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Human Factors as Determinants of AMT Adoptions in Structure of a Manufacturing Company

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Abstract
The study used the contingency theory to study the effects of human factors on the relationship between Advanced Manufacturing Technology (AMT) adoption and organization structure. When empirically tested, the research findings present the interrelationships among the main effects (AMT index and human factors) and the interactions (AMT index * human factor index). The study revealed that there is a linear dependence of organizational index from the interaction index. This implies that changes in human factors positively and significantly affect AMT adoption and organizational structure relationship. The study confirms that it is essential for a company to match their technology investment and its integration with its human factors in order to achieve the intended manufacturing performance. The degree of fit between AMT index and organizational index was found to increase as human index increased. The findings of this study reiterate the importance and the need for proactive planning to facilitate changes in the organizational structure.

Keywords: AMT Adoption, Human factors, Organizational structure

1. Introduction

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 result of this study emphasized 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).

II. 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.

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 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.

The use of AMTs is often claimed 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.

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, which is in line with the focus of this study. 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 considers it not a technology, but instead more of a practice.

III. MANUFACTURING COMPANY'S 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). An organizational structure 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 **o**rganizational structure a co-ordination mechanism between the various players in a given company is created (Mintzberg, 1979).

The Structure of an organizational 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. Our concern here is with the basic specializations within the organization such as sub-units, level of authority, span of control and programs specifications. These particular aspects of organizational structure exert considerable influence over the organizational decision-making processes.

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.

IV. 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, therefore, refers to employees reaction 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.

The human factors, in this study, entails employees' work attitude, level of psychological barriers and employee empowerment. Work attitude is concerned with job-related perspectives; job satisfaction, job involvement and organizational commitment (Waldeck, 2007). The psychological barriers of technological change are associated with job security and job displacement (Coates, 1983). Management ability to empower the employee is equally important for new technology adaptability.

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 employees 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, organizational structure and employees issue 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. 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.

V. Study Hypothesis

The behavioral characteristics of employees of an AMT company must be adaptive to existing manufacturing technology to achieve superior performance (Boothy et. al, 2010). When AMT complexity increases, the behavioral characteristics of employees should be more adaptive. Change agents play a very important role in change situations. Credibility, expertise and objectivity of change agent contribute for 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. We now propose to link these variables in terms of the following hypothesis: The relationship between AMT adoption and organizational structure depends on human factors. Thus, as the degree of job satisfaction, job involvement, organization commitment, employee empowerment increases and as psychological barriers of blue collar employees decreases the degree of fit between AMT adoption and organizational structure increases; Fig 1 shows the conceptual model.

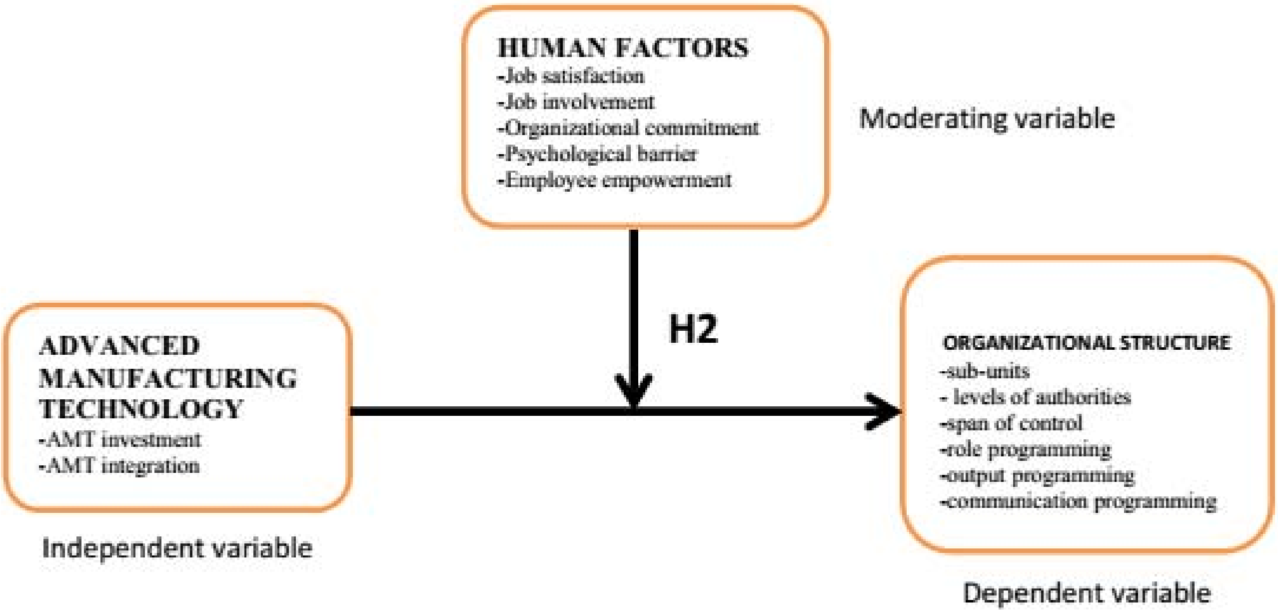


Fig 1: The moderation effect of human factors on the relationship between AMT adoption and organizational structure

VI. Measurement Procedure

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 above party 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 two variables of the study; Organizational structure characteristics and AMT adoption. Specifically, the questionnaire 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. In order to measure the level of organizational index on 1-5 continuum the list of items used in the study of Ghani (2002) were adapted. To obtain logical response and required information of the study a five point Likert type scale was used in perception questions.
Organizational structure index 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 measured on 1 - 5 polar point such that 5 indicated the structure with the highest dimension and 1 indicated the structure with the least dimension. In the case of AMT adoption, the continuum from high to low was measured by the level of AMT investment

and integration. The study investigated 14 AMTs in 5 domains based on their functionality. Companies were asked to indicate the amount of investment they had in the individual technology, on a Likert scale of 1-5, where 1 indicated little investment and 5 indicated heavy investment. The respondents were also asked to indicate the level of integration of each AMT invested in the company on a Likert scale of 1-5, where 1 indicated no integration and 5 indicated extended integration.

VII. Respondents' Profile

Gaining admission to industrial organizations for the purposes of sociological research is difficult at best. The author, dependent to a large extent on the efficacy of personal contact networks for the purposes of getting information. 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. As the AMT plants are located at different places, geographically ranging from 5 to 700 km, data collection process took nearly 7 months. 101 companies showed positive response and data from these companies were collected for analysis.

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. Out of the 101 respondents whose data was collected the credibility of 9, representing about 9%, did not meet the standard required and so were rejected in the analysis. The analysis is therefore based on 92 companies, representing all the sectors. The majority of the respondents in section 1 of the instrument 42.5% were from top management levels, i.e. director, managing director, chief executive officer or chairman, and approximately 40% of the respondents were directly responsible for manufacturing or operations or production issues of their companies. 17.5% of respondents were holding non-manufacturing-related positions such as administration manager, company secretary, marketing manager, commercial manager, purchasing manager, human resource manager and finance manager.

Section 2 of the instrument was self- administered to the blue collar workers working within AMT machines. Five (5) respondents were sampled from each company and an average for each unit of analysis was thereafter calculated. In this part of the instrument the respondents were required to answer as to 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. Since this was self-administered all the respondents sampled herein were from machine operators, shop stewards or maintenance personnel. 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.

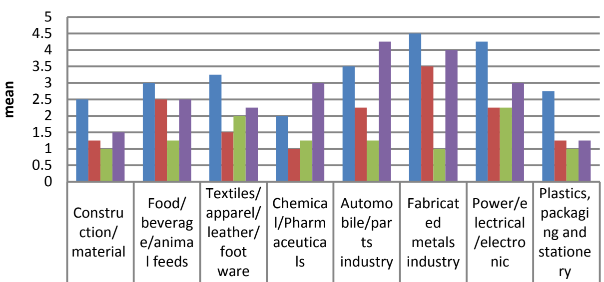
As the mean workforce number of companies surveyed was rather low, at around 50 employees, it is no surprise that the top management level were in-charge of their manufacturing function and involved in decision making in manufacturing issues. At a glance, we can infer that the sampled information collected from the survey was highly credible and with good understanding of informants, with the average duration in their respective positions as 9 years.

The 92 AMT manufacturing companies were grouped into eight sub-sectors based on manufactured products. The majority of respondents were from food, beverage and animal feeds industry at 31.5%, followed by the construction and material industry at 14.1%, chemical and pharmaceuticals industry at 12.0%, plastics, packaging and stationery industry at 12.0% and power generation and electrical/electronic industry at 10.9%. Other respondents represent a small fraction like fabricated metals industry at 7.6%, textiles, apparel, leather and foot ware industry at 6.5% and automobile and parts industry at 5.4%.

VIII. Results and interpretations

A. Product Design and Engineering Technologies

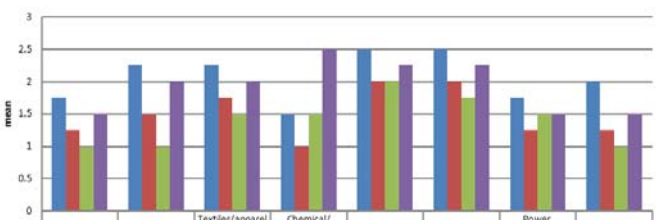
Figure 2 below shows the mean scores of companies which made actual investments in each PDET. It shows that the most common PDET among the companies surveyed was CAD, which received above moderate investments with a mean score of 3.25; followed by CAM, with mean score of 2.75. The results show that the least invested was GT with mean score of 1.25.All sub-sectors share the same point, as shown in Fig 2 that investment in CAD takes the most important position while GT is worth the least. In detail, 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 and plastics, packaging and stationery registered the lowest mean score, 1.25.



	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
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

Fig 2: Investments of product PDETs by Sub-Sector

Overall, the results show that the levels of integration in PDETs are limited, since none of the scores is over 2.5 (half way). The mean score of PDET integration with the companies age bands and Sub-Sector they shows that the levels of integration are low, with a mean score of less than 2.5. In terms of the individual PDET, almost 90 percent of the respondents invested moderately in CAD, however the majority have their CAD either stand alone, no integration, or only integrated within the department. Figure 3 compares integration mean score of product design and engineering technologies with Sub-Sectors. The results shows that among the invested technologies in these domain 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.

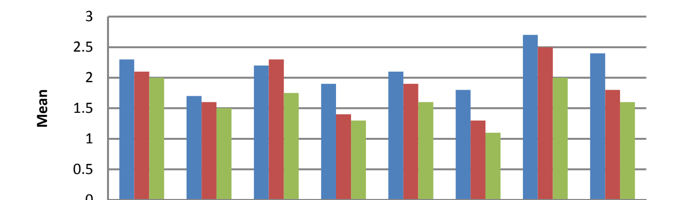


	Construction and material	Food/beverage /animal/feeds	Textiles/apparel / leather/foot ware	Chemical/ Pharmaceuticals	Automobile/ parts industry	Fabricated metals industry	Power /electrical /electronics	Plastics/packaging / stationery
CAD	1.75		2.25	1.5	2.5	2.5	1.75	2
CAE	1.25	1.5	1.75	1	2	2	1.25	1.25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

Fig 3: Integration of PDETs by Sub-Sector

B. Production Planning Technologies

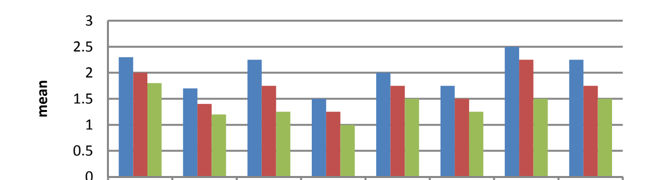
The whole manufacturing industry seems to have agreement on the investments in PPTs. As shown in Figure 4, the ranking of investments in the three technologies, from highest to lowest are MRP, MRPII and ERP. The results show that indeed companies are still very much at the early version of PPT.



	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

Fig 4: Investment in PPTs by Sub-Sectors

Generally, the level of integration for PPTs companies surveyed is limited, with a mean score of 2, showing that integration is only within the department. As shown in Figure 5, the power generation/electrical/electronic industry has slightly more integration as compared to other manufacturing industry, with MRP and MRPII above 2. Chemical and pharmaceutical industry has the least integration, with a mean score of 1.25.

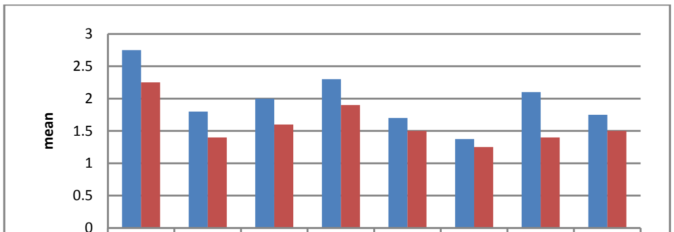


	Construction and material	Food/beverage /animal /feeds	Textiles /apparel/ leather/ foot ware	Chemical/ Pharmaceuticals	Automobile/ parts industry	Fabricated metals industry	Power /electrical /electronics	Plastics /packaging / stationery
MRPI	2.3	1.7	2.25	1.5	2	1.75	2.5	2.25
MRPII	2	1.4	1.75	1.25	1.75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

Fig 5: Integration of PPTs by Sub-Sector

C. Material Handling Technologies

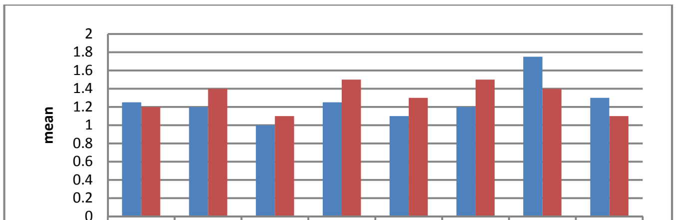
The study shows that on average companies surveyed have little investments in MHTs. Generally, companies invested more in ASRS in comparison with AGVs. Figure 6 shows that construction and material industry ranks the highest in MHTs investments but had less than moderate investment in ASRS. Fabricated metal industry had the lowest investment in ASRS with a mean score of 1.375. AGVs investment is slightly lower than ASRS investment. The leading industry, construction and material industry had a mean score of 2.25. The least investment in AGVs is in fabricated metal industry with almost negligible investment, i.e. a mean score of 1.25.



	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

Fig 6: Investment of MHTs by Sub-Sector

In general, the level of integration of MHTs is virtually no integration. Figure 7 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 have almost the same level of integration. Power generation electrical and electronics industry, which integrated its automated storage and retrieval systems almost within the department (mean score of 1.75), however, the other industries were not integrating their MHTs.

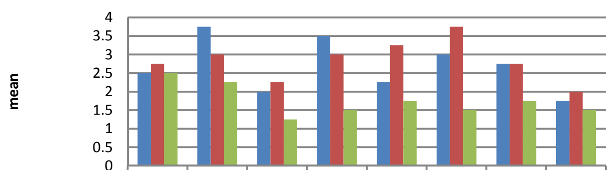


	Construction/ material	Food/beverage/animal feeds	Textiles/ apparel/ leather/ foot ware	Chemical/Pharmaceuticals	Automobile/parts industry	Fabricated metals industry	Power/electrical/electronic	Plastics, packaging and stationery
ASRS	1.25	1.2	1	1.25	1.1	1.2	1.75	1.3
AGV	1.2	1.4	1.1	1.5	1.3	1.5	1.4	1.1

Fig 7: Integration of MHTs by Sub-Sector

D. Assembly and Machining Technologies

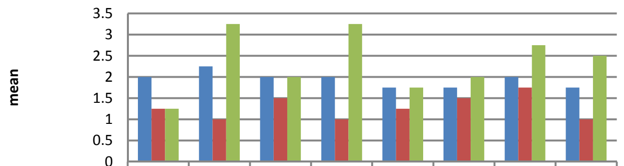
Generally, industries invested the most in numerical control machines technologies. Figure 8 shows that food, beverage and animal feed industry, fabricated metal industry, automobile and parts industry and the chemical and pharmaceutical industry invested more moderately in NC/CNC/DNC than the other industries, with a mean score of about 3. The investment in numerical control machines for other industries is less than moderate, the least being plastic, packaging and stationery with a mean score of 2. Investments in CAQCS are 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.



	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

Fig 8: Investment in AsMTs by Sub-Sector

Levels of integration of AsMTs are limited. Figure 9 shows that the highest to the lowest mean scores of integrations are NC/CNC/DNC, CAQCS and robotics technology. Integration of CAQCS is 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.

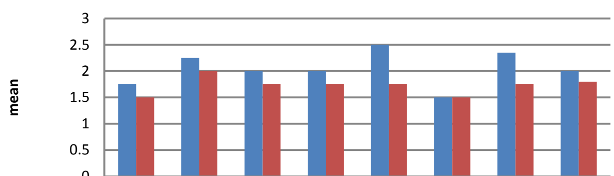


	Construction and material	Food/beverage/animal/feeds	Textiles/apparel/leather/footware	Chemical/Pharmaceuticals	Automobile/parts industry	Fabricated metals industry	Power/electrical/electronics	Plastics/packaging/stationery
CAQCS	2	2.25	2	2	1.75	1.75	2	1.75
Robotics	1.25	1	1.5	1	1.25	1.5	1.75	1
NC/CNC/DCN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

Fig 9: Integration of AsMTs by sub-sector

E. Integrated Manufacturing Technologies

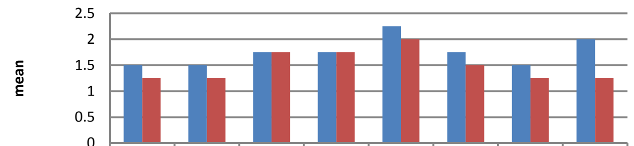
Figure 10 shows that the mean score of investments in FMC/FMS by surveyed companies is slightly higher than ClM. FMS/FMC registered a mean score of 2.05 as compared to CIM that registered a mean score of 1.725. It is the same scenario when compared by their Sub-Sectors. For most Sub-Sectors investments in FMC/FMS are slightly more than ClM.



	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 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

Fig 10: Investments in IMTs by Sub-Sector

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 11, is rather low, both at mean score of 1.75 for FMC/FMS, 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 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.



	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

Fig 11: Integration of IMTs by Sub-Sectors

F. Generation of AMTs Scores

For the purpose of a summary and analysis, the aggregate AMTs investment and integration of surveyed companies generates ten AMTs investment and integration scores, which are product design and engineering technology investment score (PDETinv) and integration score (PDETint), logistics related technology investment score (PPTinv) and integration score (PPTint), material handling technology investment score (MHTinv) and integration score (MHTint), assembly and machinery technology investment score (AsMTinv) and integration score (AsMTint), and integrated manufacturing technology investment score (IMTinv) and integration 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. $IMTint = \frac{1}{2}[FMC/FMSint + CIMint]$

The score for AMT for each sub-sector or individual company is as follows;

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

G. 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 sub-units (8) followed by fabricated metal industry (7). Construction/material industry registered the lowest (3.5). It was also observed that the importance of sub-units is moderate for small companies as compared to large companies. The data also suggests that the importance of sub-units vary depending on the age of the company.

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

Table 1: Number of Sub-Units by Sub-Sectors

Sub-sector	mean	Score value
Construction and material industry	3.75	1
Food, beverage and animal feeds industry	6	2
Textiles, apparel, leather and foot ware	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

H. Levels of Authority

Levels of authority are the formally delimited zones of responsibility along the organizational hierarchy. This dimension of organizational structure measures the hierarchical authorities in the production line. Across the eight sub-sectors, the mean rankings are above 3, which suggest low vertical differentiation. Overall, across the data the lowest registered levels of authority was 2 and the highest registered levels of authority was 6.

Table 2: 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 foot ware	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

I. Span of Control

Span of control is the number of workers a manager/supervisor controls. 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. 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 is assumed in our study that each sub-unit is controlled by one manager/supervisor. In our study the highest mean of number of employees was about 284 in power generation electrical/electronics industry and the number of sub-units in this sub-sector was found to be 8. Therefore largest number of employees controlled by a single manager was found to be about 36. Our score scale is 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 managers for 36 people. The results are shown in Table 3 and Figure 13.

Table 3: 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/foot ware	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	284	8	35	1
Plastics, packaging and stationery	59	4	15	3

K. Role Programming

Role programming herein is the formalization of duties and responsibilities as in sets of job specifications. The mechanistic design is synonymous with bureaucracy, high formalization, downward communication and little participation by low-level employees in decision-making. The organic design is 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. 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 data, it is observed that the importance of overlapping of jobs in the organization was relatively high for small and medium companies. The results form sub-sectors is as shown in Figure 13.

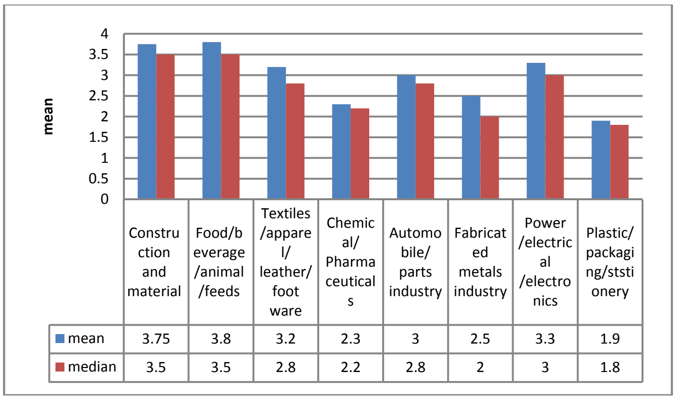


Fig 13: Role Programing by Sub-Sector

L. 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. ow-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 are shown in Figure 14. The results reveal that companies from automobile and parts industry performed better than the rest and had a mean score of 4.5. Plastic, packaging and stationery performed the worst with a mean score of 2.3.

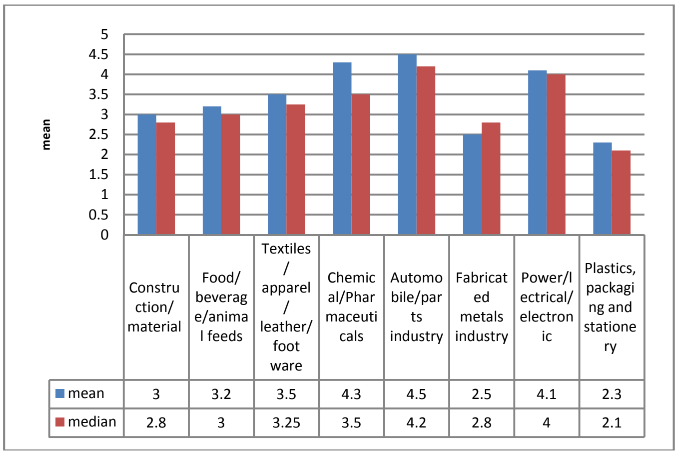


Fig 14: Communication Programming by Sub-Sector

M. 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. Overall, across the eight sub-sectors, the mean ranking was above 5, which suggest a steady stream of output. Most of the studied companies are either continuous production lines with little variation in output and rare stops, individuals are 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 is involved in fabrication of large equipment in stages or production of technically complex units. Where technically complex units are made, the process involves assembling of parts that are imported.

The result shows that there is 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 our 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 foot ware industry and fabricated metal industry. Table 4 shows the results.

Table 4: 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 foot ware	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

N. Generation of Organizational Index Score

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 do not need a high degree of differentiation of subtasks and integration between units.

From the analysis above, we have descriptive knowledge of detailed organizational structure dimensions from our surveyed companies. Organizational index of each company is taken 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

O. 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 require 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.

The data shows 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 15 shows the result from the surveyed companies.

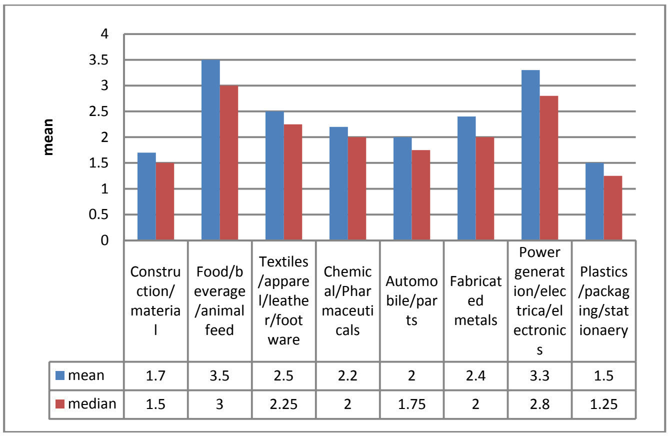


Fig 15: Job Satisfaction by Sub-Sector

P. Job Involvement

Job Involvement refers to the psychological and emotional extent to which employees participates 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 terms of 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.

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 ware 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 is limited, and decision-making is centralized, thus, decreasing the potential for the flexible use of AMT. Figure 16 shows the results.

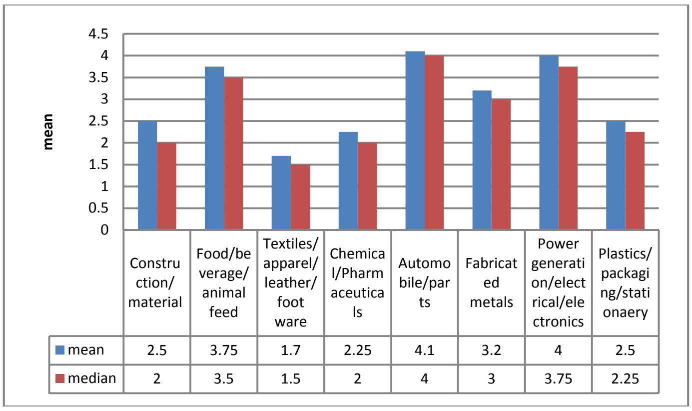


Fig 16: Job Involvement by Sub-Sector

Q. 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.

In Figure 17, 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.

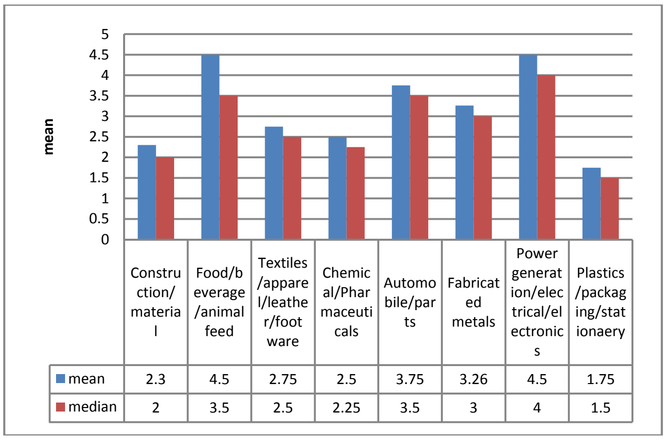


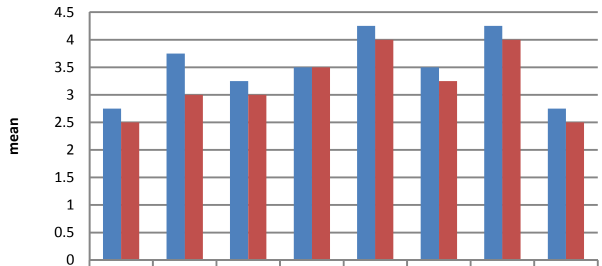
Fig 17: Organizational Commitment by Sub-Sector

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.

R. 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-Likert scale, with 1 as 'to a great extent' and 5 as 'not at all', the respondents were asked to rate the extent to which they agreed with 10 statements relating to their psychological barriers.

Surveyed companies generally think that implementation efforts fail because some under estimate the scope or importance of preparation of employees. The data showed that 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 as well as plastic, packaging and stationery suffered the most with a mean score of 2.75. Figure 18 shows the results.

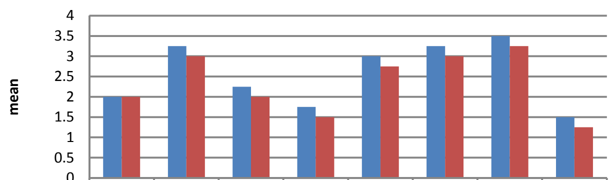


	Construction/material	Food/beverage/animal feed	Textiles/apparel/leather/footware	Chemical/Pharmaceuticals	Automobile/parts	Fabricated metals	Power generation/electrical/electronics	Plastics/packaging/stationaery
mean	2.75	3.75	3.25	3.5	4.25	3.5	4.25	2.75
median	2.5	3	3	3.5	4	3.25	4	2.5

Fig 18: Psychological Barriers by Sub-Sector

S. Employee Empowerment

Employee empowerment is giving employees a certain degree of autonomy and responsibility for decision-making regarding their specific organizational tasks. Based on a 5-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 19 reveals that companies from power generation, electrical/electronic industry was 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 here indicated that workers empowerment. 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.



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

Fig 19: Employee Empowerment by Sub-Sector

T. Generation of Human Factor Index Score

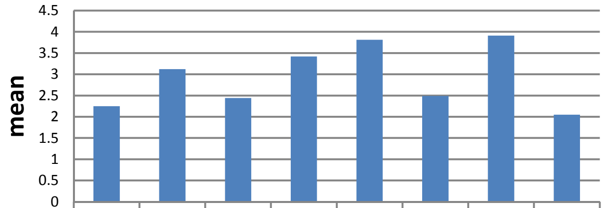
From the analysis above, we have descriptive knowledge of detailed human factors variables from our surveyed companies. For the convenience of comparison and calculation of Human Factor index among the eight sub-sectors, we generate the following equation.

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 Figure 20 are generated for each Sub-Sector.



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

Fig 20: Human Factor mean score by Sub-Sector

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.

IX: Moderating Effect of Human Factors

The objective of the study was to establish the effect of human factors on the relationship between AMT adoption and organizational structure. This hypothesis was tested using stepwise forward regression analysis. In the first model, organizational index was regressed against advanced manufacturing technology index. In the second model organizational index was regressed against advanced manufacturing technology index and human factor index (main effects). In the third model, organizational index was regressed against Advanced manufacturing technology, human factor index and interaction between the two (AMT*HFI). To check for the moderation effect the significance of the independent variable and the moderator variable is not particularly relevant but moderation is assumed to take place if the interaction term (AMTI*HFI) is significant.

Results shows that when human factor is 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 results shows that with the interaction term 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 results reveals that R^2 increased by 9%, from 0.744 to 0.811, when the interaction variable was added. The results shows a statistically significant relationship between OI and AMTI, HFI and AMTI*HFI (F=125.704 with p< 0.05).

Results suggest that interaction between AMT index and Human index is significantly related with Organizational index. 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 is positive at 2.946 with p-value < 0.05 and the constant for the model is 15.985 with p-value < 0.05. The three model regression equations can be fitted as follows:

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

Model 1 $OI_{22} = -3.599 + 2.888(AMTI) + 0.455(HFI) + \varepsilon_{22}$

Model 2 $OI_{23} = 15.985 - 7.769(AMTI) - 0.4986(HFI) + 2.946(AMTI*HFI) + \varepsilon_{23}$

Where,

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

The equation indicates that HFI statistically moderates the relation between AMT adoption and organizational structure indicating that there is a linear dependence of OI from AMTI*HFI. This implies that for every unit change of the interaction term organizational index will increase by 2.96 when all other terms are held constant. Changes in HFI positively and significantly affect AMTI and OI relationship as the direction of the relation is positive. This means that the hypothesis that the relationship between Advanced Manufacturing Technology and Organizational structure depends on human factors is therefore supported.

In summary, the significance of human factor in this relationship shows that as use of AMTs increases the demand on workers in terms of decision-making and therefore higher knowledge intensity is required by workers during 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 this structural adjustments. Consequently, catering for employees` job satisfaction and intrinsic motivations by creating opportunities of employee involvement can be considered as a viable method to affiliate the goals of employees' with the company's.

X. Conclusions

The objective of the study was to determine the effect of Human Factors on the relationship between AMT adoption and organizational structure. The hypothesis we seek to test is that human factors moderates the relationship between AMT adoption and organizational structure. The degree of fit between AMT index and organizational index will increase as the level in eliminating psychological effects among blue collar employees increases. The reactions of the blue collar workers that arise in most periods of technological and structural change were operationalized in terms of job satisfaction, job involvement, organization commitment, psychological barriers and employee empowerment. When empirically tested, the research findings present the interrelationships among the main effects (AMT index and human factors) and the interactions (AMT index * human factor index). Five dominant findings emerged from the study.

First, human factors statistically moderates the relation between AMT adoption and organizational structure. There is a linear dependence of organizational index from the interaction index (AMTI*HFI) as supported by the regression equation; $OI = 15.985 - 7.769(AMTI) - 0.4986(HFI) + 2.946(AMTI*HFI) + \varepsilon_{23}$. This implies that for every unit change of the interaction term (AMTI*HFI) organizational index will increase by 2.946 when all other terms are held constant. Changes in human factors positively and significantly affect AMT and organizational structure relationship as the direction of the relation is positive. In agreement with Davids & Martin (1992) blue Collar workers' resistance to technological change can lead to work slowdowns, poor employee morale, high maintenance cost, and even sabotages. 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.

Secondly, there is 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. The study showed that Power generation, electrical and electronics industry which had the highest score in AMT adoption (2.025), second highest score in organizational structure (3.067) had also the highest score in human factors (3.91). In contrast Plastic, packaging and stationary industry which had the lowest score in AMT adoption (1.668), lowest score in organizational structure (2.033) had also the lowest score in human factors (2.00). This finding is in agreement with several studies that suggested that technology implementation was more likely to be successful when the technology, organization, and people issues have been designed to complement and integrate with each other (Preece, 1995; King & Anderson, 1995, Ghani, 2002).

Thirdly, there is a positive relationship between Human factors and AMT adoption ($AMTI = 1.542 + 0.99(HFI)$). The study showed that Power generation, electrical and electronics industry which had the highest score in AMT adoption (2.025) had also the highest score in human factors (3.91). In contrast Plastic, packaging and stationary industry which had the lowest score in AMT adoption (1.668) had also the lowest score in human factors (2.00). The lack of suitable skills at a number of levels will not only slow the absolute rate of take-up of technology, but also will limit the range of applications which could be made because of a lack of trained manpower to support the development of sophisticated manufacturing options. In agreement with Dawal et al, (2014) the efficient use of new technologies requires motivated skilled workforce, especially in an increasingly interconnected application.

Fourthly, the organizational structure in a developing country is different from a developed country. Emerging from the current study the number of skilled workforce is very low. Most blue collar workers were either certificate holders or secondary level graduates with no further specialization. The lack of suitable skills at a number of levels will not only slow the absolute rate of take-up of technology, but also limit the range of applications which could be made. Lack of trained manpower in developing countries will hinder the development of sophisticated manufacturing technologies. Developed countries with higher basic skill level such as West Germany or the Scandinavian countries are able to exploit much of the innate flexibility in AMT and achieve significantly higher productivity and other benefits (Dawal et al, 2014).

Fifthly, skilled labor is an indispensable precondition for diffusion of AMTs. 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 (Song et al., (2007). According to Song et al. (2007) training to upgrade skill was often done in Japan while in our surveyed companies there was no proper laid down structure on retraining/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.

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