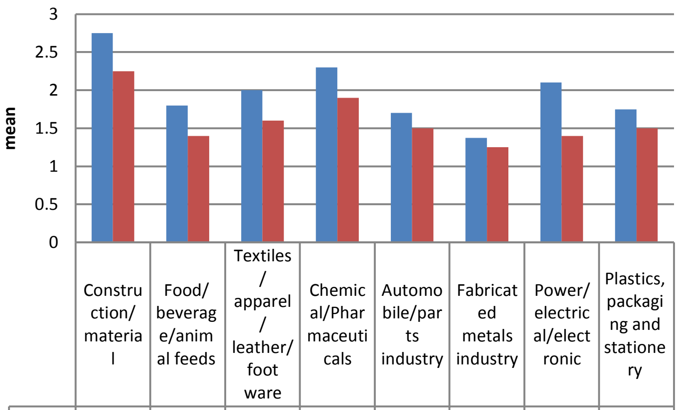


	Construction and material	Food/beverage/animal/feeds	Textiles/apparel/leather/foot ware	Chemical/Pharmaceuticals	Automobile/parts industry	Fabricated metals industry	Power/electrical/electronics	Plastics/packaging/stationery
MRPI	2.3	1.7	2.25	1.5	2	1.75	2.5	2.25
MRPII	2	1.4	1.75	1.25	1.75	1.5	2.25	1.75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

C Material Handling Technologies

The study shows that on average companies surveyed had little investments in MHTs. Generally, companies invested more in ASRS in comparison with AGVs. Figure 5 shows that construction and material industry ranked the highest in MHTs investments but had less than moderate investment in ASRS. Fabricated metal industry had the lowest investment in ASRS with a mean score of 1.375. AGVs investment was slightly lower than ASRS investment. The leading industry, construction and material industry had a mean score of 2.25. The least investment in AGVs was fabricated metal industry with almost negligible investment, i.e. a mean score of 1.25.

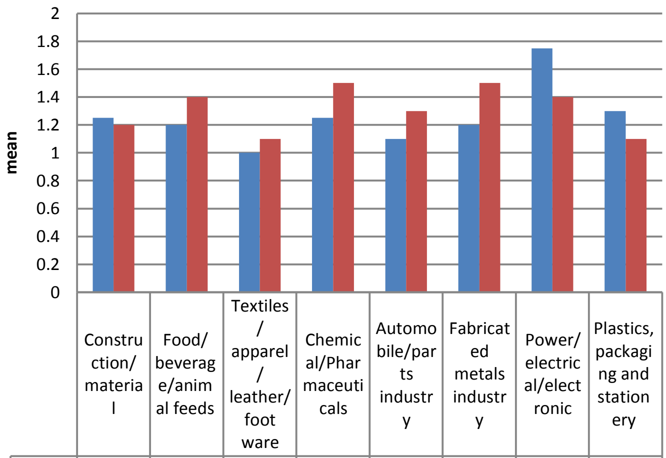
Fig 5: Investment of MHTs by Sub-Sector



	Construction/material	Food/beverage/animal feeds	Textiles/apparel/leather/foot ware	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

In general, the level of integration of MHTs was virtually no integration. Figure 6 shows that material handling technology is either in stand-alone mode or only linked within the department. When comparing the level of integration of 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), however, the other industries did not integrate their MHTs.

Fig 6: Integration of MHTs by Sub-Sector

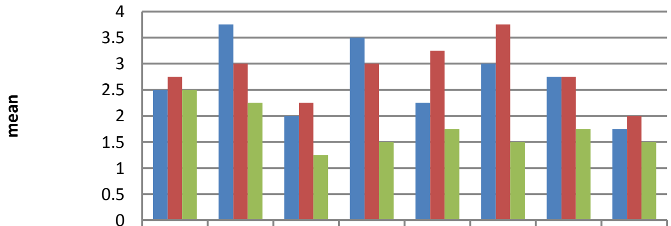


	Construction/material	Food/beverage/animal feeds	Textiles/apparel/leather/foot ware	Chemical/Pharmaceuticals	Automobile/parts industry	Fabricated metals industry	Power/electrical/electronic	Plastics, packaging and stationery
ASRS	1.25	1.2	1	1.25	1.1	1.2	1.75	1.3
AGV	1.2	1.4	1.1	1.5	1.3	1.5	1.4	1.1

D Assembly and Machining Technologies

Generally, industries invested the most in numerical control machines technologies. Figure 7 shows that food, beverage and animal feed industry, fabricated metal industry, automobile and parts industry and the chemical and pharmaceutical industry invested more moderately in NC/CNC/DNC than the other industries, with a mean score of about 3. The investment in numerical control machines for other industries was less than moderate, the least being plastic, packaging and stationery with a mean score of 2. Investments in CAQCS were limited, except for food, beverage and animal feed industry and fabricated metal industry. Companies invested least in robotics technology with a mean score of 1.75.

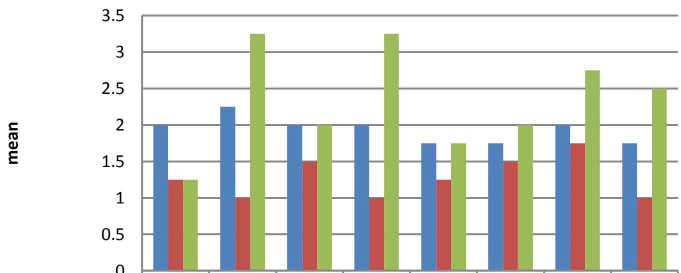
Fig 7: Investment in AsMTs by Sub-Sector



	Construction and material	Food/beverage/animal/feeds	Textiles/apparel/leather/footware	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

Levels of integration of AsMTs were limited. Figure 8 shows that the highest to the lowest mean scores of integrations were NC/CNC/DNC, CAQCS and robotics technology. Integration of CAQCS was on the highest level in the food, beverage and animal feed industry. Power generation, electrical/electronic made the most integration in robotics as compared to other industries.

Fig 8: Integration of AsMTs by sub-sector



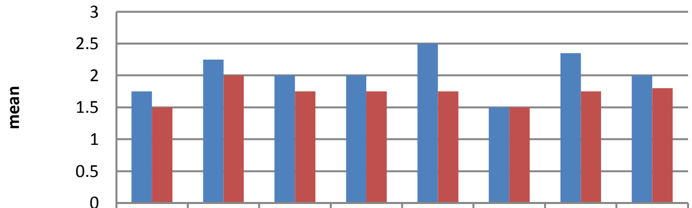
	Construction and material	Food/beverage/animal/feeds	Textiles/apparel/leather/footware	Chemical/Pharmaceuticals	Automobile/parts industry	Fabricated metals industry	Power/electrical/electronics	Plastics/packaging/stationery
CAQCS	2	2.25	2	2	1.75	1.75	2	1.75
Robotics	1.25	1	1.5	1	1.25	1.5	1.75	1
NC/CNC/DCN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

E Integrated Manufacturing Technologies

Figure 9 shows that the mean score of investments in FMC/FMS by surveyed companies was slightly higher than ClM. FMS/FMC registered a mean score of 2.05 as compared to CIM that registered a mean score of 1.725. It was the same scenario when compared by their Sub-Sectors. For most Sub-Sectors investments in FMC/FMS were slightly more than those in ClM.

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 10, was rather low, both at mean score of 1.75 for FMC/FMS, and 1.5 for computer-integrated manufacturing which meant that both integrated manufacturing technologies had limited integration. This meant that the technology was only limited to the department.

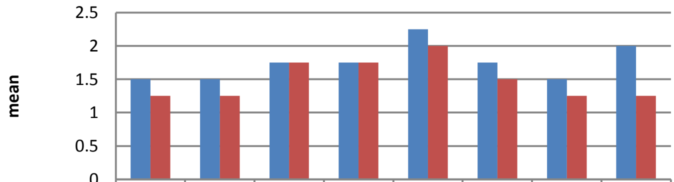
Fig 9: Investments in IMTs by Sub-Sector



	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

Automobile and parts industry registered the highest level of integration in 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 inr 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 10: Integration of IMTs by Sub-Sectors



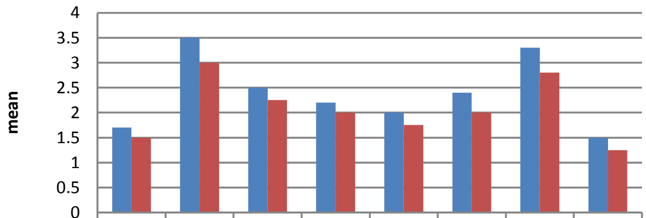
	Construction and material	Food/beverage/animal/feeds	Textiles/apparel/leather/footware	Chemical/Pharmaceuticals	Automobile/parts industry	Fabricated metals industry	Power/electrical/electronics	Plastics/packaging/stationery
FMC/FMS	1.5	1.5	1.75	1.75	2.25	1.75	1.5	2
CIM	1.25	1.25	1.75	1.75	2	1.5	1.25	1.25

F Job Satisfaction

Job satisfaction or employee satisfaction is simply how content an individual is with his or her job. AMTs require workers to be equipped with a variety of new skills at various levels. 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.

The data showed that food, beverage and animal feed workers were the most satisfied with a mean score of 3.5 followed by power generation, electrical/electronic 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. Figure 11 shows the result.

Figure 11: Job Satisfaction by Sub-Sector

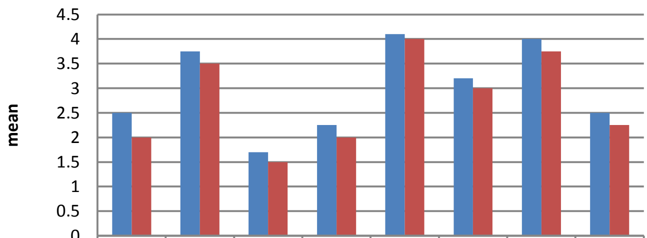


	Construction/material	Food/beverage/animal feed	Textiles/apparel/leather/foot ware	Chemical/Pharmaceuticals	Automobile/parts	Fabricated metals	Power generation/electrical/electronics	Plastics/packaging/stationery
mean	1.7	3.5	2.5	2.2	2	2.4	3.3	1.5
median	1.5	3	2.25	2	1.75	2	2.8	1.25

G Job Involvement

Job Involvement refers to the psychological and emotional extent to which employees participates in their work. 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. The results revealed that companies from power generation, electrical/electronic industry, automobile and parts industry were the most involved with a mean score of 4. Textile, apparel, leather and foot wear 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. Figure 12 shows the results.

Figure 12: Job Involvement by Sub-Sector

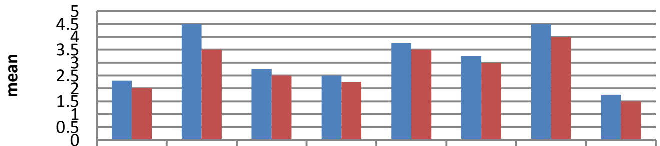


	Construction/material	Food/beverage/animal feed	Textiles/apparel/leather/foot ware	Chemical/Pharmaceuticals	Automobile/parts	Fabricated metals	Power generation/electrical/electronics	Plastics/packaging/stationery
mean	2.5	3.75	1.7	2.25	4.1	3.2	4	2.5
median	2	3.5	1.5	2	4	3	3.75	2.25

H Organizational Commitment

Organizational commitment is the individual's psychological attachment to the organization. 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. In Figure 13, it is 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 lowest means 2.3 and 1.5 respectively.

Figure 13: Organizational Commitment by Sub-Sector



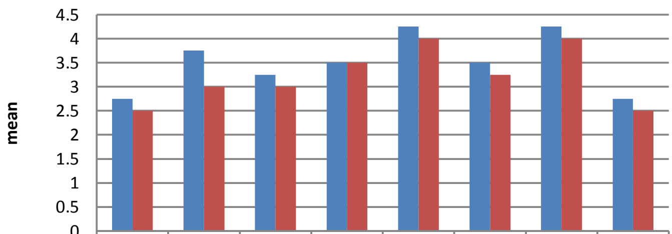
	Construction/material	Food/beverage/animal feed	Textiles/apparel/leather/foot ware	Chemical/Pharmaceuticals	Automobile/parts	Fabricated metals	Power generation/electrical/electronics	Plastics/packaging/stationery
mean	2.3	4.5	2.75	2.5	3.75	3.26	4.5	1.75
median	2	3.5	2.5	2.25	3.5	3	4	1.5

Companies with higher basic skill level were able to exploit much of the innate flexibility in AMT and most of these 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.

I 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. The data showed that workers in power generation, electrical and electronic industry as well as automobile and parts industry suffered less by scoring a mean of 4.25. Construction and material industry workers as well as plastic, packaging and stationery suffered the most with a mean score of 2.75. Figure 14 shows the results.

Figure 14 Psychological Barriers by Sub-Sector

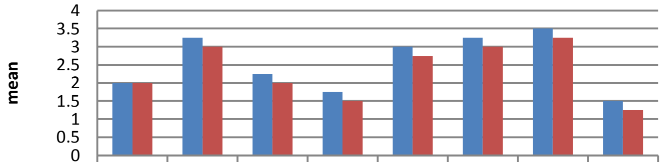


	Construction/material	Food/beverage/animal feed	Textiles/apparel/leather/foot ware	Chemical/Pharmaceuticals	Automobile/parts	Fabricated metals	Power generation/electrical/electronics	Plastics/packaging/stationery
mean	2.75	3.75	3.25	3.5	4.25	3.5	4.25	2.75
median	2.5	3	3	3.5	4	3.25	4	2.5

J Employee Empowerment

Employee empowerment is giving employees a certain degree of autonomy and responsibility for decision-making regarding their specific organizational tasks. Figure 15 reveals that companies from power generation, electrical/electronic 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 above a mean score of 2, the findings indicated that workers empowerment was very low. 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.

Figure 15: Employee Empowerment by Sub-Sector

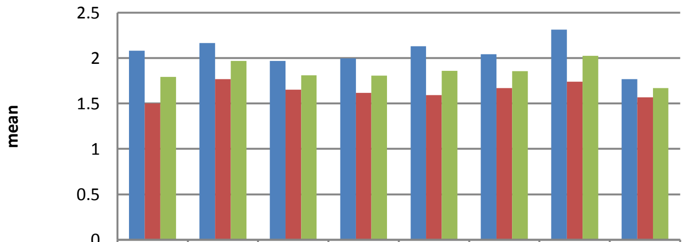


	Construction/material	Food/beverage/animal feed	Textiles/apparel/leather/foot ware	Chemical/Pharmaceuticals	Automobile/parts	Fabricated metals	Power generation/electrical/electronics	Plastics/packaging/stationery
mean	2	3.25	2.25	1.75	3	3.25	3.5	1.5
median	2	3	2	1.5	2.75	3	3.25	1.25

K Advance Manufacturing Technology adoption and Technical Labour Relationship

From the analysis above, we have descriptive knowledge of detailed AMT adoption and technical labour characteristics from the 92 surveyed companies. The objective of the study was to establish the relationship between AMT adoption and technical labour. As shown above several constructs of each dimension were measured in order to capture a wide range of information regarding each variable of the surveyed companies. However, it is not feasible to examine each one of the dimension as too many explanatory variables would reduce the degree of freedom, which will then result in less favorable test results. For the convenience of comparison, calculation of AMT mean score was summarized by the equation $AMTindex = \frac{1}{2}[AMTinv + AMTint]$ and the results are shown in Figure 16

Figure 16: AMT mean score per Sub-Sector.

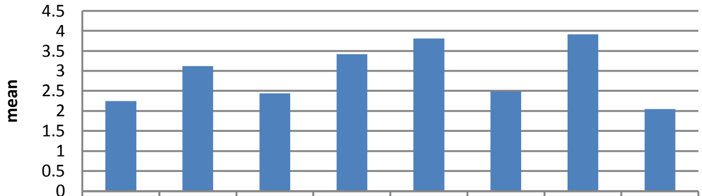


	Construction/material	Food/beverage/animal feed	Textiles/apparel/leather/footwear	Chemical/Pharmaceuticals	Automobile/parts	Fabricated metals	Power generation/electrical appliance	Plastics/packaging/stationary
AMTinv	2.081	2.164	1.968	1.997	2.128	2.043	2.311	1.767
AMTint	1.502	1.769	1.652	1.617	1.593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

The results shows that 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).

Calculation of technical Labour mean score was summarized by the equation $TL = (X_{01} + X_{02} + X_{03} + X_{04} + X_{05})/5$ and the results are shown in Figure 17.

Figure 17: Technical Labour mean score 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	2.25	3.12	2.44	3.42	3.81	2.49	3.91	2.05

The results shows 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 may be attributed to the number of unskilled workforce in this industry. Most blue collar workers in plastic, packaging and stationery industry are certificate holders or just obtained secondary level education.

The objective of the study sought to establish the relationship between AMT adoption and technical labour. To achieve this objective, the analyzed data was tested using simple bivariate regression analysis of technical labour on AMT adoption. 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. Technical labour (TL) mean score was found to be negatively skewed at a 0.165 while AMT mean score was found to be positively skewed at 0.769 all indicating a magnitude of the coefficients less than 1. This indicated a measure of normality. The range of AMT mean score was between 1.75 and 2.04 TL mean score ranged between 2.20 to 4.00.

When TL was regressed on AMT using simple bivariate regression analysis the model explained 74.4% of variation an indication of a good goodness of fit of the model. This was 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). The results of regression showed a positive relationship between AMT and TL namely $(AMT = 1.542 + 0.99(TL))$.

VIII. DISCUSION OF RESULTS

Results of this study indicated that the level of AMT adoption is Kenya's manufacturing sector is very low (1.75 – 2.04 on a scale of 1-5). The results showed that as the use of AMTs increased the demand on workers in terms of technical labour characteristics increased. This showed that higher knowledge intensity is required by workers of AMTs. Manufacturing sector that have traditionally absorbed rural workers is slowly undergoing technological revolution and millions of jobs are likely to be shed to make room for highly automated work environments.

The study showed that power generation, electrical and electronics industry had the highest score in AMT adoption and technical labour characteristics. This is an indication that this industry has adopted time-saving technologies that are eliminating jobs at various stages of the production process faster than other industries. Plastic, packaging and stationary industry had the lowest score in AMT adoption and also in technical labour characteristics. As a labour-intensive industry Plastic, packaging and stationary industry was the least affected by AMTs adoption.

The results indicate that lack of suitable skills at a number of levels have slowed the absolute rate of take-up of technology and limited the range of applications which could be made. As more and more of the manufacturing process bends toward automation Kenya will be forced to shift from current labour- intensive manufacturing processes to the cheaper and faster methods of mechanized production. In agreement with [1] the efficient use of new technologies requires motivated skilled workforce, especially in an increasingly interconnected application. Skilled labor is an indispensable precondition for diffusion of AMTs. 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 survey revealed that, in small and medium companies, the current ratio of engineers to production workers is about one to twenty, indicating 5% of workforce being trained engineers. In contrast, Japan, where more than two thirds of the CNC machines are in small and medium sized companies, more than 40% of the work force is made up of college-educated engineers, and all had been trained in the use of CNC machines [10]. According reference [10] training to upgrade skill was often done in Japan while in our surveyed companies there was no proper laid down structure on retraining. 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.

From the regression equation AMT =1.542 +0.99(TL) it can be argued that as adoption of AMTs increased, the aforementioned characteristics of technical labour increased. However, since the lower polar point was 1 and the upper polar point was 5 for all indices, the positive constant (1.542) in the above equation sets the range for AMT index as 2.532 to 5.00. AMT was measured from 1 to 5, 1 indicated early simple stage of adoption (low technical complexity) and 5 indicated complex stage of adoption (high technical complexity). Thus when technical complexity is below 2.532 the equation does not give meaningful results.

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 technical labour at values of AMT adoption less than 2.532. In this connection it can be argued that it is not only important to take into account the level of technical labour but also to consider other contingencies that might accompany AMT adoption.

IX CONCLUSIONS

This study has highlighted the importance of informational skilled human labour and higher company's capabilities in managing AMTs adoption. The study has shown that 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.

Reflecting on the significance of the transition taking place in manufacturing sector and vision 2030 that aims to create employment and wealth in manufacturing sector policy makers need to balance between protecting employment levels within manufacturing sector and encouraging practitioners to bends toward reengineering and automation. Policies should be made that will shift manufacturing processes from current labour-intensive to the high-tech automated production while at the same time equipping technical workers with the state of art technology in the industry.

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