

Advanced Manufacturing Technology Implementation Performance: Towards A Strategic Framework

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Abstract

Advanced manufacturing technologies (AMTs) are perceived by companies to be an important element in surpassing competitiveness. However, excelling in today's market is not as simple as the acquisition of new technologies alone. To achieve the desired benefits, the structure and infrastructure of organizations must match to ensure that the implementation of technologies lead to the expected benefits. Therefore, a framework that facilitates AMT adopters in determining the requirements of the AMT adoption, with the right mix of strategic elements is needed. This important prompted us to develop a framework that illustrates set of propositions suggesting that company performance will be increased by aligning the organizational structure, culture and manufacturing strategy with appropriate practices to improve human resource ability and skills in technology implementation. This framework can be summarized into a T-O-P map to show the alignment of technology, organization, and performance in technology adoption.

Keyword

Advanced Manufacturing Technology, Performance, Theoretical Study, Strategic Framework, Technology Fit

Introduction

The rapid development in both availability and range of choices in AMT opens up major opportunities not only for improving what has always been done but also for more radical alternatives that lead to a key condition for long term competitiveness [1]. Changes in communication and interaction related to AMT implementation have been shown to result in greater satisfaction with the technology [2]. However, many AMT projects fail to meet the expectations of their adopters [3] 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 the cheque for a new piece of equipment.

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 [4]. To have a successful AMT implementation, the questions like "what are the organizational and strategic factors which make a firm more competitive and adept at using AMT in improving its performance?" and "Is AMT's impact on company performance more pronounced if associated with a compatible organizational design and human resource practices?" should be answered.

What seems to be missing in literature is a unifying framework or model within which the various claims of interrelationships among the concerned factors could be analyzed. As Fry and Smith [5] noted, theoretical models that specify linkages between variables will have no contributory value unless embrace a predictive component such as performance to test the efficacy of the linkage in those models. Though several attempts have been made to find and analyze the strategic significance of AMT and its impact on company performance in different form of models, there is a lack of model/framework which cumulate studies that systematically build upon each other rather than to be isolated representations and will be able to direct managers and AMT adopters in improving company performance. This paper is a step in paving the way in developing a framework with the right mix of strategic and important elements that leads to effective use of AMT in enhancing company performance.

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Technology and Performance

Advanced manufacturing technology poses tremendous advantages and challenges for organizations [6]. Many companies invested in AMT mainly because they believe it will provide them simultaneous benefits of faster speed, greater product variety and increased productivity. These technologies believed to empower the firms to blend small-batch and custom-order operations with the low-cost efficiency of standardized mass production [7].

However, the literature showed that technology in isolation is not enough to improve performance and needs to be supported by other factors [8]. This finding is the basis of the current research. Although models have considered factors that are related to the organization, technology, strategy, and environment, none of them have completely covered all the pertinent dimensions in one model, beside that the role of organizational culture has often been ignored. In addition, performance is not treated as a multidimensional construct. A typical performance measure was either an aggregate financial or market measure (ROI, ROA, market share) [9]. Though, the contributions of past studies have not been discounted, a new and richer theoretical model to fill these gaps and address the issues of performance improvement in firms using AMT is needed. The framework proposed here uses the fit paradigm by paying attention to these areas. The proposed model is shown in figure 1. The framework can be changed to a T-O-P map that was first suggested by Sun (1994) [10] in the form of two-dimensional map (T-O map). Sun's proposed map lacks determination of the relationship between the fit paradigms between technology and organization with performance as the most important predictive variable in technology adoption. The T-O-P map will enable us to describe the organization and technology in both dynamic and static manner and relate the 'fit' or alignment of technology-organization with company performance.

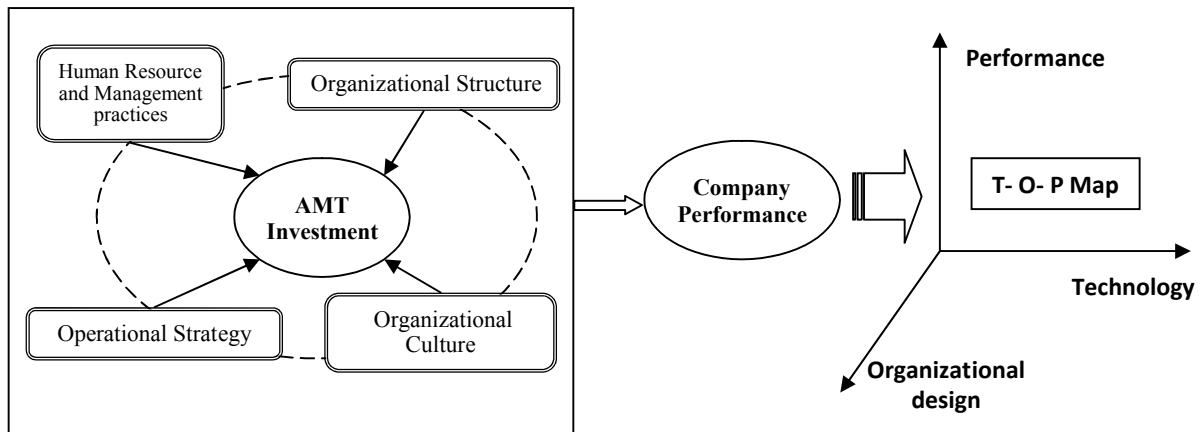


Figure 1: Proposed framework

Framework Elements

Advanced Manufacturing Technology and different level of utilization

Advanced technologies can be classified as *Stand-Alone Systems* such as (e.g. computer-aided design (CAD), and computer-aided process planning (CAPP), *Intermediate Systems* like (e.g. automated guided vehicles (AGVS), and automated storage and retrieval systems (AS/RS), and *Integrated Systems* such as flexible manufacturing systems (FMS), and computer integrated manufacturing (CIM) [11]. 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. 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 even though the adoption of these technologies are expensive and difficult to justify [12].

Proposition: The performance of companies with investment in AMT is higher compared with companies that have less AMT investment.

Organizational Structure

By emerging advanced technologies, industrial organizations have profoundly changed their manufacturing processes through the adoption of computerized technologies. This development is frequently viewed as the basis for a new industrial revolution—the advent of the "factory of the future"- and new form of organizational structure [13]. Generally, structure of an organization is the formal system of working relationships that both divide and coordinate the tasks of multiple people and groups to serve a common purpose. The three dimensions used in research and practice to describe structure are centralization, formalization and complexity [14]. *Centralization*

refers to the delegation of power among the jobs in the organization. *Formalization* refers to the extent to which expectations regarding the goals and ends of work are specified and written. *Complexity* refers to the number of distinctly different job titles or occupational groupings, and the number of definitely dissimilar departments, in an organization.

Structural mechanism must be matching with the process of effective implementation of new technologies [2]. The firm's technology influences the structure at operational and administrative levels and consequently on performance. It is theorized that the correct organizational structure is in place, a company will be more successful in implementing new or advanced manufacturing technologies [15]. Organizational structures appropriate for flexible, computer-based technologies are more organic, flatter with less hierarchical structure and needs change of current shape of organization from the hierarchical pyramid to more of a diamond shape, with more middle managers. But the greatest challenge of achieving this type of structure was the need for greater sharing of information, which is both one of the benefits of AMTs (greater distribution and availability of information) and one of the challenge of AMTs since information is the essence of managerial control [16].

Proposition: Flatter, less complex structures with maximum administrative decentralization companies who have invested in AMTs, have higher performance compared with companies with more centralization, formalization and complexities.

Organizational Culture

Organizational culture has been used as an holistic construct that describe the complex set of knowledge structures which organization members use to perform tasks and generate social behavior and is affected by and impacts many aspects of organization including structure, role expectations and job description, how to act on the job, how to solve problems, and who makes decision in various situations [17]. The most common conceptualization of organizational culture is along two axes reflecting different value orientations. These two axes form a four-cell model of value systems in which each cell has a different means-end emphasis. One axis is a Flexibility-Control dimension reflecting preferences about organizational structuring. Flexibility-oriented value systems emphasize decentralization and differentiation where as control-oriented value systems emphasize centralization and integration. The second axis is an Internal-External focus dimension that reflects whether organizations' value systems emphasize the maintenance of an organization's socio-technical system or the improvement of its competitive position within the environment [18].

Organizational characteristics or capabilities are likely to affect the success of the implementation, because these technologies are fairly different from the equipment they may be replacing. Organizational culture is a factor that may ultimately impact the performance with which a firm implements AMT [19]. The control-oriented approach may well lead to increased productivity, but can hinder AMTs implementation, because centralization of responsibilities reduces opportunities for organizational learning, which, in turn, can make it more difficult to get an AMT up and running reliably, where as flexible-oriented culture increase the likelihood that adopting organizations will gain AMTs' flexibility benefits, because these approaches attempt to compartmentalize the uncertainties associated with AMT operations so that problems are resolved at the point at which they occur [18].

Proposition: The organization with flexibility-oriented culture, whether internal or external-oriented achieved higher performance in implementing AMTs.

Organizational/Manufacturing Strategy

Strategy is denoted as actions or patterns of actions intended for the achievement of goals [20]. There is general agreement that a firm's operations/manufacturing strategy is comprised of four key competitive priorities: cost, quality, flexibility, and dependability/delivery [21]. *Cost* is manufacturing's strategic counterpart to price as a competitive weapon in the marketplace. *Quality* is a variable associated with a firm's ability to provide superior products. *Dependability/Delivery* is the strategy of providing on-time delivery of an item. *Flexibility* is a act in response to changes in production, changes in product mix, modifications in design, fluctuations in materials, and changes in sequence [22].

The degree of fit between an organization's competitive priorities and its key decisions regarding its investments provides the key to developing the full potential of operations as a competitive weapon that lead to quality, cost efficiency, and flexibility at the same time [23]. This is nowhere more truly than for AMT, which fits within the realm of "bricks and mortar" structural investments. It has been noted that although AMT creates a world of opportunities, these opportunities will not be converted to advantages unless the adopting firm uses a strategic planning approach [2]. However, there are some different ideas in setting priorities among these strategies. For example, Investments in AMTs in some research fitted best with a strategy which emphasizes the competitive priorities of flexibility, delivery and quality [24]. While other researchers declared that AMTs' greatest advantage

over more traditional technologies are considered to be in the mixture of flexibility, delivery, quality, and cost and to drastically enhance their production performance, these technologies consistently combined all four strategies [25]. Therefore, accentuating on one dimension does not relate directly to AMT performance.

Proposition: Performance of the companies implementing AMT that simultaneously focused on flexibility, delivery, quality and cost strategies will be higher compared with other companies which focus on one of the strategies only.

Human Resource and Management

Along with technology development, there is no doubt that the human resource is the greatest asset for any organization, without which the use and development of technology will not happen [26]. Under AMT implementation, the worker's discretion and scope of responsibility is expected to increase. It is obvious that providing workers with opportunities to improve their intrinsic motivation and job satisfaction by means of employee-involvement practices could be deemed an acceptable policy to align the goals of employees with the firms using AMTs [27]. Human resources can provide the firm with a source of competitive advantage with respect to its rivals.

On the top of that, effective management of people is critical to the successful implementation and use of new technological systems. In policy terms there is again a growing recognition that the main problems in technology transfer are not in the technology itself but in the managerial capabilities of firms [28]. The impact of management personal characteristics, experience, style and background on their decisions they make is very important. Generally, adopting effective management practices, capable of keeping pace with the changing technological environment, is particularly important to success in global markets.

Proposition: Firms with more emphases on human resource and management practices have higher performance in applying AMT compared with others.

The Interaction Effect of Variables

Research has indicated that the application of AMT can be successful if designing technology, organization, and people are base on the principle of reinforcing each other and their integration [29]. As employees need higher skill, and organizations adopt teamwork gradually, decentralization among organization occurs. In new AMT environments, employees are not only single operators, but would be coordinators or decision-makers. 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 [30]. 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 [29]. 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 [31].

In addition, effective cooperation between process changes and factors of organizational changes is good to the achievement of performances of AMT [30]. 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 [32]. It is indicated that an appropriate 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.

Conclusion

Today, technological capabilities can be strategically used to achieve sustainable competitive advantage and the implementation of these technologies is an organizational transformation process, in which people's value, organizational culture, competition strategy, arrangement of people all will change to well-matched with each other [33]. The key to the successful AMT implementation appears to be the collaboration of appropriate factors and their integration that will offer maximum benefits from AMT implementation. But there is little conceptual work done to show the nature of the relationships between influencing factors and their impact on company performance. The meaning of this research is to provide an integrated study that systematically builds upon past researches in order to

guide investigation into the effect of AMT implementation on company performance. In particular, the model proposes the interaction of AMT with several organizational and strategic factors, and the compatibility between them as an indicator of a firm's performance. In other words, the focus of this study is to suggest those most critical organizational and strategic elements which if present, can make a firm better able to use AMT in enhancing performance. 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 will stimulate empirical and practical investigations that will in turn generate the empirical evidence on which more adequate and strong hypothesis can be built. For future study, it is recommended to examine this framework empirically and justify its propositions statistically. Testing the proposition empirically, enable us to map the alignment of technology, organization, and performance on the T-O-P map and define and interpret the probable exciting situations.

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