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Effective Factors on Advanced Manufacturing Technology Implementation Performance: A Review

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Abstract: This study reviews an extensive body of literature to investigate the factors effective on performance of companies implementing Advanced Manufacturing Technology (AMT). The purpose of this study is to provide a comprehensive viewpoint of issues related to successful AMT implementation and offer some directions to managers and investigators to make a company well-prepared to accept technology. The factors are grouped into three categories: technological, organizational and internal/external. The literature showed that in order to have a fruitful result from AMT investment, the organizational structure and culture, operational strategy and human resource should be organized and integrated appropriately with each other to avoid probable barriers and problems. Proposed framework can be used as a guideline for managers and investors in improving their AMT implementation process.

Key words: Advanced manufacturing technology, performance, strategic framework and technology fit

INTRODUCTION

A variety of pressures either locally or globally encourage manufacturers to become more agile, responsive and flexible if they wished to survive (1994). Firms that operate in developing, and/or newly industrialized countries face many uncertainties when venturing into the modern global markets (Noori, 1997). Thus, it was vital for manufactures to have the ability to compete due to the globalization in all aspects of product manufacturing such as product variations, labor, technology and markets (Mitala and Pennathur, 2004). These included massively increased competition and globalization of manufacturing and they served to place emphasis on a wide set of non price factors such as design, product innovation frequency, customization and delivery responsiveness (Bessant, 1994).

These conditions are bringing great challenges to firms, which can affect corporate strategic directions and alter business and manufacturing strategies. In an effort to survive under such conditions, companies are giving a strategic role to manufacturing, from simply supporting marketing strategies to playing a major role in strengthening a company's market position (Monge *et al*., 2006). The effective implementation of advanced manufacturing technology is considered to overcome this turbulent and hostile environment. This option is an important solution especially for small and medium size companies (Rosnah *et al*., 2003) in which lack organic structure and inadequate level of skilled workers and engineers and are not aware of the ways in which AMT can be helpful for them (Yusuff *et al*., 2005).

The rapid growth in both availability and range of AMT choice opens up major opportunities not only for improving substitution innovation but also for radical alternatives. These opportunities have never been done before and are doing in ways which were not possible hitherto (Bessant, 1994). Changes in communication and interaction related to AMT implementation have been shown to result in greater satisfaction with the technology (Stock and McDermott, 2001) and AMT adoptions appear to be a key condition for long term competitiveness. However, many AMT projects fail to meet the expectations of their adopters (Koc and Bozdag, 2009) and increasing signs of difficulty began to emerge which suggested that the translation of potential benefits into real competitive advantage was not always as simple as signing a cheque for a new piece of equipment (Bessant, 1994). In many cases not only AMT investments have been criticized for not yielding the

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desired results (Chung, 1996), but also some researchers found a negative contribution of AMTs to the firm performance (Boyer *et al*., 1997; Swamidass and Kotha, 1998). The researchers concluded that the relationship between AMTs and firm performance has a complex relationship (Koc and Bozdag, 2009) and the link is influenced by other factors, some controllable and some not controllable (Heine *et al*., 2003).

Thus, applying and adopting new technologies indicated that there are broader issues that have to be considered. Management of firms that are considering the adoption of AMT need to recognize, understand and address these issues in order to overcome or circumvent the problems of previous installations. They require knowing what the organizational and strategic factors are which make a firm more competitive and adept at using AMT in improving its performance and whether AMT's impact on company performance more pronounced if associated with a compatible organizational design and human force and management practices. Because of high cost and moderate-to high risk involved in AMT investment, it is so important for any organization to know more about these the factors. Generally, the investigated factors can be classified as technological, organizational and internal/external. This classification is illustrated in Fig. 1.

This study is a step in paving the way to provide an overview and guidance in AMT adoption and the right mix of strategic and important elements that leads to effective use of AMT in enhancing company performance.

Overview of AMTs: In studying AMT implications, the choice of AMT types and their classification is a decision of crucial importance that should be made on the basis of existing theory and the nature of the research study to be conducted. Advanced manufacturing technology has different meanings in different situations, but it can be broadly defined as 'an automated production system of people, machines and tools for the planning and control of the production process, including the procurement of raw materials, parts, components and the shipment and service of finished products (McDermott and Stock, 1999). More specifically, AMT can be described as a group of computer-based technologies, including Computer-Aided Design (CAD), robotics, Flexible Manufacturing Systems (FMS), Automated Materials Handling Systems (AMHS), Computer Numerically Controlled (CNC) machine or other automated identification techniques (Small and Yasin, 1997a).

Youssef (1992) defined advanced manufacturing technology as a group of integrated hardware and software based technologies, which if properly implemented, controlled and evaluated, will improve the efficiency and effectiveness of the firm. Boyer *et al*. (1997) used the term advanced manufacturing technology in their research to describe a variety of technologies like CAD and Electronic Data Interchange (EDI) which primarily utilize computers to control, track, or monitor manufacturing activities, either directly or indirectly. In addition, several technologies or programs such as bar codes or group technology which do not directly involve computers are also considered to be AMTs since they are closely associated with other AMT technologies.

AMT has been classified in different ways. Based on the automation and integration of manufacturing activities, Ghani and Jayabalan (2000) and Ghani *et al*.

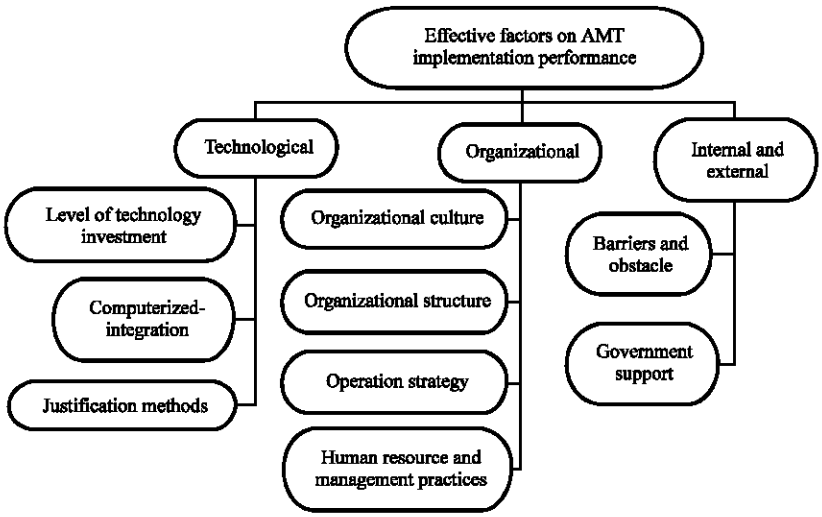

Fig. 1: Contextual factors effective on company performance

(2002) have been classified AMT into four levels. First level includes numerically controlled machine and robots called stand-alone machine tools or equipments that are controlled by self-contained computers. In level 2 or manufacturing cells a grouping of machines such as group technology and flexible manufacturing system perform a variety of tasks to produce a family of parts. In level 3 cells in level 2 are connected to form linked islands through network of computerized information like computer-aided design/computer-aided manufacturing, automated storage and retrieval systems. In level 4 all the manufacturing activities including marketing of products are integrated through information network and formed computer-integrated manufacturing.

Waldeck (2007) classified advanced technologies in her study by Factor analysis in two levels: first level is *Basic technology* including Computer-aided design, Computer-aided manufacturing (CAM) and Direct numerical control. Next level is Artificial intelligence or complex technologies comprising vision systems, knowledge-based systems and decision-support systems. Zhang *et al.* (2006) also classified AMTs as Design technologies, such as CAD and CAE that support product design and engineering; Manufacturing technologies, such as CNC, CAM and AMHS which make production easier and faster; Planning and control activities are facilitated by the development of MRP, MRP II, electronic data interchange and bar coding and Integration technologies such as CIM, Local Area Networking (LAN) and enterprise-wide resource planning that allow a flow of information and coordinated decision-making between functions within and between the firms.

Small and Chen (1997) and Small and Yasin (1997b) classified AMT into three levels based on complexity, automation and integration of manufacturing activities. Stand-alone systems include machine tools or equipment controlled by independent computers such as (computer-aided design and computer-aided process planning (CAPP)); Intermediate systems contain a group of machines to produce a family of parts such as (automated guided vehicles (AGVS) and automated storage and retrieval systems (AS/RS)); and Integrated systems which are connected to form linked islands through computerized information network, for example (flexible manufacturing systems and MRP). In summary, Table 1 presents the classifications found in the literature.

It is reasonable to state that most technological advancements that have changed the nature of manufacturing performance have taken place since 1950 (Mitala and Pennathur, 2004). AMTs enable both economies of scale and economies of scope to be achieved without changing the hardware and allow firms to blend small-batch and custom-order operations with the low-cost efficiency of standardized mass production (Efstathiades *et al.*, 2002). 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 (Millen and Sohal, 1998; Efstathiades *et al.*, 1999). AMT has been viewed as a strategic weapon to gain competitive advantage, to improve productivity and performance, to enhance quality of production (Zhao and Co, 1997; Efstathiades *et al.*, 2002) and decrease lead-time (Preece, 1995; Ghani and Jayabalan, 2000; Hofmann and Orr, 2005). In effect AMT changes the external risk propensity of the firm from risk-averse to risk-prone. That is, firms using AMT in practice create a series of call options to enter new markets and industries in the future (Efstathiades *et al.*, 1999). It also was mentioned that even the benefits of advanced techniques such as Just-In-Time can be realized with applying only a few component of JIT

Table 1: Advanced manufacturing technology classification

Resource(s)	Dimensions
Boyer *et al.* (1996), Jonsson (2000), Dýaz *et al.* (2003)	Design, Manufacturing, and administrative
(Swamidass and Kotha, 1998)	Information exchange and planning technology, Production design technology, High-volume automation technology, and low-volume flexible automation technology
Small and Chen (1997) Small and Yasin (1997a, b)	Stand-alone, Intermediate, and integrated systems
Sanchez (1996), Beaumont *et al.* (2002)	Direct, indirect, and administrative
Meredith (1987)	Engineering techniques, manufacturing techniques, business techniques
Ghani and Jayabalan (2000), Ghani *et al.* (2002)	Stand-alone, manufacturing cells, linked islands, integrated manufacturing
Majchrzak and Paris (1995)	Integrated AMT , Non-integrated AMT
Kotha (1991), Kotha and Swamidass (2000)	Product design technologies, process technologies, logistics/planning technologies, information exchange technologies
Beaumont and Schroder (1997)	Direct, indirect, communication
Zhang *et al.* (2006)	Design technologies, manufacturing technologies, planning and control, integration technologies
Waldeck (2007)	Basic technology, artificial intelligence
Small (2006)	Stand-alone, moderate, and high complexity
Burgess and Gules (1998)	Hard technologies, soft technologies

and as a result companies can gradually invest in these technologies to get the most benefit from it (Yusuff *et al*., 1997). Certainly, it takes some time for plants to realize the potential benefits of an AMT investment. It can be because of the learning curve associated with these technologies that may delay performance gains. As a fairly complicated technology, employees need extensive training and experience to master for new technologies. Therefore, time may act as a confounding variable in obtaining AMT benefits (Boyer, 1999; Nahm *et al*., 2006).

A synopsis of performance measurement: Evaluating the performance of AMTs relies on defining what success means (Burgess *et al*., 1997). For a company, performance is a measure of where it is; how far it has achieved its per-specified plans and more importantly, how it can efficiently use its capacity to improve its performance compared with its competitors (Agarwal, 1997).

At the beginning of the 1980s, AMT was seen only as a panacea to solve the financial problems in manufacturing companies. Managers concentrated only on the *financial* measures (Kidd, 1990) such as sales growth, market share and return on investment to justify the AMTs. Later on, the researchers found that such criteria do not capture the information that is required to judge the true effectiveness and outcomes of the new technologies. They found that the use of AMTs has substantial impacts to both individual and process requirements as the processes are reconfigured through computerization. They focused on operational measurement like the productivity and flexibility to justify the purchase of equipment to upper management. *Organizational* measures include other company's performance criteria like workflows, communication, integration of work and managerial control, also were considered as a new measurement system for AMT outcomes (McDermott and Stock, 1999; Efstathiades *et al*., 2002). Those measurement criteria were not enough to assure a manger whether his company got all possible benefits from AMT or not. AMTs are in relation with increased job responsibilities and the creation of new roles for employees. These technologies might enlarge employee control, even though such control may be limited to task design as opposed to task execution (Siegel *et al*., 1997). Therefore, human resource benefits relate to human force such as operator autonomy and the use of work teams were introduced (Chung, 1996; Mitala and Pennathur, 2004; Waldeck and Leffakis, 2007).

EFFECTIVE FACTORS ON AMT IMPLEMENTATION PERFORMANCE TECHNOLOGICAL CHANGE

Integration: One of the greatest advantages associated with AMTs is that of integration. Theoretically, by using the abilities of computers to electronically connect different machines and workstations together, a single integrated system will be formed to control all of the activities of a given firm starting with raw materials and finishing with finished goods ready to deliver to the final customer (Boyer, 1994). Integration either realized through computer-integrated transactions between functions, for example between marketing, engineering, production and maintenance, or between processes, such as linked between product design (e.g., CAD) with Process Planning (e.g., CAPP), manufacturing (like CNC), or production planning (e.g., MRP II) (Jonsson, 2000). Much of the attraction of AMTs has always been the potential to integrate different systems to create a complete system in which information and production can be controlled by computer, without the need for considerable human intervention (Boyer, 1994).

From an organizational perspective, Nemetz and Fry (1988) and Parthasarthy and Sethi (1992) argued that integration have resulted from using AMTs. Boyer *et al*. (1996), Diaz *et al*. (2003) and Melnyk and Narasimhan (1992) believed that more investment of AMTs leads to heavier integration between processes. Jonsson (2000) showed that the level of investment in AMT and the integration between processes/functions affect the performance of companies. It is concluded that technology integration offers more benefits than the automation of individual processes (Boyer, 1994).

Justification approaches: Obviously the first decision any firm considering in AMTs adoption is whether such an investment would be wise (Boyer, 1994). The high costs of hardware and software of many of the advanced manufacturing technologies and the complexities of the operational and organizational problems related to adopting these systems, make justification a necessary but difficult proposition (Small, 1993). Generally justification methods has been classified into three categories of approaches: *economic*, *analytic and strategic* approaches (Suresh and Meredith, 1985). Economic methods justify based on the cost reduction or capacity expansion (Mcdaniel, 1989; Small, 1993). The Analytic methods frequently consider uncertainty, flexibility, risk and non-economic benefits of AMTs (Meredith and Suresh, 1986; Mcdaniel, 1989; Chan *et al*., 2001). The strategic approaches tend to be less quantitative than either the economic or analytic techniques and typically involve subjective estimates of the key indicators or surrogate measures related to strategic objectives (Mohanty and Deshmukh, 1998; Chan *et al*., 2001). It is demonstrated that most companies are using only one method, most probably simple economic method or using hybrid evaluation approaches (i.e., strategic and economic or economic and analytic) (Meredith and Suresh, 1986; Chadwell-Hatfield *et al*.,

1996; Stuart, 2002) for AMT investment decision but Small and Chen (1997) showed that companies utilizing hybrid method attained higher levels of success from their AMT projects than plants that used only one method. It seems that inappropriateness of one criterion might be partly balanced by the use of the other methods. It is unlikely that any single justification method will lead companies to all or even a wide range of AMT benefits and improve performance. Thus, integrated approaches (i.e. using strategic, economic and analytic methods in parallel) were recommended to quantify the tangible and intangible benefits throughout the technology investment (Small and Chen, 1995).

Organizational design: Successful implementation of AMT involves the mutual adaptation of both the new technology to the organization and the organization to the technology (Frohlich, 1998). In fact the adjustment of technology to the organization and vice versa can ease the accomplishment of new technologies and avoid management problems associated with AMTs (Yusuff *et al*., 2004a). This importance embraces structure, culture and strategy of any organization.

Organizational structure: It has been argued that manufacturing companies that adopt AMTs without first redesigning organizational structures and processes, encountering high difficulties (Millen and Sohal, 1998). Along with AMTs emergence, industrial organizations have deeply changed their manufacturing processes through the acquisition of computerized technologies. This evolvement is frequently viewed as the basis for a new industrial revolution-the arrival of the factory of the future- and new form of organizational structure (Dean *et al*., 1992). Generally, structure of an organization is the formal system of working relationships that share and harmonize the tasks of multiple people and groups to serve a common purpose. Centralization, formalization and complexity are the three dimensions often use in research and practice to describe structure. Centralization in the organization refers to the delegation of power among the jobs. The less power delegated in an organization the greater the centralization in the organization and vice versa. Formalization refers to the extent to which expectations regarding the aims and objectives of work are specified and written. Highly formalized organization structures recommend what each individual should act based on rules and procedures that are obtainable. Last dimension, Complexity, refers to the number of distinctly different job titles or occupational groupings and the number of definitely dissimilar units/departments, in a group/organization (Gibson *et al*., 1973).

The structure of the organization has been considered as the key factor to successfully implementing AMT in various literatures (Dalton *et al*., 1980; Kotha, 1991; Dean *et al*., 1992; Belassi and Fadlalla, 1998; Ghani *et al*., 2002; Jin-Bo *et al*., 2006; Song *et al*., 2007; Sun *et al*., 2007). It is theorized that the correct organizational structure is in place, a company will be more successful in implementing advanced manufacturing technologies (Boyer, 1994; Anderson, 1998). Boyer *et al*. (1996) stated that the multiple levels of authority involved with hierarchical organizations often represent an obstacle to the effective implementation of AMTs and streamlining the organization with fewer level of authority brings a greater ability to integrate AMTs. They concluded that rigid, bureaucratic organizational structure which has been associated with highly automated, but non-computerized manufacturing systems such as assembly lines, is not appropriate for more flexible technologies. Gupta *et al*. (1997) also indicated that only decentralization with fewer rules and more employee involvement were positively relate to technology whereas formalization and mechanistic structure interacted negatively with AMT. The result of this study emphasized that irrespective of the technology type, a firm needs to be as least mechanistic as possible to be effective. In examining the relationship between structure and AMT Ghani *et al*. (2002) found that, at high proactive level, the mechanistic structure of AMT plants has been found to change into an organic structure. In fact organizations with many different types of jobs and departments generate more complicated managerial and organizational problems than those with fewer jobs and units. Flatter, less complex structures with maximum administrative decentralization, are more likely toward creating a potential for improved attitudes, more effective supervision, greater individual responsibility and company performance (Belassi and Fadlalla, 1998; Malhotra *et al*., 2001; Chang and Lung, 2002).

Organizational culture: Successful implementation of AMT often requires dissimilar types of organization and or management practices than are found in more traditional environments (Zammuto and O'Connor, 1992). This is because new technologies directly challenge established norms and strategic options. Organizational culture referred to a holistic construct that describes the complex set of knowledge structures which organization members use to perform tasks and generate social behavior. This construct is affected by and impacts many aspects of organization such as structure, role expectations and job description. Culture defines how to act on the job, who makes decision in various situations

and how to think and behave toward coworkers, supervisors, industry norms and practices. This view of culture includes the organization's internal system of power including formal authority structures, control systems, task structures and organization rules (Bates *et al*., 1995). In other word, culture is to the organization what personality is to the individual, a hidden, yet unifying topic that provides meaning, direction and mobilization (Belassi and Fadlalla, 1998).

Generally the culture was picture into two main dimensions as flexibility and control (Zammuto and O'Connor, 1992; Denison and Mishra, 1995). Flexibility-oriented culture is based on norms and values related to the affiliation. It focuses on the development of human resources and values member involvement in decision making. In this culture, individuals are encouraged by the significant or ideological appeal of the task being undertaken. On the other hand, control-oriented culture is penetrated by assumptions of achievement such as planning, productivity and efficiency. More specifically, assumptions of stability are the foundation of this culture and individuals respect to the organizational mandates because roles are formally announced and enforced through rules and regulations.

Regarding to the effect of culture on company performance, Zammuto and O'Connor (1992) hypothesized that the control-oriented approach may well lead to increased productivity, but can hinder AMTs implementation, because centralization of responsibilities diminishes opportunities for organizational learning, which, in turn, can make more difficulties to get an AMT up and running reliably. They concluded that flexibility-oriented values will gain AMTs' productivity and flexibility benefits. McDermott and Stock (1999) examined how organizational culture is related to outcomes associated with advanced manufacturing technology implementation, such as, operational benefits, organizational or managerial benefits, competitive benefits and satisfaction. They found that implementation effects that may take longer to happen, such as overall satisfaction or competitive performance, did depend on the cultural flexibility. Chang (2000) tried to find the relationship between organizational culture and successful implementation of AMTs in Taiwan. Analysis showed that the control-oriented culture did result in reduced AMT implementation success while good internal process, rational goals and horizontal coordination have positive effect. Results demonstrated that companies with a history of successful AMT implementation preferred a flexibility-oriented culture in a more conducive environment to ease the AMT implementation (Yusuff *et al*., 2008).

Operational/manufacturing strategy: Basically, the importance of manufacturing strategy to the overall success of the corporation has received considerable attention as Skinner published his landmark article in 1969, manufacturing-missing link in corporate strategy (Mcdaniel, 1989). According to the new approach to manufacturing strategy, managers should think about investments more in their capacity to build new capabilities that provide enduring sources of competitive advantage and are usually built over time through a series of investments in facilities, human capital and knowledge. The early approach to manufacturing strategy led top managers to focus their companies' operations around specific competitive priorities that tended to make them vulnerable to strategic shifts. A good manufacturing strategy was one that defended a company's position through a narrowly focused set of capabilities (Hayes and Pisano, 1994). In other words, strategy was denoted as actions or patterns of actions intended for the achievement of goals. The term strategy covers more than just intended or planned strategy in an organizational setting; it also contains the sequence of decision that exhibit a posteriori consistencies in decisional behavior (Swamidass and Newell, 1987).

There is general agreement that a firm's operations/manufacturing strategy is comprised of four key competitive priorities: cost, quality, flexibility and dependability/delivery (Nemetz and Fry, 1988; Dangayach and Deshmukh, 2003). Cost strategy is based on the production and distribution of product at lower cost. It is a measure of the manufacturing function's efficiency and traditionally it has been associated with high volume/mass production. Quality strategy is associated with a firm's ability to provide superior products or services, often at higher prices. Dependability/Delivery strategy is defined with on-time delivery schedules and quickly response to customer orders. *Flexibility* is a measure of a firm's ability to react to market demands by switching from one product to another through matched policies and actions and react to changes in production and product mix, modifications in design, fluctuations in materials and changes in sequence. The effectiveness of a company's operations strategy is the function of degree of linkage or consistency between the competitive priorities that are emphasized on the corresponding decisions regarding the structure and infrastructure of operations (Hayes and Wheelwright, 1984; Boyer and Pagell, 2000; Stock and McDermott, 2001). The emphasis placed on these priorities varies by firms, depending on a large number of factors including availability of resources, business strategy, existing capability, managerial behavior, nature and intensity of competition and environmental condition (Agarwal, 1997).

One of company's most important variables for coping with environmental uncertainty is flexibility that is particularly relevant to the rapidly changing conditions affecting manufacturing organizations (Nemetz and Fry, 1988). This is nowhere more truly than for AMT, which provides the biggest source of flexibility in any manufacturing organization (Boyer and Pagell, 2000; Stock and McDermott, 2001). It has been noted that although AMT creates a world of opportunities, they will not be converted to advantage unless the adopting firm uses a strategic planning approach (Small and Yasin, 1997b). Swamidass and Newell (1987) conducted an empirical study to find the relationship between operational strategy and performance. They found that environmental uncertainty such as manufacturing flexibility and the role of manufacturing managers in strategic decision making influenced manufacturing strategy and among different dimension of manufacturing strategy, flexibility has a strong relationship with business performance. Efstathiades *et al*. (1999) declared that AMT implementation is more related to quality and delivery strategy. Results from Lewis and Boyer (2002) showed that among the two groups in their sample (high performers and low performers) in applying AMTs during the last 3 years, high performers generally were more likely to stress on flexibility, quality and delivery strategy than cost strategy and specifically the most dramatic difference appeared with regard to quality strategy between the two groups. Other researchers believed that all four manufacturing strategy dimensions are important in implementing new technologies and gaining related benefits (Ferdows and De Meyer, 1990; David *et al*., 1996) and focusing on one dimension does not relate directly to AMT performance. The simultaneous achievement of cost, quality, delivery and flexibility by many Japanese companies has highlighted this new possibility that can be realized by adopting advanced process technologies and management techniques (Agarwal, 1997).

Human resource and management practices: Along with technology development, the human resource is an asset for any organization, without which the use and development of technology will not happen (Efstathiades *et al*., 2000) and has significant impact on strategic success (Malhotra *et al*., 2001). Human resources' qualities, attitudes and behavior can provide the firm with a source of competitive advantage with respect to its rivals (Bidanda and Cleland, 1995; Bayo-Moriones and De Cerio, 2004). Researchers emphasize the importance of providing appropriate workforce development activities such as socialization ability (Chen *et al*., 2008) and managers involvement in R and D projects (Liu and Tsai, 2007) to improve skills and relational requirements resulting from modifications in technology and new production processes in enhancing company performance. Inherently, all AMTs will increase worker requirements as workers are given more autonomy over issues including planning and problem solving (Waldeck, 2007). Evidence from the literature suggested that planning and implementation activities aimed at preparing workers for AMT adoption, play a critical role in guaranteeing an exploitation of the system benefits (Small and Yasin, 1997a, b). Thus, a major challenge for future successful implementations lies in addressing the needs imposed by AMT on the human elements.

In order to turn workers into key elements for building a competitive edge, people have to be managed in a distinctive way (Bayo-Moriones and De Cerio, 2004) and being more capable in terms of knowledge, skills, attitudes and responsibility (Bidanda and Cleland, 1995; Waldeck, 2007). As a result, providing workers with opportunities to improve their inherent motivation and job satisfaction by means of employee-involvement practices could be deemed an acceptable policy to ally the goals of employees with the firms using AMTs (Bessant, 1994; Bayo-Moriones and De Cerio, 2004; Waldeck, 2007). Education and training are also crucial to the successful implementation of AMT. Experience has shown that between 25 to 40% of the total cost of an extensive successful automation project should be spent on education and training (Zhao and Co, 1997). Firms with successful AMT implementations also enlist *champions*. These individuals support a continual driving force throughout the initiative (Millen and Sohal, 1998). The effect of these three practices beside the other seven factors were tested on ERP systems in some Malaysian companies and the results showed their importance in real situations (Jafari *et al*., 2009). Widening of the marketplace, increasing importance of technology and imperative of innovation and focusing on cross-functional groups, are appropriate ways to develop viable business solutions (Doolen *et al*., 2003). Because of the importance of the management personal characteristics, experience and background on their decisions, any change has to start with the managers on the top and in the middle, then the organization of workers on the shop floor (Sun and Gertsen, 1995). Besides, to facilitate the psychological, physical and cultural change resulting from AMT implementation, management must build trust and co-operation (Cook and Cook, 1994). These practices can grantee the achievement of technology investment projects.

Internal/External factors

Government support: An important feature of the optimistic climate common in the 1980's was a strong faith placed by government relate to AMT affecting manufacturing industry. It is generally recognized that some measure of state support for innovation is necessary in order to preserve a position of international competitiveness. During this period, governments of most advanced industrial economies proposed a range of programs designed to smooth the progress of advanced manufacturing technologies adoption (Bessant and Rush, 1993). Approximately, the increase in interventionist-technology policy-making has been the outcome of increasing government awareness of the extent that innovation is joined to economic growth and with the recognition of the strategic role of technologies in the evolvement of new industries and markets (Vickery and Blau, 1989; Hilpert, 1991). Government support programs was introduced to compensate for deficiencies in economic/industrial environment, to strengthen the technological infrastructure that facilitates the convey of technology from the developer or supplier to the user, to tackle specific firm-level obstacles of technology diffusion and to increase the supply of technical and managerial personnel (Bessant and Rush, 1993). It is argued that end-users of AMT, mostly private firms in the manufacturing sector, are competing in the global market with leading foreign companies and hence in need of up-to-date AMT. Beside, domestic and AMT suppliers and R and D institutes lack the native capability to meet the complex demands. It is not unusual that technology developers and technology users are separated from each other. Meanwhile, governments programs coordinate these diverse and even contradictory demands in developing national policy of AMT (Park, 2000). Lay (1993) analyzed how subsidized firms have been planning and implementing their technology (CIM, in that case) and whether AMT projects in subsidized firms differ, from those in non-subsidized firms. For about two-thirds of supported firms, public support for a technology project showed the effect of extending or speeding up the finalizing of the project already planned to take place at that time. A group of firms stated that they would not have embarked on the project at all, or not at that time, without public support. In other words, these programs including direct financial support, information/consultancy support and so on, affect the competitiveness of firms in promoting their market share, open up significant new opportunities and allow firms to deal with strategic challenges in their environment (Lay, 1993).

Barriers/Obstacles: By the mid-1980s the diffusion of AMT, as measured by adoption rates, was high amongst large firms and trickling down to the small and medium sized companies. However increasing signs of difficulty began to emerge which suggested that the translation of potential benefits into real competitive advantage was not always as simple as signing the check for a new piece of equipment (Bessant, 1994). Successful implementation of AMT projects needed persistent efforts to integrate operating and organizational systems to support these operations (Small, 1993). The introduction of a new technology can reduce performance when the organization initially struggles to acquire the requisite skills and knowledge; i.e., there may be an substantial lag between installing new technology and getting benefits from it (Beaumont and Schroder, 1997).

Beatty and Gordon (1990) list three classifications of barriers to implementation: structural, related to organizational infrastructure and justification difficulties; human, related to uncertainty and workers' resistance; and technical, related to the incompatibility of systems. Adler (1988) suggests that in the decisive majority of cases, the human resource management issues are the major stumbling blocks in implementing the new technologies. Meredith (1987) notes that in the early stages of FMS implementation, human and organizational infrastructure and worker education were major difficulties. Bessant (1994) concluded that AMT investment was unlikely to succeed unless it was located within a coherent business strategy and accompanied by relevant parallel organizational change. Sambasivarao and Deshmukh (1995) showed that adoption of AMTs involves major investment and a high degree of uncertainty and hence, warrants significant consideration within a manufacturing firm at the strategic level. In a survey among Malaysian small and medium size companies, Yusuff *et al*. (2004b) identified that lack of understanding of technologies and inappropriate planning are the biggest obstacles in obtaining the strategic benefits of AMT implementation. Shortage of suitable man power (Cook and Cook, 1994; Zhao and Co, 1997; Shepherd *et al*., 2000), inadequate organizational planning and preparation for the adoption of the AMT (Small and Yasin, 1997a, b), failure to balance investments in technological systems with investments in the infrastructure to support these systems (Boyer *et al*., 1997), inadequate cost-justification methods (Cook and Cook, 1994), technology mania, lack of top management's continued support, financial limitation (Ratnasingam *et al*., 2009) and inadequate managerial training for AMT projects (Marri *et al*., 2007) are other major problems hindering the success of factory

Table 2: A summary on effective factors

Factor	Factor dimension	Supported Literature
Advanced Manufacturing Technology	Stand-alone systems Intermediate systems Integrated systems	Small and Chen (1997), Small and Yasin (1997a, b) Small (2007)
Justification method	Economic justification Strategic justification Analytic justification	Suresh and Meredith (1985), Chan *et al.* (2001), Small (2006), Narain *et al.* (2007)
Integration		Boyer *et al.* (1996), Jonsson (2000), Diaz *et al.* (2003)
Manufacturing strategy	Flexibility strategy Cost strategy Delivery strategy Quality strategy	Lewis and Boyer (2002), Diaz *et al.* (2003)
Organizational structure	Centralization, Formalization Complexity	Gupta *et al.* (1997), Belassi and Fadlalla (1998)
Organizational culture	Flexibility Control	Zammuto and O'Connor (1992), Chang (2000)
Human resource and Management practices		Chung (1996), Small and Yasin (1997, 2000) Bessant (1994), Cook and Cook (1994), Majchrzak and Paris (1995)
Obstacles and Barriers		Cook and Cook (1994), Schroder and Sohal (1999), Hofmann and Orr (2005)
Government programs		Bessant and Rush (1993), Lay (1993), SMIDEC (2007)

automation. In summary Table 2 illustrates all explored factors and their dimension and related references.

The interaction effect of variables: Research has indicated that the application of AMT can be successful if only designing technology, organization and people are base on the principle of reinforcing each other and their integration (Sun *et al*., 2007; Waldeck, 2007). As employees need higher knowledge/skill and organizations adopt teamwork gradually, decentralization among organization occurs (Gupta *et al*., 1997). In new AMT environments, employees are not only single operators, but would be coordinators or decision-makers. The role of organizations can not be a single task-distributor and coordinator anymore, but it would promote employees' enthusiasm and independence through multifold manners to bring them into the most potential (Sun *et al*., 2007). Fewer complexities in a flatter organization are helpful to encourage employees to apply AMT and enhance their responsibility. Less formalization could stimulate employees, awake their sense of responsibility and improve working efficiency of employees and implementation effects of AMT (Song *et al*., 2007). Consequently, organic structure with less complexity will be the feature of decentralized management, minimal organization levels and more teamwork enterprises that must reduce organization levels to make fast transfer of information and communication (Sun *et al*., 2007). Less formal delegation of authority in flexibility-oriented culture allows top management to provide the general strategic direction. Lower level management is then free to work and innovate under the assumption that its efforts will lead the organization towards the desired, top management imposed (Gupta *et al*., 1997).

In addition, effective cooperation between process change and factors of organizational change is good to the achievement of performances of AMT (Song *et al*., 2007). Manufacturing strategy is best implemented when plant personnel understand the strategic aims and direction of the plant and can exercise appropriate judgments in less formalized organization. Once again it is impossible to speculate about casualty but this association may indicate that processes of strategic goal orientation and decentralized decision making reinforce each other over time (Bates *et al*., 1995). Well aligned and implemented manufacturing strategy was found to coexist with a flexible-oriented organizational culture. It is indicated that a well arranged strategy, which includes informal planning processes, communication strategy and contribution to all four dimension of competitive priorities, coexist with- a clan oriented culture characterized by the use of group and teams, low emphasis on hierarchy and high level of loyalty and shared plant-wide philosophy. +Consequently, contribution of these factors leads companies materializing their wish by applying new advanced technologies.

But the performance story does not end to this point. By applying performance appraisal to measure the performance of the employees and the organization, firms are capable of checking the progress towards the desired goals and aims (Badawy, 2007). The history of performance appraisal can be dated back to the 20th century and then to the second world war when the merit rating was used for the first time. An employer evaluating their employees is a very old concept. Performance appraisals are an indispensable part of performance

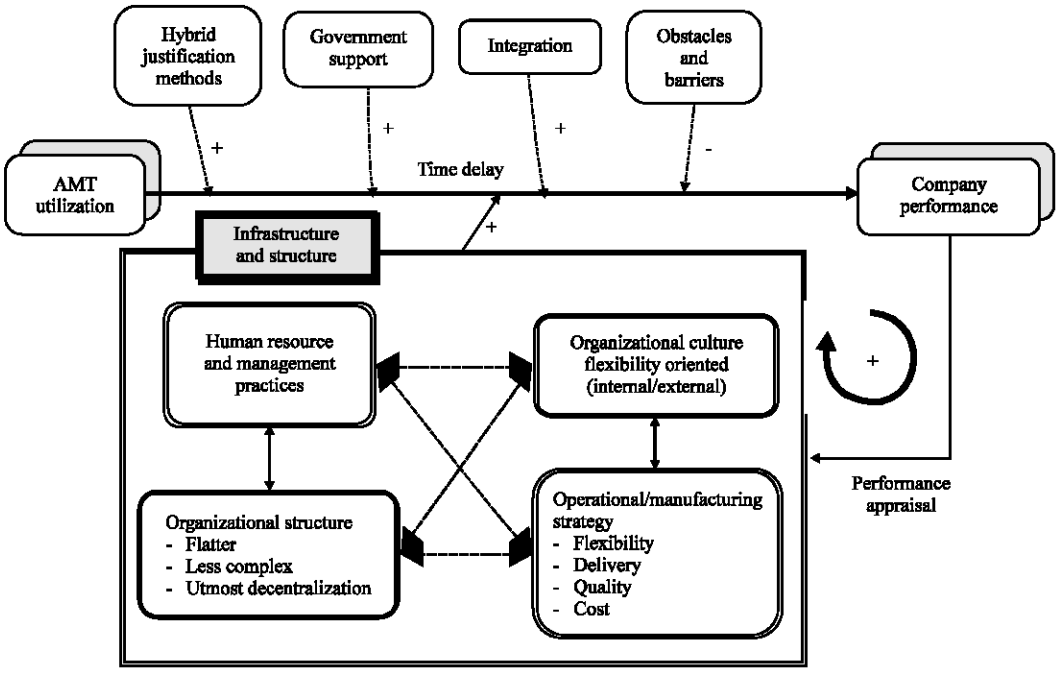

Fig. 2: A framework of investigated factors and their relationship with company performance

measurement. It takes into account the past performance of the organization and focuses on the improvement of the future performance of the organization. The performance appraisal process provides an opportunity for introducing organizational change. It facilitates the process of change in the organizational culture/structure. The interactive sessions between the management and the employees, the mutual goal setting and the efforts towards the career development of the employees help the organization to become a learning organization that can solve the obstacles better than the past (Gloet and Terziovski, 2004). Conducting performance appraisals on a regular basis helps it to become an ongoing part of everyday practice and helps employees to take the responsibility of their work and boosts their professional development and as a result, company productivity. Totally Fig. 2 shows a framework containing all investigated elements and their relationship with the company performance.

CONCLUSIONS

Today, technological capabilities can be strategically used to achieve sustainable competitive advantage and the implementation of these technology is an organizational transformation process, in which people's value, organizational culture, competition strategy and arrangement of people all will change to well-matched with each other (Zhao *et al*., 1992). The key to successful AMT implementation appears to be the collaboration of appropriate factors and their integration that will offer maximum benefits from AMT implementation.

The meaning of this research is to provide a comprehensive study on that systematically builds upon past researches in order to guide investigation into the successful AMT implementation and to determine those most critical organizational and strategic elements which if present can make a firm able to use AMT in enhancing performance. The framework presents the intra/inter-relationship among the variables influencing company performance in parallel with technology utilization that can be analyzed and offers testable propositions. This literature suggests that utilization of AMT will not also ipso facto guarantee performance but will further require appropriate changes in the firm's structure and infrastructure and continue with performance appraisal to improve company capability. In conclusion, the proposed framework can be used as a guideline for managers and engineers in improving their AMT implementation process. The offered framework is in the hope that it will stimulate empirical and practical investigations that will in turn generate the empirical evidence on which more adequate and strong hypothesis can be built.

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