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SOME PROBLEMS AND BENEFITS OF ADVANCED MANUFACTURING TECHNOLOGIES ADOPTION

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Abstract

During the past twenty years, we have witnessed a wide array of advanced manufacturing technology and computer based technology implemented in varying degree of success. AMT systems, when properly understood and implemented, can help firms compete along dimensions of cost, quality, flexibility, delivery speed, productivity and even profitability of the firms. Although adoption of Advanced Manufacturing Technology (AMT) promises benefits but are potentially risky. Many firms that have adopted these new technologies have not been able to reap all the potential benefits. In response to the mix result from adoption and implementation of AMTs, this paper attempts to discuss about the issues on factor inducing technology adoption, some empirical finding on AMT and the role of AMT in manufacturing sectors. There is also growing consensus that many of the failures in adopting AMT are, in fact, due to inadequate planning for, and/or faulty implementation of the systems. The key to successful AMT planning and implementation appears to be choice of an appropriate manufacturing systems and the attainment of an organizational infrastructure that will offer maximum support to the chosen system. The achievement of desired benefit from AMT requires systematic and integrated operational planning prior to the adoption of new systems. Such planning requires the identification of likely product and the matching of these products with efficient AMT processes.

Keywords: t*echnology, adoption, performance, strategy, implementation.*

INTRODUCTION

During the past twenty years, we have witnessed a wide array of advanced manufacturing technology and computer based technology implemented in varying degree of success. A growing body of research in manufacturing and technology management literature suggests that firms are investing considerable sums into advanced manufacturing systems to deal with fast changing product and fragmentation of traditional market, and to learn new process technologies that are important for shaping future industry evolution.

In 21st century, the market place is evolving into one merging national market and rapidly changing product and process technologies. All these changes are driving business organizations such as design, manufacturing, distribution, communication, sales, and others. Although manufacturing has not yet been utilized as a competitive weapon for most of firms, the market of 21st century demands manufacturing firms to exploit the role of manufacturing function in the competitive arena. Japan, for example has succeeded in the world market by focusing its attention on the importance of superior manufacturing system and techniques. One way that firm can achieve competitive advantage in manufacturing firms is through the employment of AMTs.

AMT systems, when properly understood and implemented, can help firms compete along dimensions of cost, quality, flexibility, delivery speed, productivity and even profitability of the firms. Schroeder and Sohal (1999) assert that AMT provides

tangible and tangible benefit to the firms. In a study by Currie (1989) is found that most firms aimed at achieving narrow operational benefits. Zammuto and O Connor (1992) came to the same conclusion from their review of a number of studies, which had assessed the success of adoption.

In response to the mix result from adoption and implementation of AMT, this paper attempt to discuss about the issues on factor inducing technology adoption, some empirical finding on AMT and the role of AMTs in manufacturing sectors. This paper is ended by the general conclusion and direction for future researches on AMT adoption and implementations.

IMPACT OF AMTs ADOPTION ON PERFORMANCE: SOME EMPIRICAL EVIDENCES

The term "AMT'' refers to computer-aided technologies in design, manufacturing, transportation and testing, etc. AMT also refers to the group of manufacturing technologies, which combine both scope and scale capabilities in manufacturing environment. Since manufacturing strategy has become more sophisticated, as a result AMT can play an important role in making its possible to compete on 'traditionally' contradictory competitive priorities simultaneously.

According to Youseff (1993), advanced manufacturing technology can be classified into three groups (1) technology used in the design of the product, (2) technology used in the manufacture of the product or advanced manufacturing technology and (3) technology used in planning, administrating and controlling activities related to the product. In other words, the term AMT refers to hardware-based technology in the design, manufacturing and administration of all the activities that are necessary to produce a product or provide service.

Many past studies (e.g. Youseff, 1993; Zammuto & O' Connors, 1992; Beaumont & Schroeder, 1999) have looked at the role of hard technology for improving performance, especially manufacturing performance. Empirical research by Youseff (1993) found that firms that adopted and implemented computer based technology have a higher degree of flexibility than firms that did not. It also suggests that the proper implementation and utilization of AMT leads to increased manufacturing productivity (reflected by efficiency and effectiveness), which in turn will increase the firm's flexibility in responding to customer's needs and demands. AMT has given new dimensions to compete (beyond cost and quality) in terms of agility, quick response to customer's needs and timelines in all manufacturing activities.

Zammuto and O'Connor (1992) found that advanced manufacturing technology (AMT) gives a number of benefits such as 40% reduction in lead time, 30% improvements in machine utilization, 12% reduction unit cost, 30% reduction in labor costs as well as improved quality of product and work in the process. The integration of AMT will create economies of scale (the ability to produce a large volume of one or a few products efficiently) and economies of scope (the capacity to efficiently and quickly produce any range of products).

The literatures provide evidences that the benefits of AMT are not only to large firms but also to small firms (Mechling et al., 1995; Rishel & Burn, 1997; McGregor & Gomes, 1999). McGregor and Gomes (1999) highlighted that technological change enables small and medium firms to become more competitive through improved product development and technological planning. By adopting and exploiting AMT, small and medium manufacturing firms can respond to customer needs in global markets (Mechling et al., 1999). Rishel and Burn (1997) argued

that the use of AMT is one alternative that may enable small firms to become and remain competitive by providing them with the tools and techniques to accommodate the increasing demands of their customers. Further, they found that the environment of firms using AMT was found to be quite different from the production environment of traditional technology firms. Product and process precision are higher in firms adopting AMT. Firms using AMT were more likely to adopt additional advanced production technologies and advanced management techniques.

A study by Burgess et al. (1998) of Turkish manufacturing firms revealed that no statistically significant relationship between AMT adoption and performance (measured by sales and market share). This contrary result may be related to the low level of technology adoption and if an effect is presented, it may be too small to be detectable. Another possible reason is that the link between innovation and technology adoption is moderated by some countervailing factors such as organization structure, competitive priorities and environment. Similarly Dean and Snell (1996) found that there is no relationship between AMT adoption and firms' performance. Perhaps the performance-enhancing effect of AMT is concentrated in the period of time just after the AMT is up and running effectively. Alternatively, it is due to the differing strategic posture of firms in implementing AMT, thus resulting in a mixture of positive and negative relationship between AMT and performance that simply cancelled each other out in the whole sample.

Curiously, Beaumount and Schroeder (1997) found that quality of product is negatively correlated with technology. There are possible reasons for this. In a more demanding environment, the expectation of internal and external customers for quality is higher, thus they have a higher standard for quality. The companies became more cautious to detect product defect before leaving the factory. Regarding this situation, the defect rate seems to be higher. Further, their finding revealed that CAM and CAE has a negative with several performance measures. The adoption of CAE and CAM increased cost of quality, longer factory schedules and more defect. This is hard to explain, probably those who have adopted these technology still learning about it to help cope with their problems.

Based on the above discussion, the following can be concluded regarding the hard technology-performance relationship. Most of the studies found that hard technology positively influence firms' performance (Youseff, 1993; Zammuto & O' Connor, 1992; Rishel & Burn, 1997; McGregor & Gomes, 1999). However, some of the studies revealed that hard technology has no significant impact on performance (Burgess et al. 1998; Dean & Snell, 1996). Even Beaumount and Scroeder (1997) found that hard technology has a negative impact on performance. Thus studies relating the impact of hard technology-performance relationship have produced contradictory results.

The Problems and Element of Successful Implementation of AMTs

Some industrialists and economists (Stainer et al., 1996) believe that AMT has great potential to offer manufacturing companies, with many tangible and intangible benefits. Some examples of the benefits which may be obtained are reduced labour (Hayes & Jaikumar, 1991), improved product quality (Attaran, 1989; Poo, 1990), increased product/ process flexibility (Attaran, 1989; Willis & Sullivan, 1984), enhanced time efficiency (Meredith, 1987a) and shortened time-to market.

Moreover, some manufacturers hold the view that the adoption of AMT

involves a high level of investment, and its payback period is usually longer than that traditionally required by business enterprises. Consequently, the investment may initially result in an increase in the cost of manufacturing. Apart from these factors, there is often a lack of sufficient experience with AMT implementation and it is not unusual for organizations that have invested in AMT to discover unexpected areas of application or benefit. There is also a growing belief that managerial issues, from planning to implementation, present the major barrier to employing these technologies effectively. Chen and Small (1994) proposed seven elements of successful AMT adoption and implementation:

a. Strategic planning for the adoption of AMT. The strategic planning approach takes a long term, comprehensive view of both business and technology issues. There is a greater possibility of adoption success if the decision to implement AMT is based on strategic consideration. Whatever the basis of the particular strategy that is adopted, the firm should develop an integrated business plan which provides the vision and sense of direction for each organization unit of the company to meet the strategic objectives.
b. Match product with process. Companies should first identify the range of product types that are to be manufactured, followed by identifying the technologies and processes required to manufacture this product. In seeking to match product and process, companies should be aware that adoption of AMT can bestow not only operational benefits but also marketing and strategic benefits as well. Benefit such as increased market share, reduced prices, improved responsiveness to changes in the market places, the ability to offer a continuous stream of customized product, faster product innovation and improvement of the company's image, have all been ascribed to the operation of the flexible advanced manufacturing technologies.
c. Monitoring advanced manufacturing technology. To determine the strategic and operational benefits offered by AMT, firms should continuously monitor the usage and performance of AMT in their core industry. Etlie (1988) emphasized the importance of monitoring technology. He argued that firms must be more innovative in new processing technologies and management practices in order to improve their competitive position and ensure survival.
d. Management commitment and control. It is critical for the success of AMT adoption and implementation. The lack of an appropriate management commitment and control proves to be the greatest impediment to the effective implementation of new manufacturing technologies. Management should be committed to training during the adoption phase and develop worker selection programs.
e. Functional relationship. In order to take full advantage of the considerable manufacturing and marketing capabilities offered by AMT there must be a balance between marketing and manufacturing strategies. In the condition when radical changes happened in process capabilities, market strategies must also be innovated. Likewise, rapid changes in market capabilities or market condition will signal a need for manufacturing strategy changes.
f. Relationship with the external environment. The adoption of AMT requires close collaboration with system vendors, customers and suppliers. During the implementation phase, there is a need for major vendor commitment. Firms should also foster tighter link

with customer, with the emphasis being on achieving quick response to customer demand and improved customer service. Wherever possible, customer should be allowed to participate in product development. Further, manufacturing firms should work toward a relationship of interdependence with supplier.

g. Justifying advanced manufacturing technology. The major considerations in economic justification of AMT project are the quantification of cost and benefit. While the costs (hardware, software, planning, training, operation, etc.) are generally easily quantifiable, the benefits are often very difficult to quantify. Specifically, major strategic benefit such as early entry to market, perceived market leadership, the ability to offer a continuous stream of customized products and improved flexibility, although extremely important for the growth and survival of the firms, are not readily convertible into cash value.

To the extent that global and domestic environment, manufacturing firms are adopting AMT as mean to effectively compete in their respective markets 9e.g. Flexibility, delivery, quality, and time based competition). Whatever the objectives may be the adoption of any new technology involves uncertainty about achieving the objectives.

In addition, to the inherent human resistance to change and to be innovative, at least two types of uncertainty emerge when adopting AMT (Mamer & Cardle, 1987):

a. Technological uncertainty, which refers to the problem whether the adoption of technology will be profitable, and
b. Strategic uncertainty, which involves the decision to adopt a new technology.

The effect of technological uncertainty can be reduced by research and testing. On the other hand, strategic uncertainty is more difficult and problematic to evaluate. It might be due to the difficulties to anticipate the decisions and actions of the competitors. Mechling et al. (1999) argued that it is difficult to reduce the technological and strategic uncertainty both in the acquisition and implementation stages. The first attempt to identify critical factors to reduce these uncertainties and support their strategic objectives is to provide a link between firm's long-term competitive strategy and its technology (Kantrow, 1980).

AMTs: EXPECTED BENEFIT VERSUS ANTICIPATED RISKS

This section is devoted to discuss proposed AMT adoption/implementation activities, expected benefits and anticipated risk based on studies done in developed countries and developing countries. To summarize the results of the previous studies, a detailed list of activities identified most prevalently in the literature as being critical for Amt implementation success is presented in Table 1.

Furthermore, based on a lot of studies done on AMT adoption, Tables 2 and 3 summarized the expected benefits as well as anticipated risks and difficulties of the manufacturing firms those adopt, implement and invest on sophisticated technologies.

Table 1: Proposed AMT Implementation activities

a.	Linking manufacturing to business strategy
b.	Coordinating marketing and manufacturing strategy
c.	Developing a long term automation strategy
d.	Monitoring AMT being used in the core industry.
e.	Matching capabilities of AMT to benefit expected by the plant
f.	Ensuring compatibility of AMT with existing production systems.
g.	Ensuring vendor commitment during and after installation.
h.	Obtaining the services of knowledgeable AMT consultants
i.	Hiring or retaining AMT experts on plant staff.
j.	Having multi-skilled production workers.
k.	Communicating the likely impact of the AMT to all plant workers.
l.	Emphasizing team work and group activities
m.	Pre-installation training of all project participate.
n.	Considering likely impact on suppliers
o.	Considering likely impact on customers
p.	Establishing multidisciplinary implementation teams.
q.	Establishing multidisciplinary planning teams.
r.	Top management involvement
s.	Choosing knowledgeable project leaders
t.	Financial investment evaluation prior to installation.
u.	Strategic investment evaluation prior to installation.
v.	Developing system performance measures prior to installation.

Table 2: Expected Benefit of AMT Adoption

a.	Improved quality
b.	Reduced cost
c.	Obtaining competitive advantage
d.	Increase throughput
e.	Increased flexibility
f.	Better management control
g.	Increased sales
h.	Improved response to variation in product volume
i.	Improved integration of manufacturing information system
j.	Improved response to variation in product mix
k.	Reduced work in progress
l.	Improved workforce attitude
m.	Improved integration of management information systems across function
n.	Improved working environment
o.	Reduced change over set up times
p.	Improved ability to response variation in supplier lead times
q.	Overcoming skill deficiency
r.	Improved management attitudes
s.	Enhance company image
t.	Reduced product development time
u.	Improved ability to implement engineering changes
v.	Widening product range
w.	Overcoming production skilled deficiencies
x.	Better working environment

Source: Previous studies.

Table 3: Anticipated Risks and Difficulties with AMT Investment

a.	Disruption during implementation
b.	Adverse effect on workflow
c.	Failure to achieve financial target.
d.	Problems with interconnection of equipment
e.	Amt skilled deficiencies
f.	Lack of integration of information system
g.	Production and management skilled deficiency
h.	Opposition by workforce
i.	Opposition by staff/management
j.	Obsolesce of technology
k.	Lack of integration across system.

Based on the above review, it is important to note that many determinants of implementation success, anticipated risks and difficulties as well as expected benefit are actions and conditions that should be in place prior to purchase and installation. Thus the pre installation stage is indeed an essential part of the entire AMT implementation process.

Motivated by this pressing need, this paper proposes some stages to help management determine when the adoption of new technology is necessary and the planning procedures to follow and to ensure successful AMT adoption and implementation. For manufacturers to analyze their operational and organizational environment as well as make critical decision about accepting or rejecting new technology development can utilize these stages below.

a. Define the company objectives and determine required product/process changes. The need for technological innovation in production processes is often initiated as a result of changing strategic or business objectives, which require an evaluation of current production processes. If existing process are found to be adequate for achieving the firm's business and strategic objectives, the manufacturers will maintain the existing processes, otherwise system changes that could be made in order to obtain the most efficient and cost effective should be considered.
b. Technology monitoring. Monitoring technology is an integral part of the planning process and should consist of the following: (a) the development of an awareness of available AMT (b) matching of these technologies to the process requirement of the manufacturing concern (c) ensuring the compatibility of the available technology with the plant's existing systems.
c. Operational and organizational planning for the adoption of AMT and financial strategic justification. The stage consists of the development of integrated operational and organizational plans for the adoption of the AMT followed by financial and strategic justification. The operational plan identifies the activities that are needed to ensure the successful adoption of the AMT into existing operating system. The organizational plan details the type of operational structure and human resource changes that will be needed to support the operation of the new system.

A study of Chen and Small (1995) showed that in term of organizational planning activities, successful manufacturing firms expended significantly higher level of effort in following areas:

a. Communicating the likely impact of AMT to all plant staff.

b. Emphasizing team work and group activities.
c. Having multi-skilled production workers.
d. Pre-installation training for all project participants.

Therefore, it is recommended that these elements be viewed as integral part of organizational planning process of adoption of AMT. In addition, the more successful AMT adopted had exhibited significantly higher level of effort on the following operational activities:

a. Establishing multidisciplinary implementation teams
b. Establishing multidisciplinary planning teams
c. Considering likely impacts on customers
d. Considering likely impact on suppliers
e. Top management involvement.

OVERALL CONCLUSION

The advent of AMT has given manufacturing organization a new dimension on which to compete. Product-base competition must not be driven by cost alone. In 21st century, management must move beyond cost and quality as the only dimensions on which to compete. Agility, quick responses to customer needs, timeless in all manufacturing activities necessitate the use of time as a new metric or dimension for competition.

In order for organization to be more flexible and responsive to customer needs, it is necessary that proper environment for implementing AMT is created. For the environment to exist, we suggest the following:

a. Top management must be convinced about the synergistic impact of these technologies.
b. The motive for implementing AMT should be of a strategic nature.
c. The integration of these technologies beyond the design of the product.

The implementation of AMT is a complex process whose success depends on myriad aspects of the organization structure, systems (formal & informal) culture and environment.

There is also growing consensus that many of the failures in adopting AMT are, in fact, due to inadequate planning for, and/or faulty implementation of the systems. The key to successful AMT planning and implementation appears to be choice of an appropriate manufacturing systems and the attainment of an organizational infrastructure that will offer maximum support to the chosen system. The achievement of desired benefit from AMT requires systematic and integrated operational planning prior to the adoption of new systems. Such planning requires the identification of likely product and the matching of these products with efficient AMT processes. In addition the processes should be matched with the organizational structure and worker's skills to allow for organizational infrastructure changes, which might be needed prior to adoption of the technology. Closer working relationship among all functions of the organization will be required.

Finally, planning for AMT must be seen as a critical step in the implementation process if up front planning for the operational and organizational aspect of the AMT project is performed, the likelihood of encountering installation will be greatly reduced. Management to continuously meet organizational objectives and determine when the adoption of an innovative technology is warranted can use the three stages that we propose in this paper

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