Advanced Manufacturing Technology And Size As Determinants Of Organizational Structure

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ABSTRACT

The study used data from 92 companies to study the effects of company size index (CSI) on the relationship between Advanced Manufacturing Technology Index (AMTI) and organization structure index (OI). Company size was operationalized in terms of workforce number and capital invested. When empirically tested, the research findings present the interrelationships among the main effects (AMTI and CSI) and the interaction effect (AMTI*CSI). Coefficient for the interaction term was positive at 0.468 with p-value at 0.041 while coefficients of the main effects were 0.652 with p-value at 0.502 for AMTI index and -0.568 with p-value at 0.177 for company size index. The constant of the model was 0.974 at p-value of 0.582. This implies that the interactions term positively and significantly affect AMTI and OI relationship. With this findings company size positively moderates the relationship between AMT adoption and Organizational structure.

Keywords: AMT Adoption index, Company size index, Organizational structure index

1. 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. Complexity, dynamism and uncertainty have become dominant characteristics of recent competition patterns which have resulted in a demand-diversified market with more multifaceted products (Efstathiades et al., 1999). Advanced Manufacturing Technology (AMT) appears to represent a perfect interaction between technological potential and the manufacturing challenges. The major benefits of AMTs include faster machine cycle, greater reliability, reduced inventory, saving on labor, greater flexibility and improved quality. For these benefits to be realized, organizations will require a flexible structure and higher company’s capabilities in managing and planning the manufacturing processes.

The benefits of advanced techniques can be realized equally by applying only a few components of AMTs and as a result firms can gradually invest in these technologies to get the most benefit from it (Yusuff et al., 2008). Larger companies often own sufficient business, human and technology resources to invest in AMTs (Xu et al., 2004). However, larger companies also have a great disadvantage in the form of structural inertia, which may exert a negative impact on AMT adoption. Smaller companies with flexible structure can make rapid adjustment to dynamic environment and survive the fierce competition.

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

Although some authors argue that the company age has a significant role in the assimilation of technology (Simpson and Doherty, 2004). Li et al. (2010) reveals that there is not significant association between these two variables. However both agree that the size of a company do influence the company’s technological adoption strategy. Edwards-Schachter et al.(2011) found that smaller companies do not have efficient funding instruments for technology adoption as do larger companies. Smaller companies tend to employ technology to gain competitiveness, whereas larger companies regard AMT as a source to lower manufacturing costs (Li and Xie, 2012).

2. 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.

3. 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 organizational 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.

4. COMPANY SIZE

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

In Kenya, according to MSME bill (2009), companies employing 10 workers or less and having a capital invested of less than Ksh 500,000 are termed as micro companies, 10 to 99 workers and capital investment of Ksh 500,000 to Ksh 5M as small companies, 100 to 199 workers and capital investment of Ksh 5M to Ksh 800M as medium companies and 200 and above workers and capital investment of over 800M as large companies. It is however unlikely that micro companies will invest in AMTs and so our attention will focus mainly on the continuum small to large companies. The term smaller and larger company purely describing the side of continuum of a company.

Smaller companies tend to use AMTs as a source to acquire competitive advantages, while larger companies tend to take it as a way to simplify company operation and lower costs (Mirmahdi, 2012). The skill demand of AMT is a formidable challenge for smaller manufacturing companies to acquire and retain. The strongest determinants of the level of AMT adoption are by far the technical skills of blue-collar workers followed by the influence of customers and vendors. Mansfield (1993) found that larger companies tend to use Flexible Manufacturing System (FMS) in order to make manufacturing easier, more accurate, flexible, sophisticated, faster and cheaper. Meredith (1987) noted that large companies are able to afford the often extreme expense of these computerized manufacturing technologies and the cost of the failure should the investment fail. Large companies also are likely to have the skills and human resources it takes to understand, implement, and manage such technologies (Noe et al., 2008).
The implementation of AMT in smaller companies is necessary to face the challenges of globalization and to ensure their future survival. Rosnah et al. (2003) reported that the level of AMT implemented in smaller companies are low and maybe due to the lack of understanding of the ways in which AMT can help them. It has been noted by researchers that company size is an enabler variable in the use of AMTs and that it is common for smaller companies to lag behind larger companies in implementing the new technologies (Ettlie, 1990, Voss, 1988; Scott and Davis; 2007). The obvious fragile financial resource of smaller company has been stated as the main obstacle which leads to reluctance to invest in AMTs (Love et al., 2001). Likewise, Pearson and Grandon (2004) found that availability of monetary assets is indispensably significant to managers and owners, and such subjects often determine the fate of AMT implementation, particularly in smaller manufacturing companies.

5. STUDY HYPOTHESIS

Larger capacity companies are able to afford the often extreme expense of these computerized manufacturing technologies and have the skills and human resources it takes to understand, implement, and manage such technologies (Yusuff et al., 2008). Therefore the larger a company is the greater the benefits from using these technologies. We now propose to link these variables in terms of the following hypothesis: The relationship between AMT adoption and organizational structure depends on Company size. Thus, as the degree of capital invested and workforce number increases organizational structure characteristics increases; Fig 1 shows the conceptual model.

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

6. 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 three variables of the study; Organizational structure characteristics, AMT adoption and company size. 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. Company size was operationalized in terms of workforce number in the plant and the registered capital invested.

7. 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%.
8. RESULTS AND INTERPRETATIONS

8.1 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.

![Fig 2: Investments of product PDETs by Sub-Sector](image)

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.
8.2 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.

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.
8.3 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.

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.
8.4 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.

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.
8.5 INTEGRATED MANUFACTURING TECHNOLOGIES

Figure 10 shows that the mean score of investments in FMC/FMS by surveyed companies is slightly higher than CIM. 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 CIM.

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.
8.6 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 (PDE Tinv) and integration score (PDE Tint), 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. \( PDE_{\text{inv}} = \frac{1}{4} \left[ \text{CAD}_{\text{inv}} + \text{CAE}_{\text{inv}} + \text{GT}_{\text{inv}} + \text{CAM}_{\text{inv}} \right] \)
2. \( PDE_{\text{int}} = \frac{1}{4} \left[ \text{CAD}_{\text{int}} + \text{CAE}_{\text{int}} + \text{GT}_{\text{inv}} + \text{CAM}_{\text{int}} \right] \)
3. \( PPT_{\text{inv}} = \frac{1}{3} \left[ \text{MRP}_{\text{inv}} + \text{MRPII}_{\text{inv}} + \text{ERP}_{\text{inv}} \right] \)
4. \( PPT_{\text{int}} = \frac{1}{3} \left[ \text{MRP}_{\text{int}} + \text{MRPII}_{\text{int}} + \text{ERP}_{\text{int}} \right] \)
5. \( MHT_{\text{inv}} = \frac{1}{2} \left[ \text{ASRS}_{\text{inv}} + \text{AGV}_{\text{inv}} \right] \)
6. \( MHT_{\text{int}} = \frac{1}{2} \left[ \text{ASRS}_{\text{int}} + \text{AGV}_{\text{int}} \right] \)
7. \( AsMT_{\text{inv}} = \frac{1}{2} \left[ \text{CAQCim} + \text{ROBOTICS}_{\text{inv}} + \text{NC/CNC/DCN}_{\text{inv}} \right] \)
8. \( AsMT_{\text{int}} = \frac{1}{2} \left[ \text{CAQCint} + \text{ROBOTICS}_{\text{int}} + \text{NC/CNC/DCN}_{\text{int}} \right] \)
9. \( IMT_{\text{inv}} = \frac{1}{2} \left[ \text{FMC/FMS}_{\text{inv}} + \text{CIM}_{\text{inv}} \right] \)
10. \( IMT_{\text{int}} = \frac{1}{2} \left[ \text{FMC/FMS}_{\text{int}} + \text{CIM}_{\text{int}} \right] \)

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

\[ \text{AMT index} = \frac{1}{2} \left[ \text{AMT}_{\text{inv}} + \text{AMT}_{\text{int}} \right] \]

8.7 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

<table>
<thead>
<tr>
<th>Sub-sector</th>
<th>mean</th>
<th>Score value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Construction and material industry</td>
<td>3.75</td>
<td>1</td>
</tr>
<tr>
<td>Food, beverage and animal feeds industry</td>
<td>6</td>
<td>2</td>
</tr>
<tr>
<td>Textiles, apparel, leather and foot ware</td>
<td>5</td>
<td>2</td>
</tr>
<tr>
<td>Chemical and Pharmaceuticals industry</td>
<td>4</td>
<td>1</td>
</tr>
<tr>
<td>Automobile and parts industry</td>
<td>5</td>
<td>2</td>
</tr>
<tr>
<td>Fabricated metals industry</td>
<td>7</td>
<td>3</td>
</tr>
<tr>
<td>Power generation and electrical/electronics</td>
<td>8</td>
<td>3</td>
</tr>
<tr>
<td>Plastics, packaging and stationery</td>
<td>4</td>
<td>1</td>
</tr>
</tbody>
</table>

8.8 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

<table>
<thead>
<tr>
<th>Sub-sector</th>
<th>mean</th>
<th>Score value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Construction and material industry</td>
<td>4</td>
<td>3</td>
</tr>
<tr>
<td>Food, beverage and animal feeds industry</td>
<td>5</td>
<td>4</td>
</tr>
<tr>
<td>Textiles, apparel, leather and foot ware</td>
<td>3</td>
<td>2</td>
</tr>
<tr>
<td>Chemical and Pharmaceuticals industry</td>
<td>4</td>
<td>3</td>
</tr>
<tr>
<td>Automobile and parts industry</td>
<td>5</td>
<td>4</td>
</tr>
<tr>
<td>Fabricated metals industry</td>
<td>4</td>
<td>3</td>
</tr>
<tr>
<td>Power generation and electrical/electronics</td>
<td>5</td>
<td>4</td>
</tr>
<tr>
<td>Plastics, packaging and stationery</td>
<td>3</td>
<td>2</td>
</tr>
</tbody>
</table>

8.9 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>
<thead>
<tr>
<th>Category</th>
<th>Employees</th>
<th>Sub-units</th>
<th>Span of control</th>
<th>Scale</th>
</tr>
</thead>
<tbody>
<tr>
<td>Construction/ material</td>
<td>92</td>
<td>3.75</td>
<td>25</td>
<td>2</td>
</tr>
<tr>
<td>Food/ beverage/animal feeds</td>
<td>215</td>
<td>6</td>
<td>36</td>
<td>1</td>
</tr>
<tr>
<td>Textiles/ apparel/leather/footware</td>
<td>97</td>
<td>5</td>
<td>19</td>
<td>2</td>
</tr>
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<td>Chemical/Pharmaceuticals</td>
<td>80</td>
<td>4</td>
<td>20</td>
<td>2</td>
</tr>
<tr>
<td>Automobile/parts industry</td>
<td>145</td>
<td>5</td>
<td>29</td>
<td>2</td>
</tr>
<tr>
<td>Fabricated metals industry</td>
<td>120</td>
<td>7</td>
<td>17</td>
<td>3</td>
</tr>
<tr>
<td>Power generation/electrical/electronic</td>
<td>284</td>
<td>8</td>
<td>35</td>
<td>1</td>
</tr>
<tr>
<td>Plastics, packaging and stationery</td>
<td>59</td>
<td>4</td>
<td>15</td>
<td>3</td>
</tr>
</tbody>
</table>

8.10 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 12.
8.11 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 13. 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.

8.12 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>
<thead>
<tr>
<th>Sub-Sector</th>
<th>Mean no of steps</th>
<th>Scale value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Construction and material industry</td>
<td>4.25</td>
<td>1</td>
</tr>
<tr>
<td>Food, beverage and animal feeds industry</td>
<td>5</td>
<td>2</td>
</tr>
<tr>
<td>Textiles, apparel, leather and foot ware</td>
<td>4</td>
<td>1</td>
</tr>
<tr>
<td>Chemical and Pharmaceuticals industry</td>
<td>7</td>
<td>3</td>
</tr>
<tr>
<td>Automobile and parts industry</td>
<td>10</td>
<td>4</td>
</tr>
<tr>
<td>Fabricated metals industry</td>
<td>4</td>
<td>1</td>
</tr>
<tr>
<td>Power generation and electrical/electronics</td>
<td>8</td>
<td>3</td>
</tr>
<tr>
<td>Plastics, packaging and stationery</td>
<td>5</td>
<td>2</td>
</tr>
</tbody>
</table>

8.13 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) = \( \frac{X_{01} + X_{02} + X_{03} + X_{04} + X_{05} + X_{06}}{6} \) 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

**8.14 CAPITAL INVESTED**

Based on MSME bill (2009), respondents were requested to choose a response on an array of 5 choices namely; below Ksh 5 Million meriting a score of 1, Ksh 5 Million –50 Million a score of 2, Ksh 50 Million -500 Million a score of 3, Ksh 500 Million-5 Billion a score of 4 and over Ksh 5 Billion a score of 5. This measure of company size is anchored on the two polar point continuum of small to large company. The term smaller and larger company purely describing the side of the continuum. The results are shown in Figure 14 in which fabricated metal industry, Construction and material industry and chemical and pharmaceutical industry lead with a mean score of 4.0. The lowest was plastic, packaging and stationery industry with a mean score of 2.

**Figure 14: Capital invested in terms of sub-sectors**

**8.15 WORKFORCE NUMBER**

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

For this study all the respondents in section 1 and section 2 were on full-time basis and had worked in the company for more than 5 years. From Figure 15, it is observed that, on average, companies in the power generation, electrical/electronic industry are the largest and employ more than twice the AMT manufacturing average, with mean and median at 284 and 130 employees respectively. Companies in the plastics, packaging and stationery had the highest part-time workers and the lowest FTE with a mean of 59 and a median of 45.

![Company size pattern by Sub-Sector](image)

As the median company size across all industry sectors is around 50 employee level, it indicates the presence of some very large companies which are pulling the whole sector average up. Yet, this is most stark in power generation, electrical/electronic industry as well as food, beverage and animal feed industry suggesting a few giant companies are present in these industries. This suggests that these two industries may have oligopolistic tendencies that is dominated by a few giant corporations.

### 8.16 COMPANY SIZE INDEX SCORE

Company size index score was based on the workforce number and invested capital of the companies. As regards workforce number the largest number of employees by sector was at a mean of 283.75 and the lowest at a mean of 59. Therefore to calculate Company size score on our 1-5 polar scale, our scale was based on these two extremes and scale of 1 was selected for 51 – 100 employees, 2 for 101-150 employees, 3 for 151-200 employees, 4 for 201 – 250 employees and 5 for over 250 employees. Calculation of Company size index score is as per the equation below.
Company Size Index (CSI) = \( (X_{01} + X_{02})/2 \)  where
\( X_{01} \) = Capital invested score
\( X_{02} \) = Workforce number score

The results of the above equation is as shown in Table 5.

<table>
<thead>
<tr>
<th>Category</th>
<th>Employees</th>
<th>Workforce Score</th>
<th>Capital Invested Score</th>
<th>Company size score</th>
</tr>
</thead>
<tbody>
<tr>
<td>Construction/ material</td>
<td>92</td>
<td>1</td>
<td>4</td>
<td>2.50</td>
</tr>
<tr>
<td>Food/ beverage/animal feeds</td>
<td>215</td>
<td>4</td>
<td>3</td>
<td>3.50</td>
</tr>
<tr>
<td>Textiles/ apparel/ leather/foot ware</td>
<td>97</td>
<td>1</td>
<td>2.5</td>
<td>1.75</td>
</tr>
<tr>
<td>Chemical/Pharmaceuticals</td>
<td>80</td>
<td>1</td>
<td>4</td>
<td>2.50</td>
</tr>
<tr>
<td>Automobile/parts industry</td>
<td>145</td>
<td>2</td>
<td>3.75</td>
<td>2.88</td>
</tr>
<tr>
<td>Fabricated metals industry</td>
<td>120</td>
<td>2</td>
<td>4</td>
<td>3.00</td>
</tr>
<tr>
<td>Power generation/electrical/electronic</td>
<td>283.75</td>
<td>5</td>
<td>3</td>
<td>4.00</td>
</tr>
<tr>
<td>Plastics, packaging and stationery</td>
<td>59</td>
<td>1</td>
<td>2</td>
<td>1.50</td>
</tr>
</tbody>
</table>

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

9. MODERATING EFFECT OF COMPANY SIZE

Objective of the study sought to establish the effect of company size on the relationship between AMT adoption and organizational structure. To achieve this objective, hypothesis was formulated based on the literature review as: The relationship between Advanced Manufacturing Technology and Organizational structure depends on company size.

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 company size (main effects). In the third model, organizational index was regressed against advanced manufacturing technology, company size index and interaction between the two (AMT*CSI). 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 (AMT*CSI) is significant.

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

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

\[
\begin{align*}
\text{model 1} & : OI_{31} = -5.55 + 4.722(AMTI) + \epsilon_{31} \\
\text{model 2} & : OI_{32} = -2.524 + 2.559(AMTI) + 0.297(CSI) + \epsilon_{32} \\
\text{model 3} & : OI_{33} = 0.468(AMTI*CSI) + \epsilon_{33}
\end{align*}
\]

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

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

10. 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 third objective of the study was to determine the effect of company size on the relationship between AMT adoption and organizational structure. Evidence in the literature shows that conventional technology use increases with company size, measured as the logarithm of workforce number (Yasai-Ardekani, 1989). In our study company size was operationalized further in terms of workforce number and capital invested. With this measure of company size the hypothesis we seek to test is that the relation between AMT adoption and organizational structure depends on company size. The average employment
Research journal’s Journal of Technology Management
Vol. 2 | No. 4 October | 2015

across the sub-sector was found to be around 140 but the median was at around 50. This is an indication of the presence of some very large companies which were pulling the whole sub-sector average up. When empirically tested, the research findings present the interrelationships among the main effects (AMT index and company size) and the interactions (AMT index * Company size). Four dominant findings emerged from the study.

First, company size positively moderates the relationship between AMT adoption and Organizational structure. Our stepwise regression equation on organizational structure against the main effects (AMTI and CSI) and the interaction term (AMTI*CSI) revealed that the coefficients of the main effects were 0.652 with p-value at 0.502 for AMT index and -0.568 with p-value at 0.177 for company size index. Coefficient for the interaction term (AMTI*CSI) was positive at 0.468 with p-value at 0.041. The constant of the model was 0.974 at p-value of 0.582. From these results only the interactive term is significant at 95% level of confidence. The regression equation reduced to $OI = 0.468(AMTI*CSI) + \varepsilon_{33}$. The equations indicates that CSI statistically moderates the relation between AMT adoption and organizational structure indicating that there is a linear dependence of OI from AMTI*CSI. This implies that changes in company size index 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 company size is therefore supported. In agreement with Yusuff et al. (2008) the broader product line in large companies may contribute to better use of AMTs. This finding means that Company size enhances the fit between AMT adoption and organizational structure perhaps due to larger companies’ command of resources which gives them access to skilled operators and professionals who could get more out of these technologies.

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

Thirdly, we found a weak positive linear relationship between AMT adoption and company size ($AMTI = 1.700 + 0.048(CSI)$). The investment of numerical controlled machines was highest in the medium industries but integration of this technology increased linearly with company size. The study found that the skill demand of AMT is a formidable challenge for smaller manufacturing companies to acquire and retain. The strongest determinants of the level of AMT adoption are by far the technical skills of blue-collar workers followed by
the influence of customers and vendors. In agreement with Noe et al. (2008) large companies also are likely to have the skills and human resources it takes to understand, implement, and manage such technologies.

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

11. Reference


Rosnah et al. (2003)


