Advanced Manufacturing Technology Implementation On Industries

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ABSTRACT

With the advent of advanced manufacturing systems new modifications have been introduced in the working environment. Several areas including economics as well as engineering have benefited a lot from this drastic change. Similar to that of the technical aspects, the human factors has played a key role in the advancement area. And these factors have resulted in the fructification of many new systems. Hence, prior to the design of a flexible manufacturing system, the technicians' management and the unions should be aware of the entire alternative to design the same.

01. Introduction

What the keys are that allow the greatest benefits to be obtained from investments in advanced manufacturing technologies (AMT) and that contribute to maintaining and improving the competitive position of investing companies is a question that is still open to research; and not only for scholars of operations management, but also, and more especially, for company management and for the public authorities whose objective is the strengthening of the capacity for innovation within their industrial fabric. A number of studies (Krafcik 1988, Matthews and Foo 1991, Swamidass and Kotha 1998, Cagliano and Spina 2000) conclude that AMT investment alone does not lead to great improvements in a firm's performance if innovation does not extend to organizational and strategic issues. It would therefore seem to be necessary to determine which other activities and factors affect the performance of investments that have been made, such as investments in infrastructure for example (Boyer et al. 1997, Jonsson 2000).

Key words:- Advanced manufacturing technology, implementation, investments, infrastructure, organization, factors, manufacturing, Management support, improvement, planning

02. Key factors

02. 01.Strategic adjustment factors

(1) Explicit operations strategy
(2) Clear objectives for automation
(3) Strategic investment analysis
(4) Investment/strategic plan co-ordination

02. 02.Infrastructure factors

(1) Appropriate financial and accounting techniques
(2) Integrated inter-functional communication
(3) Previous experience
(4) Staff versatility

02.03.Technical organizational adjustment factors

(1) Technical feasibility analysis
(2) Study of impact on organization

(3) Systems integration plan

02. 04. Planning factors

(1) Implementation plan (2) Supplier support (3) Creation of multifunctional work team
(4) Presence of a leader or person in charge (5) Personnel training

02. 05. Motivation factors

(1) Management support and commitment (2) Worker motivation (3) Appropriate rewards

Regarding the specific factors that should be considered at each stage, more than a decade has gone by since the initial surveys were carried out [a broad compilation of works carried out since the beginning of the eighties can be found in Meredith (1987b)]. However, the latest surveys still highlight the very same problems that were prevalent at that time, namely a lack of strategic far sightedness, and planning and integration (A´ lvarez Gil 1995), to a greater or lesser degree. After studying the experiences of companies located in a wide variety of industrial countries all round the world, and with different records as far as industrialization is concerned, Burcher et al. (1999) in effect concluded that there are many more similarities than differences in the actions taken when implementing AMT.

A total of 19 different factors have been identified although, as yet, no conclusive results have been reached regarding the degree to which they have a positive effect on the result of investments in the factories where AMT were implemented. There are various reasons for these diverging results. On the one hand, there is the undeniable lack of empirical studies and this is exacerbated by the fact that even though a response rate of not less than 50% is usually recommended (Flynn et al. 1990), this is rarely achieved. On the other hand, the studies that have been conducted do not usually cover the complete adoption and implementation process . This means that to achieve an overall picture of the process it is necessary to resort to studies with extremely different objectives and conducted using different methodologies (Machuca and Sacrista´ n Dıaz 1998). These two defects — the lack of studies with a wide sample-base and the lack of studies which provide a complete working framework — are accepted as the norm by a range of authors, both in literature specifically dealing with innovation implementation (Klein and Sorra 1996, Vokurka et al. 1998), and that dealing with generic studies of practices in the area of operations (Bolden et al. 1997).

Nevertheless, more ambitious projects with a wider scope would probably have a negative effect on the response rate as longer questionnaires would be required which would, presumably, be more complex to fill out. It would seem that two of the issues that are still pending are the finding of a balance, and an increase in company participation.

The 19 factors presented above have been grouped into five categories depending on their characteristics and using grouping criteria similar to those found in other studies (Udo and Ehie 1996, Boyer et al. 1997, Small and Yasin 1997, Co et al. 1998):

- Strategic adjustment factors relating to how much consideration is given to investments on the strategic side of company planning and operations, and to the ability of the company to appreciate the strategic advantages afforded by AMT.
- Factors related to infrastructure. These are

basic conditions and technical and management support mechanisms which should be available if AMT are to be implemented successfully.

- Technical and organizational adjustment factors. This includes all the factors that are aimed at analysing and guaranteeing the compatibility of the new technology with existing assets in the company.
- Planning factors. Activities that the company must do and conditions that it must guarantee throughout the whole AMT adoption, implementation and control process.
- Motivational factors. Related to the degree of personal interest the workers and management might show in the planned AMT investment.

However, it is not only important to discover which factors are critical, but also to take into consideration the point in time they are applied, that is, during which stage of the adoption and implementation process they are taken into account. If we therefore take the factors presented above and analyse the studies in which they are highlighted, they can be grouped together on the basis of whether they are actions to be taken during the adoption phase (such as, for example, strategic analysis, the technical feasibility analysis and the implementation plan) or the other activities that are initiated during implementation (such as staff training and motivation or supplier support). Other features or circumstances are, however, specific to the company making the investment which, while possibly facilitating investment in advanced technologies, need not have been motivated by any specific project (amongst these are included an explicit operations strategy, appropriate accounting techniques and previous experience).

Nevertheless, the dividing line between the stages is not always clear-cut since it is not always easy to limit some of these factors to a single part of the process. To give an example: the commitment of the management team to the project is crucial during the whole of the adoption phase, as this will allow it to be taken on board from a strategic point of view. But, moreover, it will still be of vital importance during the implementation phase which follows, when it will continue to be of use in supporting the rest of the personnel involved. We agree with other authors (Schroder and Sohal 1999) when we state that this issue requires further study, and we shall attempt to go into as great a detail as the study's population size allows. It is the factors that are taken into account, at whatever point-in-time that may be, that are the starting point for determining their possible positive effect both on the performance of investments and of factories. We therefore formulate the following hypotheses:

H1: The presence of certain factors during AMT adoption and implementation has an effect on the performance of investments.

H2: The presence of certain factors during AMT adoption and implementation has an effect on the performance of factories.

If we accept the premise that companies in the Andalusian aeronautical sector behave in a rational way, as stated by Salas (2001), that is, that actions are under- taken in such a way as to maximize opportunities for benefits in whatever way these are perceived by the various companies, it should be expected that more effort and resources are devoted to achieving the consolidation of those factors that are believed by these companies to have a greater impact on the performance of their investments; they should also be expected to choose investment options from those that are available to them that

would, presumably, result in greater organizational performance.

03. Methodology

Population and data gathering the target population is made up of manufacturing plants that were operating in Kerala during the period in which the field work was carried out. Some factors led us to consider that conducting the empirical analysis in the manufacturing sector would be particularly interesting and opportune: being extremely technologically intensive and, as such, a potential user of a wide and diverse range of AMT, this sector is strategically important, not only for Kerala, but also for India as a whole. The target population covered three plants belonging to the L&T Group and seventeen small and medium-size ancillary companies who supply. In view of the small number of companies, we decided to study the entire population, achieving a 100% response rate.

The inclusion of the L&T factories in the analysis was essential if we were to be able to analyse the whole population. The fact that they all belong to one business group does not distort the results. Although final approval had to be gained from central management, the technical strategy was totally independent for each factory, not only as far as team selection was concerned, but also with regard to team-member evaluation (as was confirmed by the heads of the Engineering Department).

The analysis of the research project within which this specific study is encompassed has a relatively wide scope. The basic objective of the study is to determine the types and extent of AMT being used in the sector and for determining the performance of the plants in relative terms and a postal questionnaire was sent out for this purpose.

In order to avoid another long period of time compiling responses to the survey and prevent possible problems in interpretation, it was decided to conduct personal interviews for the completion of the questionnaires; this decision was helped by the relatively small number of plants in the population. The questionnaire was sent out beforehand so that respondents could familiarize themselves with its content well before the interview. On this occasion, the process of data collection took less than three months. In most of the smaller ancillary companies, it was the managing director/owner who completed both questionnaires, an advantage that cannot usually be guaranteed in this type of study when the only contact is via mail. It was the engineering manager or assistant engineering manager who attended the interviews at the larger factories.

Measurement of variables: Three types of AMT have been distinguished following the most widely used criteria in research (Boyer and Pagell 2000, Kotha and Swamidass 2000) according to their function or the type of activity in question: design, manufacturing and planning.

As previously stated, the 19 key factors taken into account in AMT adoption and implementation have been theoretically grouped into five main types according to the focus of their effect: strategy, corporate infrastructure, technical and organizational issues, planning, and motivation of personnel. The small number of plants in the population studied led us to analyse all these factors independently in order to test the hypotheses formulated. The effect of each factor on the process was measured on the Likert seven-point scale (1 = very negative effect; 4 = no effect; 7 = very positive effect).

As in other studies on this subject (e.g. Gupta et al.

1997), we have approached the measurement of investment performance on two levels: one approach is by gauging the degree of improvement obtained in the tactical and operational aspects that the plant managers had identified as the principal objectives of the investment. The usual indicators were used to measure strategic operations objectives (Corbett 1996, Roth 1996, Boyer and McDermott 1999, Boyer and Pagell 2000, Ward and Duray 2000), although the opportunity was also provided for other objectives not included in this list to be added (a complete list is available in table 6 below).

It was discovered during the interviews that the companies in question were not excessively clear about what benefits they hoped to derive from the investments they had planned. For Design AMT, only 37.5% of the user plants were able to point to as many as three specific benefits they expected to obtain after making the investments. This percentage increased to 60% for Manufacturing AMT and 41.7% for Planning AMT. These results were obtained only after much insistence, as many companies stated that they had invested simply because they had to, which indicates that the investments had not been wholly thought through beyond the strategic obligation of survival. On this basis, a maximum of three performance indicators have been considered for each plant. The indicators have been measured on the Likert seven-point scale (1= considerable deterioration; 4 = no change; 7 = considerable improvement).

The second approach was to measure plant performance by means of four indicators, two related to growth (market share and sales) and two to profits (ROI and ROS); the validity of these indicators is supported by previous empirical studies (Boyer et al. 1996, 1997, Gupta et al. 1997, Ward and Duray 2000). For each indicator, the position of the company compared to its competitors over the past three years was measured on a Likert scale of seven points (1 = significantly worse; 4 = similar; 7 = significantly better).

The fact that this scale had been previously validated in other research — as advised by some (Malhotra and Grover 1998, O'Leary-Kelly and Vokurka 1998, Hensley 1999) — led us to expect, a priori, high levels of inter-item reliability. As a measure of the inter-item reliability of scales, we have employed Cronbach'scoefficient, which is by far the most extensively used. Our _ value results can be seen in table 3 and in both cases these are notably higher than the 0.7 level usually required for well-established scales (Nunnally 1978, Flynn et al. 1990, Hair et al. 1999).

The validity of the scale was measured by means of content validity. As the use of statistical tools is impossible (Hoskisson et al. 1993: 217) any evaluation of content has to be based on the expert judgment or on references in the literature as to whether the scale in question truly measures the concept or construct for which it was developed. This measurement is therefore by nature subjective and, as such, will always be arguable. The content validity in our research has been checked using previously developed scales, as is recommended by various authors (Flynn et al. 1990, Malhotra and Grover 1998, Hensley 1999).

Table1. Performance: scales and reliability coefficients.

Scale	Objectives	Mean	SD
Growth	Market share growth	5.15	1.31
(α = 0.8645)	Sales growth	5.45	1.19
(Scale)		5.3	1.17
Profit	Return on Investment (ROI)	4.95	1.08
(α= 0.9596)	Return on Sales (ROS)	4.74	1.04
(Scale)		4.84	1.04

As far as the point in the process when each factor

is taken into account, three possibilities have been distinguished: exclusively during the adoption stage, exclusively during the implementation stage, or during both stages, that is, throughout the whole process.

04. Data Analysis

The testing of hypotheses was performed by applying the t statistical test to independent samples. As the complete population is involved, it must be pointed out that the objective of contrasting cannot, by nature, be inferred. It is also important to highlight the fact that the relatively small size of the population does not affect the significance of the contrasts, as the statistics take the size of the sample into account. The SPSS 10.0 statistical program was used for data analysis.

05. Results

Table 2 shows firstly, and in descending order, the proportion of companies that have taken into account each of the key factors when adopting and implementing AMT. Secondly, it shows the point when these factors are taken into account indicating the number of plants (and percentage) that considered them: before acquisition, i.e. exclusively during the adoption process (column A); after acquisition, and therefore solely during the implementation and following control process (column I); or both before and after acquisition, that is throughout the whole of the adoption and implementation process (column AþI). Possessing previous experience is a factor that companies decided not to take into consideration at any time; put bluntly, either they had or they had not previously invested in similar technologies.

This factor was therefore not included in this point. With regard to the first issue, the relevance of personnel versatility is of note, as are the support and commitment of management. These are present in all the plants that employ AMT. Next come personnel training and supplier support, which figure in almost 95% of the plants. Equally notable is the appearance of an explicit operations strategy in the group of six factors that are least present: only nine of the 19 plants that use AMT, that is to say, less than half the population (37.5% in the case of ancillary small and medium-size companies) stated that they had such a strategy. This is a considerably smaller number of firms than those who stated they had a strategic business plan (65%). This would seem to suggest that, at the very least, the sector's business strategies are lacking, as they do not include the field of operations in their development plans. Another point of interest is that only 11 of the companies that employ AMT stated that they coordinated investments they made in these technologies with previously devised strategic plans. If we again turn our attention to the percentage for ancillary companies, we find that it stands at 50%, which means that the remaining 50% make their investments outside the framework of strategic planning. There is a patent need for greater awareness and training in this respect.

Table 2 Degree to, and point at which, factors considered to be key to AMT adoption (A) and implementation (I) are taken into account

	Do plants take into account the factor?		Point at which the factor is considered		
Factor	Frequency (%)		Frequency (%)		
	Yes	No	A	I	A+I
Staff versatility	19 (100)	0 (0)	4 (21.0)	3 (15.8)	12 (63.2
Management support and commitment	19 (100)	0 (0)	3 (15.8)	0 (0.0)	16 (84.
Personnel training	18 (94.7)	1 (5.3)	2 (11.1)	10 (55.6)	6 (33.3)
Supplier support	18 (94.7)	1 (5.3)	3 (16.7)	5 (27.8)	10 (55.5
Worker motivation	16 (84.2)	3 (15.8)	3 (18.8)	4 (25.0)	9 (56.2)
Presence of a leader or person in charge	16 (84.2)	3 (15.8)	0 (0.0)	1 (6.2)	15 (93.8
Clear objectives for automation	14 (73.7)	5 (26.3)	7 (50.0)	0 (0.0)	7 (50.0)
Strategic investment analysis	13 (68.4)	6 (31.6)	11 (84.6)	0 (0.0)	2 (15.4)
Inter-functional integration	13 (68.4)	6 (31.6)	1 (7.7)	0 (0.0)	12 (92.
Previous experience	13 (68.4)	6 (31.6)	-	–	–
Implementation plan	13 (68.4)	6 (31.6)	9 (69.2)	2 (15.4)	2 (15.4)
Investment/Strategic plan	11 (57.9)	8 (42.1)	11 (100)	0 (0.0)	0 (0.0)
Multifunctional work team	10 (52.6)	9 (47.4)	0 (0.0)	0 (0.0)	10 (100
Explicit operations strategy	9 (47.4)	10 (52.6)	6 (66.7)	0 (0.0)	3 (33.3
Appropriate financial and accounting techniques	9 (47.4)	10 (52.6)	4 (44.4)	1 (11.1)	4 (44.4
Technical feasibility analysis	8 (42.1)	11 (57.9)	7 (87.5)	1 (12.5)	0 (0.0)
Study of impact on organization	7 (36.8)	12 (63.2)	4 (57.1)	2 (28.6)	1 (14.3
Systems integration plan	7 (36.8)	12 (63.2)	4 (57.1)	1 (14.3)	2 (28.6
Appropriate rewards	6 (31.6)	13 (68.4)	2 (33.3)	3 (50.0)	1 (16.7

The question now is whether it can be stated that the point in the process when the factors were taken into account had any effect on the extent to which they bore influence on it. Table .3 has been drawn up to try and answer this question. It shows the influence each factor had per group of companies according to the time it was taken into consideration.

As can be seen, the averages per factor are relatively similar for each group. This suggests that what is important for the analysed population is the factor itself, and not the point in the process the factor is taken into account. However, the limited amount of data does not allow us to go into any deeper analysis. On the one hand, the number of elements in each group is in many cases limited to a single company— those where the typical deviation has not been calculated, which is indicated by a — whereas in others, the point where they are taken into consideration is always the same.

Table 3. The influence of key factors according to when they were taken into consideration

	Influence		
Factor	Adoption mean (SD)	Implementation mean (SD)	A + I mean (SD)
Explicit operations strategy	5.67 (1.36)	–	6.00 (0.00)
Clear objectives for automation	6.00 (1.29)	–	5.71 (0.48)
Strategic investment analysis	5.82 (1.40)	–	6.50 (0.70)
Investment/Strategic plan co-ordination	5.54 (0.82)	–	–
Appropriate financial and accounting techniques	4.50 (1.00)	5.00 (–)	5.25 (0.50)
Inter-functional integration	–	6.00 (–)	5.83 (0.93)
Staff versatility	5.25 (0.95)	5.00 (1.00)	5.75 (1.21)
Technical feasibility analysis	5.43 (1.13)	6.00 (–)	–
Study of impact on organization	5.00 (1.15)	6.5 (0.71)	7.00 (–)
Systems integration plan	5.75 (1.50)	7.00 (–)	5.00 (0.00)
Implementation plan	5.00 (1.00)	4.50 (2.12)	5.50 (0.71)
Supplier support	5.33 (1.15)	6.00 (0.71)	5.60 (1.89)
Multifunctional work team	–	–	5.60 (0.84)
Presence of a leader or person in charge	–	7.00 (–)	6.20 (0.67)
Personnel training	7.00 (0.00)	5.50 (1.43)	6.33 (0.51)
Management support and commitment	6.33 (0.57)	–	6.37 (1.25)
Worker motivation	5.67 (1.15)	6.25 (0.50)	6.22 (0.83)
Appropriate rewards	4.50 (0.71)	5.67 (0.57)	7.00 (–)

It is, therefore, impossible to make any definite statement on this question. It can be noted, however, that some of the averages obtained approached the mean value of the scale (4) very closely, which implies that the perception that companies have of the influence borne by some factors is not overly positive. A mark of 4 indicates that the corresponding factor was present, but that it did not facilitate the introduction of AMT into the company in any way. On some occasions the mark even falls below the mean value, which means that the factors in question were thought to have had a negative effect on the process of introducing a technological asset into the company. This is the case of supplier support, for example. This means that there were cases where, in the opinion of the company acquiring the AMT at least, a bad relationship with the supplier, or a negligent attitude on the supplier's part, made the launch of the equipment more difficult. Answers were also received that barely hid feelings that an

implementation plan and training of personnel had a negative influence, which would seem to lack sense. In the specific case of personnel training, the executive we consulted stated that the problem was to be found in the point when said training was done — after the equipment had already been installed in the factory — and he regretted not having been able to train the workers before start-up. As for planning, in some cases the problem arose from the point in time it was done: during the implementation process; this was too late and only after it had been realized that it was necessary to draw up an action plan. In other cases the problem was caused by the way it was done: in one particular case the problem was that the planning had not been done properly, and this caused more drawbacks than advantages. Although these examples cannot be used to generalize, they do nonetheless help to illustrate how important it is to consider the key factors in an appropriate way as well as the point in time when they are to be taken into account.

Table.4 shows results for the objectives that guided each type of AMT investment

Goals or expected benefits	Design AMT		Manufact. AMT		Planning AMT	
	Freq.	%	Freq.	%	Freq.	%
Fast introduction of new products	13	36.1	2	5.7	1	3.8
Improvement in utilization of capacity	4	11.1	1	2.8	5	19.
Consistent quality with low rate of defect	3	8.3	7	20	2	7.7
Fast deliveries	1	2.7	1	2.8	1	3.8
Meeting promised delivery dates	1	2.7	6	17.1	7	26.
Offer a wide range of products	1	2.7	3	8.6	–	–
Fast changes in designs	3	8.3	–	–	–	–
Reduce production costs	5	13.8	6	17.1	4	15.
Reduce lead times	–	–	3	8.6	1	3.8
Offering high performance products	1	2.7	1	2.8	–	–
Supply of reliable products	2	5.5	1	2.8	–	–
Establishing a culture of quality	–	–	1	2.8	1	3.8
Increase in labor productivity	–	–	2	5.7	1	3.8
Improvement of work environment	–	–	1	2.8	–	–
Fast changes in volume	–	–	–	–	1	3.8
Improved budget control	–	–	–	–	1	3.8
Reduction in inventory	2	5.5	–	–	1	3.8
Number of responses	36	100	35	100	26	100

05. 01Goals for investments in the factories in the population.

Table 6 shows results for the objectives that guided each type of AMT investment. As can be seen, the main advantage the companies that invested in design AMT expected was an increase in new product development, basically, flexibility. The remaining advantages that were expected are equally spread between operational advantages relating to costs and quality. Only two responses indicated that the main objective sought was faster delivery times or meeting delivery dates. For benefits expected from manufacturing AMT, the main objectives were a reduction in production costs, consistent quality and meeting delivery dates, as well as a few other issues relating to flexibility, such as the ability to offer a wide range of products or the speed with which new products are developed. As for the benefits expected from investments made in planning AMT, the responses seem to point to delivery. Nevertheless, other objectives related to reductions in costs are prominent, such as an explicit reduction in production or an increase in the utilization of capacity.

Additionally, the results for the population demonstrate that the expected benefits or objectives that prompt investment in AMT vary depending on the type of technology in question. Investments in design AMT are therefore mainly aimed at greater operational flexibility, which usually comes down to the faster development of new products. Investment in manufacturing AMT is relatively evenly spread between benefits related to costs, quality, flexibility and even delivery. Finally, the motives behind investments in planning AMT seem to be related to meeting delivery dates and costs.

Table 5. Performance of investment in AMT
(degree to which expected benefits were obtained).

Variable	AMT	N	Mean	SD	Minimum	Maximum
AMT investment Performance	Design	15	6.01	0.74	4.67	7
	Manufacturing	14	6.33	0.73	5	7
	Planning	12	5.94	0.57	5	7
	Total	19	6.08	0.52	5	6.83

05. 02.Goal achievement: investment performance

Table 2. shows average investment performance according to the three types of AMT, i.e. design, manufacturing and planning. It is worth noting that average investment performance is similar for all three types of AMT. The lowest value is 5.94, which is quite high on a scale of seven, and corresponds to AMT investment in planning. This would seem to suggest that the companies are, in general terms, quite or very satisfied with the performance obtained from the investments that were made. Another point that supports this view is that the lowest minimum value is 4.67 points (see table 7) for the performance of AMT investments in design. Although this figure is not overly high, it is still above the four-point average for the scale and therefore implies there has been an improvement in the factors that were measured, albeit not a great one. This positive opinion of investments (in no cases were they regretted and none performed negatively) could have erred a little on the positive side because they were, in general terms, limited and incremental. There are indications in other studies (Shepherd et al. 2000) that the more radical the investments are, the poorer is the perception that is had of them. Nevertheless, it must not be forgotten that the figures were gauged on the Likert seven-point scale and based on the opinions of interviewees rather than objective data. Although this is regarded as the lesser of two evils for empirical studies on this subject, it must be borne in mind that the responses received in this way do suffer from certain subjectivity.

Contrasting hypotheses T-tests were performed on independent samples in order to contrast the hypotheses formulated that the presence of certain factors during AMT adoption and implementation affects investment performance (H1) and plant performance (H2) the results of which can be seen in table 2.6.With respect to H1, it would appear at first sight that the performance of investment in AMT in this sector is independent of the presence or absence of the great majority of factors that literature has considered to be key to investments of this type. This can be explained to a large extent by taking into account the fact that, in general terms, all the companies in the sector are, as seen above, either quite or very satisfied with the performance achieved by the investments that have been made. There is, nevertheless, at least one factor which allows a partial acceptance of the proposed hypothesis: personnel training. The analysis does, in effect, allow it to be accepted ($p<0.05$) that investments in AMT made in plants that have conducted personnel training have performed better. Bearing in mind that this performance has been considered satisfactory by the majority of companies in the sector (see table 3), the relationship found can be seen to have a highly explanatory nature, whereby it can be stated that training of personnel is revealed to be a key factor in determining the success of investments in AMT in this sector. Other studies obtain results that confirm the importance of this factor: Guimaraes et al. (1999) note that despite the fact that an increase in a system's complexity can have a negative effect on performance; this negative effect can be mitigated by training operator

Table 6.Relationship between investment performance, growth and profit and factors considered to be key (t-test of independent samples, $p<0.05$).

Key factor	Investment performance		Growth		Profit	
	t	p - Value	t	P- value	t	p - Value
Explicit operations strategy	0.065	0.949	–1.336	0.199	–1.196	0.249
Clear objectives for automation	1.027	0.319	–0.963	0.349	0.079	0.938
Strategic investment analysis	0.297	0.77	–0.119	0.906	1.445	0.168
Investment/Strategic plan co-ordination	0.535	0.6	–1.019	0.322	0.287	0.778
Appropriate financial and accounting techniques	–0.255	0.802	0.071	0.945	1.036	0.316
Inter-functional integration	1.721	0.135	–0.535	0.599	1.445	0.168
Previous experience	0.213	0.834	2.513	0.022	0	1
Staff versatility	–	–	–	–	–	–
Technical feasibility analysis	–0.201	0.843	0.02	0.984	0.293	0.773
Study of impact on organization	–0.479	0.638	–0.230	0.821	0.515	0.613
Systems integration plan	0.714	0.485	–0.031	0.975	1.479	0.159
Implementation plan	0.325	0.749	–1.955	0.067	–0.399	0.695
Supplier support	1.545	0.141	0.317	0.755	–0.155	0.878
Multifunctional work team	0.006	0.995	0.314	0.758	0.214	0.833
Presence of person in charge	–1.546	0.14	–0.992	0.337	0.287	0.778
Personnel training	2.178	0.044	–0.546	0.592	0.792	0.44
Management support and commitment	–	–	–	–	–	–
Worker motivation	1.464	0.162	0.319	0.754	0	1
Appropriate rewards	0.443	0.664	–0.715	0.484	0.227	0.823

With this relationship established, the effect key factors have on company performance (H2) is now analysed, the results indicating that the only relationship that is significant in a statistical sense is that between previous experience and business growth.

This relationship might draw attention to their possibly being a certain learning effect (Salas 2001), which translates into a better implementation of new investments and, consequently, into better investment performance as measured through growth. It may also be deduced that it is specifically those companies with a greater rate of growth and which are in the middle of a period of expansion that invest more and, therefore, have a greater chance of having previous experience

when acquiring new AMT. This would, in turn, facilitate the appearance of the aforementioned learning effect.As far as profit is concerned, it cannot be deduced that taking into account any of the key factors has any affect at all, either positive or negative. This highlights the fact that business performance is conditioned by circumstances other than investment in AMT as such, or, in other words, it is not enough to invest in AMT for there to be an increase in profit. This situation is prevalent amongst small Spanish companies in fairly general terms (Gonzo´ lees et al . 1999). It could therefore be said that the adoption of AMT is an essential requirement for remaining in the sector, and that it is, therefore, an order qualifier, whilst at the same time, when linked with the presence of a certain learning effect, it also serves to achieve the objective of greater growth.

06. Conclusions

This analysis allows the statement that the versatility of staff and the support and commitment of management are factors that factories in the Kerala manufacturing sector take into account to a greater extent when adopting, implementing and controlling their investment in AMT. The second group of factors, in order of importance, includes personnel training, supplier support, having a person in charge of the project, and motivation of the workforce. In view of these facts and the results obtained it could be stated that factors related to human resource management, such as versatility, training, motivation and leadership, are the factors that companies perceive as being the most important for achieving their objectives.At the other end of the scale are to be found the implementation of appropriate rewards, a study of the impact on the organization and the development of an integrated systems plan, a technical feasibility analysis, having an explicit operations strategy and the use of appropriate financial and accounting techniques.

At the same time, this analysis shows that those

companies that have undertaken training of their personnel present greater performance on investments in AMT. These results support the hypothesis that of all the factors mentioned in the literature as conditioning success, only the human factor can mark a difference between those companies that are successful and those that are less so. At the same time, our working premise would seem to have been confirmed, showing the rationality that exists in manufacturing firms in Kerala. As such, the results obtained do not allow that investments made in AMT are, by themselves, a means for increasing profit, even though investments in certain AMT seem to be indispensable for the survival of many companies in the sector. This situation could be characterized as a case of incremental innovation driven by a demand that could lead to an increase in innovative capacity and future participation in R&D efforts if it were backed up by an appropriate business.

07.References

1. Beatty, C.A., 1993. Critical implementation decisions for advanced manufacturing technologies. Int. J. Technology Management, Special issues on Manufacturing Technology: Diffusion, Implementation and Management 8 (3/4/5), 189-196.
2. Beaumount, N.B., 1997. Technology, manufacturing performance and business performance amongst Australian manufacturers. Technovation 17 (6) , 297-304.
3. Bessant, J., 1993. The lessons of failure: learning to manage new manufacturing technology. Int. J. technology Management 8 (2/3/4), 197-215.
4. Chen, J., 1994. Implementation Advanced Manufacturing Technology: an integrated planning model omega. Int. J. Mgmt. Sci. 22 (1), 91-103.
5. Efstathiades, A., 1997. Modeling the Implementation of advanced manufacturing technologies in the Cyprus manufacturing Industry. PhD thesis, Brunel University, UK.
6. Rush, H., Bessant, J., 1992. Revolution in three-quarter time: lessons from the diffusion of advanced manufacturing technologies. Technology Analysis and strategic management.