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Advanced Manufacturing Technology: The Perceived Impact on Producer's Value

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ABSTRACT

The purpose of this study is to determine which AMT has the greatest perceived impact on producer's value and to identify which AMTs has been most successfully employed. The study population consists of senior manufacturing executives in electrical and electronic firms located in the northern region of Malaysia. The study addresses the senior manufacturing executives' perceptions on how well specific AMTs have achieved the expectation of the firms implementing them. They are selected as respondents because of their understanding of the technology and their effects, and because as top manufacturing decision makers, their opinions are likely to shape the future technology of the organization. This study found that the type of AMT that perceived the greatest impact on producer's value is Flexible Manufacturing System, due to its high effects on two dimensions of producer's value: quality and cost while Just-in-Time is found to be the most successfully employed AMT among respondents. The findings of this study are significant as they contribute to the AMT literature especially in the context of Electrical and Electronic firms.

Keywords: advanced manufacturing technology, producer's value

1. Introduction

Competitiveness has made organizations to make a continuing attempt to improve manufacturing. These improvements include meeting the needs of customer, increasing volumes of output, improving product quality and reducing product costs. For a manufacturing company, Advanced Manufacturing Technology (AMT) is the answer. AMT, according to (ACARD, 1983), as any new technique which, when adopted is likely to require a change not only in manufacturing practice, but also in management systems and manufacturer's approach to the design and production engineering of the product. These technologies can improve quality through emphasis on quality of design and can affect cost through emphasis on value engineering.

However, does technology have any value if it is not applied? Many researchers believe that science and technology are crucial to produce globally competitive products (Sower and Abshire, 2003; Jayarama et al, 2010). But developing a competitive advantage in the global marketplace depends less on the ability to develop new science or technologies than on the ability to apply and continually refine those innovations. Many researchers are of the opinion that the lack of competitiveness of some industries is attributable to failure to apply the best available product and process

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technologies (Lepkowski, 1991; Sower and Abshire, 2003). But using technology to build a competitive advantage is difficult (Clark, 1988). Simply 'throwing money' or technology at the problem is sufficient, and may account for the estimated 50-75% failure rate among manufacturing firms when implementing AMT (Sower and Abshire, 2003). Research is beginning to uncover the factors which determine the success or failure of the application of technology where technology can not only confound a previously well organized operation but also incur high running costs and a long payback time (Thomas and Barton, 2007).

Thus, this paper seeks to determine which AMT has the greatest perceived impact on producer's value, and to determine which AMT has been most successfully employed. The study undertook an empirical investigation to answer this research question by investigating the usage of AMT in electrical and electronic firms and by identifying the most highly adopted AMTs among the various types of AMTs available. This study also sought to investigate which AMT has the greatest perceived impact on producer's value and which AMT has been most successfully employed. The findings of this study could serve as guidelines of firms who intend to implement AMT.

2. Literature Review

AMT is used as an umbrella term to describe a variety of technologies which primarily utilize computers to control, track or monitor manufacturing activities, either directly or indirectly. Technologies such as Computer Numerical Control (CNC) machine tools, Computer Aided Design (CAD), Computer Aided Process Planning (CAPP), Electronic Data Interchange (EDI) and Flexible Manufacturing System (FMS) all involve the use of computer to control tools and machines, store product information and control the manufacturing process. In addition, "technologies" or programs which do not directly involve computers are also considered to be AMTs since they are closely associated with other AMT technologies (Boyer, 1994).

Even though, there are many different definitions of AMT, the key to AMT is effective operational decision-making and control. Thus, AMT is the use of a potentially wide variety of techniques, some based on new machine technologies, whose implementation represents a real challenge to a company and whose objective is to provide increase in long-term profitability through some mixture of improved quality and cost reduction (Harrison, 1990).

AMT has been heralded as a new way for manufacturing companies to gain a competitive advantage (Pagell et al, 2000). The dramatic developments in AMT at various organizational levels could be attributed to numerous benefits that improve the competitive position of the adopting companies. AMT impact is not just manufacturing, but also the whole business operations, giving new challenges to a firm's ability to manage both the manufacturing and management aspects.

Each technology offers its own basket of different operational, strategic and marketing capabilities; firms always seek technologies from various technology types that can achieve a desirable set of technical capabilities. The evolving complex or sometimes simple system or technologies are expected to produce synergetic operational results that will allow adopting firms to improve their performance through achievement of their various manufacturing, marketing, business and strategic objectives (Small, 2006; 2007). Thus, implementing an appropriate technology is necessary to gain performance targets of the manufacturer or the so called 'producer' and improve manufacturing operations.

Due to this, previous studies have compiled lists of advanced manufacturing technologies that are found to be dominant in realizing the benefits promised. (Saraph and Sebastian, 1991). list of advanced manufacturing technologies omitted several key technologies (e.g. CIM, CAM, automated inspection, MRP, JIT). (Barlas, 1991), list of 12 advanced production technologies omitted CAD, CAM, JIT, CIM, and FMS. Voss (1988) listed only six AMTs (CAD, CAM, CAD/ CAM, FMS, Robots and MRP). Drawing upon these classifications, and using the broadest definition of technology (Shenhar, A, 1996; Sower and Abshire, 2003), this study defines the technologies given in Table 1 to be advanced manufacturing technologies. The types of technology listed in Table 1 is based on the list that has been studied in Malaysian manufacturing firms (Noori, ,1990; Rohani, 2006).

Table 1. Types of AMT

Type of Technology	**Abbreviation**
Just-in-time manufacturing	JIT
Manufacturing resources planning	MRPII
Computer integrated manufacturing	CIM
Robotics	Robot
Computer aided manufacturing	CAM
Flexible manufacturing systems	FMS
Flexible manufacturing cells	FMC
Bar code inventory tracking	BARCODE
Computer numerically controlled machining	CNC
Computer aided design	CAD
Automated process monitoring	APM
Automated process inspection	API
Automated material handling	AMH
Closed loop process control	LOOP
Statistical process control	SPC
Surface Mounting Technology	SMT

2.1 The Conceptualization of Producer's Value

Value is the widest term to be used, and can cover overall economic and operational aspects. Generally, discussing and measuring value provide two main goals- first, to connect company goals and objectives for improvements and second, to set targets for improvement activity. Together, these help focus energy and activity and increase the impact of any improvement initiative to gain performance target set by the manufacturer or the so called 'producer', by improving manufacturing operations. To be able to improve producer value effectively, it is important to identify those producer's values that should be particularly addressed. Hence, in their quest to survive and succeed in a highly competitive global market, organizations today are forced to produce quality products at a very low cost. Thus, given the competitiveness-related pressures, many organizations continuously seek ways to simultaneously improve productivity and quality. The desired outcome is to provide the customer with the highest quality product or services on time and at the lowest cost as possible (Goldhar and Deshpande, 1999).

Firms that previously focused almost exclusively on lower costs have adjusted to focus places just as high and often higher premiums on quality and cost. Adjusting to these changes is often made easier through adoption of advanced manufacturing technologies (AMT). These systems represent a wide variety of modern, mainly computer-based system which provides adopting firms with the potential to gain earlier entrance to market, respond more quickly to changes of customer need and offer higher quality products with lower cost (Small, 1998)(2006,2007).

In practice however, firms appear to be judging the success of their system on the achievement of a few important benefits. (Jaikumar, 1986) and (Inman, 1991) found that many of the firms that reported successful implementation of AMT were not exploiting the full benefits offered by the AMT. According to (Mohanty, 1998) and (Mtotywa, 2007), to remain competitive organizations need to integrate and synergize both cost and quality where both these dimensions are considered as critical value that must be managed by the producer.

According to (Oxford, 2007), producer can be defined as a person who deals with the business side of organizing or a person or company that makes or grows something. In the context of this study, the producer can be referred to as a person or company that makes something which is the product while value is in the mind of beholder. According to (QDI, 2007), the customer defines value not the supplier or producer. The producer can determine what is valuable to the customer by consistently selling customers' things that have no value. (As the old saying "You will be able to fool some of the people all of the time and all the people some of the time", but that's not a way to stay in business). In this situation, the producer plays a role by interpreting the customer value into product development. Thus, it is really important for the producer to clearly define what type of 'value' must be created and retained.

Defining value is not an easy task for the producer. What is most critical is that a company's decision makers have a collective understanding of what is customer perceives as value and what the company should do to increase value. Many scholars said that value is formed by the relationship between quality and price; for instance, the higher the quality, the higher the value; the higher the price, the lower the value. A product or service maybe relatively low quality, but because it is also very cheap, it may be of good value. Likewise, a product or service may be expensive and still will be of good value because its quality is very high.

A product with no defect does not imply that the customer will buy it. If the customer perceives that the product does not meet his or her needs, then it matters little to him that the "objective" quality is good. Because marketer must deal with customer perceptions, the relevant domain is psychology rather than engineering. Value is about perception, both quality and costs are often perceived as value that must be emphasized by the producer to gain competitiveness in the business (Sower and Abshire, 2003). Thus, these two dimensions are used to operationalize the concept of producer's value.

2.2 Technology and Success

Voss (1988), proposes two levels of success in implementing AMTs: technical success was measured in terms of the degree to which the AMT achieved its intended objectives. Business success was measured as the degree to which the technical benefits translated into competitive gains in the marketplace. This lends credence to the argument that the key to derive value from a technology is in the application rather than in the discovery of that technology. Therefore, the use of technology champion which is determined by the user is a good way to assess the successful and the failure of AMT application.

3. Methodology

The survey was conducted to investigate and to identify the most widely used AMT in the electrical and electronic firms in Malaysia for the purpose to identify which AMT has the greatest impact on producer's value and to determine which AMT has been most successfully employed. The questionnaire and structured interview were used to obtain information regarding the types of AMT used and the factors of producer's value. The population list for this survey consisted of 65 electrical and electronic firms across the northern region of Malaysia which is taken from Federation of Malaysian Manufacturer (FMM) directory. Finally, a total of 48 usable responses were obtained for data analysis.

4. Data Analysis

Based on the result obtained, it was found that Computer Aided Design (CAD) was the most frequently used AMT, with 39 firms were found to be users of this type of technology with approximately 81% from total respondents. The second highest AMT being used is Just-in-Time (JIT) and Automated Process Inspection (API); with 36 firms were reported to be users of both types of AMTs. Four other AMTs (MRP II, CIM, AMH and SMT) were used at least by half of the respondents. Forty percent or less of the respondents used nine of the AMTs: APM, FMS, FMC, BARCODE, CAM, CNC, LOOP, SPC and ROBOT. From the results obtained, it was found that ROBOT had the lowest usage; only 3 firms were reported to use ROBOT in their operations. The distribution of AMT frequency is presented in Table 2.

Table 2. Frequency of Reported Use of AMTs

Advanced Manufacturing Technology	Frequency	% Using
1. Just-in-time manufacturing (JIT)	36	75
2. Manufacturing resource planning (MRP II)	33	69
3. Computer integrated manufacturing (CIM)	25	52
4. Robotics (Robot)	3	6
5. Computer aided manufacturing (CAM)	13	27
6. Flexible manufacturing systems (FMS)	15	31
7. Flexible manufacturing cells (FMC)	15	31
8. Bar code inventory tracking (BARCODE)	14	29
9. Computer numerically controlled machining (CNC)	13	27
10. Computer aided design (CAD)	39	81
11. Automated process monitoring (APM)	17	35
12. Automated process inspection (API)	36	75
13. Automated material handling (AMH)	25	52
14. Closed loop process control (LOOP)	5	10
15. Statistical process control (SPC)	5	10
16. Surface Mounting Technology (SMT)	21	43

4.1 The Impact on Producer's Value

To test the impact of AMT on producer value, mean comparison from data analysis is used. To achieve this, AMT that have been selected as successful by the firm is used to test their impact on producer value. From the result, it can be seen that mean scores of all selected AMTs fall between 3.5 and 4.3. In other words, the impact of AMTs on producer value is favorable as expected. The result also indicates that there is no extreme value for the mean.

Based on the results shown in Tables 3 and 4, we can assume that most of the selected AMT are found to be favorable to producer value, among all; Flexible Manufacturing System (FMS) is found to be the type of AMT that has the greatest perceived impact on producer value with mean score of 4.3. The score indicates that FMS gives favorable impact on producer value.

Based on the result of individual score on each dimension of producer's value (cost and quality), FMS gives very favorable impact on product cost with aggregate means score of 5.0 and favorable impact on quality with aggregate means score of 3.5.

Table 3. The Impact of AMT on Producer's Value

AMT	Mean	N
JIT	3.7917	16
MRPII	3.8667	5
CIM	3.6250	4
FMS	4.2500	6
FMC	3.7500	6
API	3.7500	6
SMT	3.5000	5

Table 4. Individual Score of Producer's Value

AMT	**Cost**	**Quality**
JIT	4.15	3.44
MRPII	4.33	3.40
CIM	3.59	3.67
FMS	5.00	3.50
FMC	4.11	3.39
API	3.83	3.67
SMT	4.00	3.00

5. Results

The findings demonstrate that Flexible Manufacturing System (FMS) has the greatest impact on producer's value among all AMTs. This AMT significantly affected both dimensions of value (cost and quality). Exclusively, the technology affected very favorable on product cost and favorably on product quality.

The finding is in conjunction with the findings of (Norman, et al, 1998) and (Ali and Khan, 2010). His findings has been suggested that the only way in which the advanced industrial nations can maintain competitiveness in traditional and new manufacturing industries if they adopt technically advanced manufacturing systems that is capable of providing customized products with high quality at a very low cost tailored to their consumers' requirements . Such advanced manufacturing system (AMT) is the so called 'Flexible Manufacturing System' (FMS) that can be defined as:

> "*a production unit capable of producing a range of discrete products with a minimum of manual intervention*"
> *(US Office of Technology Assessment, 1984).*

This AMT is found to significantly reduce the operating costs, unit cost and the set-up cost of switching product specification and change dramatically the ways in which firms (and economists) should think about markets and market serving. Thus, it is not surprising for FMS in this study to have a very strong impact on product cost. And as expected, FMS also gives a strong impact on product quality in the aspect of reducing scrap and rework, increase product quality and error free; findings similar with the study conducted by (Goldhar and Jelinek, 1996) that reports that the introduction of FMS by a single firm can be expected to give it a technological and quality advantage over its more specialized competitors. One reason why organizations tend to emphasize on cost and quality is improvements on cost and quality do create corresponding improvements in productivity by reducing unit cost, errors, scrap, rework, and operating cost. Moreover, organizations that have succeeded in improving productivity, cost and quality have typically used AMT such as FMS. Just-in-(Gudgel et al, 2004) Time (JIT) is found to be the most successfully employed AMT, since the technology has been the most frequently selected by the respondents as such. The finding is not surprising since JIT is found as the second type of AMT that has been widely used by the respondents because of its intangible benefit and promised performance. This finding is also aligned by the findings reported by (Blackburn, 1991), wherein he reported that JIT is the most reliable system that can fulfil most of its promised benefits. Due to this, it is keen to be adopted by many manufacturers to reveal the potential benefit offered and thus it is not surprising for JIT to be recognized as the successful AMT from the respondent's perception.

Blackburn also suggests that just-in-time (JIT) approach is likely effective in manufacturing firms such as manufacturing that falls into electrical and electronic industry. JIT can provide the firms with the flexibility and speed essential to meet global competition, and the expansion of these principles throughout the firm's product delivery system could result in a powerful competitive tool and gives major impact on producer values.

The evolution of JIT has also contributed to the advancement of time-based competition and successful implementation. (Abegglen and Stalk, 1995) state that:

> *"The JIT system is the key relieving the ever-present tension between the desires of the marketing organization and the manufacturing organization. The marketing organization seeks greater variety in the product line to pursue growth and higher margins. The manufacturing organization resists*

> *increasing variety because the complexity of the plant is compounded: run lengths shrink, inventories swell, and costs rise. But JIT sharply reduces the impact of product line diversity on production costs, thus enabling the marketing organization to obtain needed products at a low incremental cost".*

According to (Mechling et al, 1995), the adoption of JIT is one way to respond to this growing need for greater product quality and lower cost in manufacturing. Generally, JIT applies primarily to repetitive manufacturing system which can be found in electrical and electronic industry processes in which the same products and components are produced over and over again. The general idea is to establish flow processes (even when the facility uses a jobbing or batch process layout) by linking work centers so that there is an even, balanced flow of materials throughout the entire production process, similar to that found in an assembly line. To accomplish this, an attempt is made to reach the goals of driving all inventory buffers toward zero and achieving the ideal lot size of one unit.

6. Conclusions and Recommendations

This study offers several contributions to the AMT literature. Specifically, the results of this study provided both theoretical and practical implications. First, this study presents the theoretical and empirical research regarding the usage of AMT across Electrical and Electronic firms in northern region of Malaysia and its impact on producer values.

In Malaysia, there is insufficient research dealing with AMT. This study contributes to the development of reliable information on AMT usage across northern region of Malaysia. Secondly, this study suggests that for Electrical and Electronic firms in Malaysia to be successful in their AMT implementation, they need to fully understand them before they decide on investing in such technologies and finally, it is expected that these findings will serve as an input to AMT future studies.

7. Suggestions for Future Research

Although this study has presented a statistical analysis on AMT usage in Electrical and Electronic firms, it could not cover all the important issues in this field. An area of particular importance to be addressed in future research is that certain AMTs are more appropriate for certain industries than others; for instance, AMTs in Electrical and Electronic industry might be different than those in automotive or in high volume industry. Thus, it is recommended that a comparative study could be conducted between different industries. It is further recommended that a similar study could be conducted using a wider scope of companies and more industry representations to determine if there are differences in the frequency of use and the impact of each AMTs on producer values. This would further strengthen the claim of the most successfully employed AMT.

In addition, researchers can use the findings presented in this study as a basis for further studies on AMT. The framework presented in this study can also be extended to explain the impacts of other AMTs on producer's values.

Furthermore, it is recommended that with appropriate funding, a similar study could be designed to incorporate on-site interviews as a back-up for a more robust data collection procedure for analysis. This would give the researcher an opportunity to get some reactions and a more robust data from diverse groups of people who might have experience on AMT.

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