ORGANIZATIONAL ADAPTATION FOR AMT IMPLEMENTATION IN THE SMIs

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ABSTRACT

Several factors have been identified as important to the implementation of AMT. A key ingredient to the long term benefits of AMT is the implementation of a parallel process of organizational change to match the technological changes taking place. Increased competitiveness and flexibility of the firms can be achieved if there are high levels of integration of the technologies and mutual adaptation of the organization and technology. To analyse the level of AMT integration and the level of adaptation between organization and technology, a study was conducted in the SMIs of Malaysia using survey questionnaires. The use of computers to integrate the various activities and functions in the SMIs were evaluated to determine the levels of automation practiced in the companies. The adaptation between technology and organization for the small and medium scale industries (SMIs) of Malaysia was determined by identifying the organizational factors important for AMT implementation. Using aggregated index of organizational and technological parameters developed from the questionnaire, a Technology (T)-Organization (O) map was drawn. The T-O map describes the patterns of technology and organizations for the companies and used to classify the position of the companies on the T-O map. Results of the study showed that the level of computer usage in integrating the functions were rather low. The regression analysis carried out to establish the 'best-fit' model for the aggregated index showed that the best-fit model for T-O is a polynomial regression model of the 4th order with R^2 =0.38766. The result indicates that the variability in the organization has been explained by only 39% in the model developed. A greater fit between organization and technology will be achieved only with higher R^2 values. Using the T-O map, only seven companies can be classified as high technology, high organization (HT-HO) whereas almost 83% or 113 companies are in the low technology, low organization (LT-LO) classification. The results clearly indicate that there is lack of integration between the technologies and that the companies are practicing the old methods of management not suitable for AMT implementation.

Key words: *Advanced Manufacturing Technology, SMIs, Adaptation, Organization, Technology, T-O map*

INTRODUCTION

The adoptions of advanced manufacturing technologies by companies are seen as essential to increase the competitiveness of the organizations. These technologies have the potential to improve product quality, increase process flexibility and reduce manufacturing cycle time. Properly executed this improved capability results in greater customers satisfaction and lower manufacturing operating costs [1]. Although AMTs can help manufacturers compete under these circumstances they often impose organizational challenges and at the same time providing competitive benefits. Findings from Yousef [2] and Ranta [3], confirmed that AMTs affect all dimensions of manufacturing capabilities of an organization.

Advanced Manufacturing technologies differ from earlier technologies in their capacity to increase organizational flexibility because they are programmable, allowing them to produce a wide array of different parts or products in small volumes by changing software instead of hardware. The goals in implementing AMT should be realistic, clear, well communicated, accepted throughout the organization, and, most important, targeted not at short-term payback but at improving the company's competitive positions. The implementation of AMT has long- term implications to the whole organization. Several studies have highlighted that there is a clear need for organization to change alongside the technology, and failure to effect this will likely result in inferior system performance [4],[5]. Advanced manufacturing technologies are integrative in nature and require a different way of thinking about manufacturing as compared to traditional non-integrated technologies. Organization, structures, skills, etc. need to be in harmony with the AMTs (and vice versa)[6]. Leonard-Barton [7] argues that implementation of AMT requires mutual adaptation between technology and organization. These adaptation processes are necessary since technology seldom fit the organization and organization seldom fit the technology. These misalignments must be addressed if the implementation is to succeed by altering the technology or changing the environment or both.

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To increase their competitiveness in the global markets, the SMIs of Malaysia are forced to look at advanced manufacturing technologies. The ability of the SMIs to implement AMT and gain the strategic benefits of the AMTs are largely determined by the organizational and technological constrains within the companies themselves. A study was conducted among the SMIs of Malaysia on their capabilities of adapting the organization to the needs of technology to derive the strategic benefits of these technologies. The adaptation between technology and organization was evaluated using a T-O map based on aggregated index developed for technology and organization. The study also investigated on the AMTs implemented and the level of automation in the SMIs and integration.

Classifying Advanced Manufacturing Technologies

Meredith and Hill [8] and Snell and Dean [9] distinguish four levels of integration in classifying advanced manufacturing technologies:

- Level 1 : Stand alone (unitary) equipment and materials such as robots or numerical control machine tools

- Level 2 : Cells consisting of groups of equipment and materials for the production of parts, typically utilizing group technology and computer aided manufacturing. At their highest level of integration, a cell might form a flexible manufacturing systems

- Level 3 : linked islands involving cells from level 2 being linked together into larger production systems which typically utilize CAD/CAM, automated storage and retrieval systems, JIT and MRP 11

- Level 4 : full integration providing linkage of the entire manufacturing function and all its interfaces through an extensive information network. This level if integration is commonly known as computer integrated manufacturing (CIM).

The four levels of integration suggested by Meredith and Hill [8] ranging from stand alone equipment, to cells, to linked islands, and finally to full integration implies that the gradual progression of increasing technology corresponds to increasing integration. In moving from level 1 to level 4, the extent of integration increases, the size of capital investment rises, the capability and sophistication of software and hardware increase, and a greater variety of skills are required. 'Stand-alone' items represent localized, closely targeted process innovation. A fully integrated system on the other hand, focuses attention on both the manufacturing process and the marketplace, fostering both process and product innovations. Stand-alone machines have narrow goals relating to cost reduction and to specific improvements in technical performance. The goals of fully integrated system, on the other hand, are more likely to be closely identified with broader strategic goals which may include product innovation, multidimensional aspects of quality, and the reduction of new product lead times. At the intermediate level, cells and linked islands are likely to be associated with strategic goals such as increasing product differentiation potential, broadening product mix, and increasing fast-response capability.

Mutual adaptation of organization and technology

A key ingredient to the success of AMT is the implementation of a parallel process of organizational change to match the technological changes taking place. The organizational adaptations include physical layout, skills profiles, work organization, functional and hierarchical relationship, inter-firm relationships and the overall culture of the organization [10]. Major investments in AMT are likely to have significant consequences of organizational structure; process and culture that need careful planning and management to ensure successful innovation and commitment to support change. Many implementation efforts, whilst strongly managed in technical and financial area, fail through a lack of strategic management of the necessary organizational development [4]. The successful implementation of advanced technologies depends at least as much on organizational adaptation as on technical adaptation, for functions to work effectively together and hence achieve effective integration of systems, the functions must be effectively balanced.

An adaptation process is necessary because technology almost never fits perfectly into the user environment. The 'complexity' takes the form of misalignments (poor fits) between the technology and technical requirements; the system through which the technology is delivered to users, or user organization performance criteria. To exploit the advantages of new process technologies, managers have learned that they have to adapt those technologies to fit the organization and its strategy. Companies that are applying advanced technologies to improve their competitive position must learn to embrace change [11]. The full advantages of such technologies cannot simply be purchased of the shelf; they are won by patiently and carefully tailoring the technology to fit a given firm's organizational and strategic context and vice versa [7].

An important implication from studies [12],[13],[14] for firms considering or already involved investing in AMTs, investing in the manufacturing infrastructure is critical to the success of AMT implementation. The capabilities of the AMTs will only be fully realized when companies also invest in upgrading the skills of their workforce. The vast potential of AMTs will be unlocked when investments are made in providing quality leadership and empowering workers. Managers cannot incrementally buy AMTs, than follow up at a later date with investments in training, leadership, and empowerment. These investments must be made in concurrent, not an evolutionary manner [13].

Observations of companies' experiences in implementing advanced manufacturing systems point to the problems arising from incompatibility of new technologies with organizational structures, decision techniques, management systems and employee attitudes [15]. Studies show that companies that want to squeeze performance improvement from AMT need to adapt technology to new organizational forms and emerging managerial practices. There is evidence and agreement that successful changes in companies over the past few years were more organization-driven than technology-driven, though AMT often provided strategic support for organizational restructuring[14].

METHODOLOGY

A survey questionnaire was developed to help gather data on the technology (T) and organizational (O) practices of the SMIs. The organization (O) refers to the recognition of human resource, employee involvement, skills, training and education, departmental integration, adoption of management philosophies, planning and organizing activities, and culture. The technology (T) measures the degree of automation/ computer use in various activities, computer-integration between functions and the transfer of information through computers. All these variables are captured in the questionnaire.

The questionnaire was developed based on extensive literature on the success factors of AMT implementation. A 5 point-Likert scale with 5 as most important/substantial and 1 as least important or nothing is used, indicating the strength of the parameters asked. Based on the response, mean weighted average values were used to evaluate the strength of each dimension. The quantitative data on organization (O) and technology (T) were formulated into aggregated indices for the Malaysian SMIs. Once the aggregated indices on organization and technology are calculated for each company, the best-fit regression model is established. The T-O map will enable us to describe the patterns of organization and technology in the companies. It will also help to establish the level of technology and organization, the stages in AMT implementation and the strategic implications that should be considered by the industries.

The questionnaires were sent to more than 1000 companies classified as SMIs based on the Malaysian National productivity Center (NPC) and Small and Medium Scale development Corporation (SMIDEC) directories.

RESULTS AND DISCUSSION

A total of 136 usable replies were used in the analysis. The respondents were mainly from the electronic and electrical industries, metal-based and furniture companies.

Integration of functions through computers

Higher level of systems integration is important for AMT projects to be successful [16]. Though the need for integration appears prominently in the literature review, Putterill et al. [17] found that firm-wide integration is an overwhelming difficulty in implementing these technologies. Information transferred between functions using computer systems will enable functional integration and provide access to common databases linked electronically. Diverse functions are integrated in terms of information, focus and responsibility. The benefits from the new manufacturing technologies will be greater with cross-functional applications and integration than with unlinked individual functional applications. If new technology is used to automate each function, a company will be able to achieve productivity benefits but the impact on competitiveness is limited compared if an integrated approach is taken. The use of cross functional teams or multidisciplinary teams have been viewed by various authors as necessary in the implementation of AMT [5],[17],[18],[19],[20], should include members from various functional areas [21], especially from every affected department and area, as opposed to delegating the task to a particular person [22]. Thus, if the functions are integrated electronically, the development of cross-functional teams will be facilitated as information becomes more accessible to the various functions and hasten decision-making.

The level of organizational integration is achieved through cross-functional teams and participation of the various functions in implementing AMT. Hard integration, or technical integration, is another important component of AMT application that tells how well implemented the technologies are and the stages of AMT implementation. It maybe realized through computer-integrated transactions between functions and the extent of computer use is an indication of the level of automation in the industries.

The results of the survey indicate that computer controlled equipment is hardly used in the various production functions of the industries as all the areas surveyed indicate a score below two except for measuring and testing. Material handling, transportation, assembly, welding, fabrication all had a ranking of below two for the average of all industries. Thus, the level of automation is low for all these functions. It was also found that the use of computers in the design activities such as drawing, engineering calculations and design component all scored slightly above 2. The other activities such as simulate product performances, parameter design, design retrieval and use of 3-D techniques were ranked less than two. Again, there is minimal automation in design activities and that there is no higher levels of integration in the design activities.

There is quite a reasonable usage of computers in information processing where the highest score is in processing information for finance and administration followed by in marketing and sales, production planning and least on process planning activities. However, in the SMIs surveyed, the use of computer systems to transfer information between functions such as between production and marketing, purchasing and production, design and administration, marketing and design, design and manufacturing, and purchasing and design are relatively low, ranking below three for all functions.

Integration of functions is necessary to improve the company's competitive positions. Functional integration is regarded as essential for AMT implementation and a major hurdle for most organizations. The low integration between marketing and production as shown by the results may cause the slow adoption of AMT in the companies as Small and Chen [23] found that the low participation of marketing helped to explain the slow adoption of AMT in the USA. Kotha, and Swamidass [24] also indicate that a strategic AMT-market relationship can enhance the competitive advantage.

The SMIs can achieved organizational integration by developing cross functional teams to iron out conflict, anticipate problems, ensure compatibility of the various systems, work toward systems integration, set targets and objectives, and most of all promote an AMT strategy that will enhance competitive advantage. The low level of functional integration in the SMIs may result in a minimal impact of AMT implementation on the organization.

T-O map

Aggregated indices were developed for organization and technology for each company based on questions asked on the organizational and technological characteristics of the organizations. Since a 5-Likert scale has been used in the questions asked, with 5 as substantial, 4 as considerable, 3 as reasonable, 2 as little and 1 as nothing, the mean weighted values of each of the question indicate the strength of each O and T characteristics. A scatter plot of the T-O index was drawn. A best fit model found for T and O is a polynomial regression model of the 4th order (R^2 =0.38766 compared to R^2 for 2nd order is 0.37087 and 3rd order is 0.37522 and 5th order is 0.39118). Sun et al [25] (1994) used the 4th order polynomial regression for their sample of Danish companies with R^2 = 0.81 and Nagwasdi & O'Brien [26](1999) used the 5th order polynomial with R^2 = 0. 32610. The result indicates that the variability in the organization has been explained by only 39% in the model developed. A greater fit between organization and technology will be achieved only with higher R^2 values.

Relationship between organization and technology

Based on the index developed for T and O, it was found that none of the companies had a value of T above 4, whereas for the O index there were four companies that scored slightly above 4. The scatter plot was used to partition and classify the companies into four categories, High technology-high organization (HT-HO), high technology-low Organization (HT-LO), Low Technology -High organization- (LT-HO) and Low Technology-Low Organization (LT-LO). This partition will enable us to identify where the majority of the SMIs are and what are the necessary actions required to improve the performance of the SMIs, technologically and organizationally. The companies are also able to identify their relative position in their quest for technology. Using the 3.5 score for technology and organization as the demarcation line between reasonably good performance against low performance, the scatter plot is divided into four quadrants as indicated in figure 1. The extreme corner of the quadrants would signify the extreme conditions. However, in this study, there were no extreme values recorded.

Those companies in the high technology (HT) quadrant are implementing the technologies in level 2 and moving towards level 3 since the technology index is between 3.5 and 4. This indicates that the companies are moving from independent cells to linking the islands of automation. Those in the high organization (HO) quadrant indicate slightly higher values than T, with some companies above 4, indicating that these companies are implementing some new organizational concepts and practices. These companies are structured for flexibility, therefore suitable for AMT implementation. Companies in the low technology (LT) quadrant have implemented some stand-alone or unitary AMT but mostly the equipment found in these companies would be of the conventional types. Companies in the low organization (LO) quadrant are maintaining the status quo, hardly any organizational changes and probably practicing the old methods of organization that is mechanistic. The companies have rigid and inflexible organizational structure. Companies with high organization are found to be better performers than those with high technology index.

There are only seven companies in the HT-HO quadrant, three companies in the HT-LO quadrant, thirteen in the LT-HO class and the majority of the companies are in the LT-LO quadrant. This clearly indicates that the SMIs are mostly in the stage one of AMT implementation and the organizational practices and structure have to be changed before further AMT can be implemented successfully. Those companies in the high organization and low/high technology (HT-HO/LT-HO) quadrant will be able to incorporate higher technology as the organizational index is higher.

The companies with low technology and low organization will not be able to compete in a globalized economy. They will not be able to increase productivity and quality, and faced with global competition, these companies will not survive. These companies made up of 83% of the companies surveyed or 113 companies. Only seven companies out of 136 companies (~5%) will able to compete globally and achieved the strategic benefits of AMT. This should be a cause of concern and efforts in increasing the use of technology and simultaneously changing the organizational structure should be carried out for most of the companies surveyed.

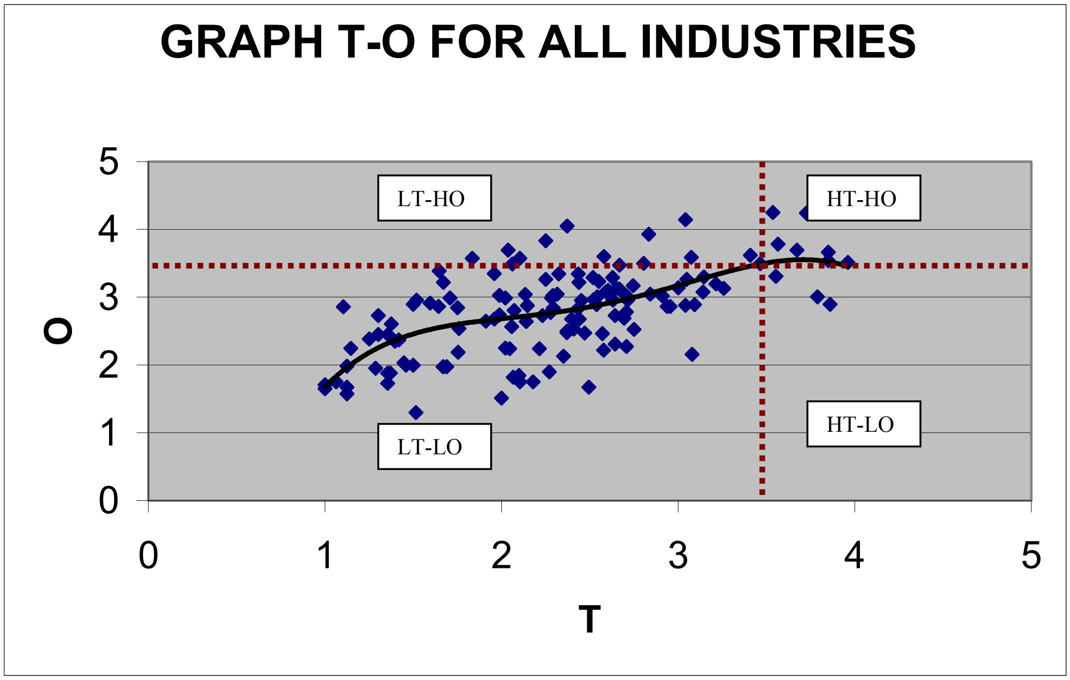

Figure 1: Relationship between Technology and Organization

CONCLUSION

Most of the SMIs surveyed are implementing low levels of technology (stand-alone systems), not integrating between and within the technologies and functions The management problems associated with new manufacturing technology arise from their dependence on integration- not just within the manufacturing process, but across the enterprise as a whole, and even extending beyond the enterprise to include suppliers and customers. The inability to integrate will probably cause the SMIs to have inferior systems. Ensuring compatibility between the technical and environmental subsystems requires that new manufacturing technologies are effective in meeting the needs of customers and are capable of enhancing the competitive position of the firm. Introducing new manufacturing technologies inevitably require a redefinition of the relationship between the technical and environmental subsystems through adjustment to overall business strategy [15].

The use of computer in integrating and linking the functions are also low except in information processing between finance and administration. The lack of computer link in information processing between the other functions will cause delays in information transfer. This may affect the process of decision making, causing delays in marketing, production and other functions, and ultimately affecting the lead and delivery times. A study conducted by Martin [27] showed that in the production sector, more than one third of the companies have CNC machine tools, but less than 1% have automated material systems. Only 9% of the firms investigated have one internal link. The interconnection implemented most frequently is that between computer-aided production planning and work planning.

The SMIs must also learn to utilize the AMT for higher-level usage. The capabilities of the technology should be explored and exploited. The use of computers and integration of the design activities are low, even though in a study [28] of AMT implementation in the SMIs of Malaysia reported that the use of CAD is highest among all AMTs at 25%. However, the level of CAM used was less than 15% and CAE only 9%. This clearly indicates the lack of integration between these activities. Beatty and Gordon [29] in their study of CAD implementation found that the high–level features were underutilized, such as integrating the computer aided design (CAD) with computer aided manufacturing (CAM), integrating the work of designers of separate components, and integrating results from engineering analysis specialists with design. The reasons for the failure to exploit the potential of CAD were caused by the high degree of specialization and fragmentation of the design process. The lack of social integration is a major cause of the failure to utilize CAD/CAM's potential. The elaborate division of labor and poor integration across functions help explain why many of the higher-level features of CAD, CAE, CAD/CAM are rarely utilized to best effect.

A fit between the three areas, design tasks, CAD integration, and organizational integration mechanism can increase the accomplishment of the system. A higher level of inter-functional integration for CAD/CAM will heighten the need for ongoing coordination of engineering and manufacturing. Such ongoing coordination will require more than procedural devices to sustain it-it will require organizational structures and strategic commitment [30]. Thus, for the SMIs to obtain the strategic benefits of AMT, they must plan for higher levels of utilization, inter-functional integration and the social system that will support it. The SMIs must understand the potential benefits of AMT, and be able to plan and commit the necessary changes that will enable them to increase the flexibility and competitiveness of their firms. If they are not able to make these changes, cultural and structural, and if the adoption of AMT is only for productivity gains, then they should not invest in AMT.

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