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THE EFFECTS OF COMPANY SIZE, OWNERSHIP AND INDUSTRY SECTOR ON AMT ADOPTION: AN AUSTRALASIAN STUDY

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ABSTRACT

In this paper the influence of company size, company ownership and industry sector on the planning and implementation activities for advanced manufacturing technologies (AMTs) in Australasian organisations is statistically assessed. The research instrument was a postal questionnaire which covered the decision areas in AMT proposal generation, assessment and implementation. The 132 respondents were the personnel most actively involved in the planning and implementation of AMT investments in their respective organisations. The statistically significant effects are presented and we suggest plausible explanations for these effects. The main conclusion of this study is that the effects of company size and ownership on AMT adoption are significant in a number of key technology management areas. The effects of industry sector, however, are fewer. We propose that a implication for managers from these findings is in the benchmarking of, or identification of "best practice", AMT management practices. The study highlights that the best AMT practices are not confined to one particular industry or type of company (size, ownership or industry sector).

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INTRODUCTION

The selection, implementation and management of Advanced Manufacturing Technologies (AMTs) is an increasingly important aspect of the responsibility of managers in all types of organisations. AMTs refer to a family of technologies which includes computer-aided design and engineering systems, material resource planning systems, automated materials handling systems, robotics, computer-controlled machines and computer integrated manufacturing systems. Through programmed flexibility these technologies allow a variety of products to be manufactured with minimal change-over and set-up disruption, maximising both flexibility and production.

The benefits of AMTs are both tangible and intangible and depend on the particular AMT and its application. Studies conducted in the 1980s showed that most firms failed to achieve overall strategic benefits from the AMTs introduced. For example, in a study of CAD implementations Currie (1989) found that most firms aimed at achieving narrow operational benefits. Similarly, Voss (1988) found that, although all the companies had claimed "technical" success with their AMT implementation, just over half of the companies studied had achieved benefits from their AMTs in terms of flexibility, reduced lead-times, improved quality and customer responsiveness. Zammuto and O'Connor (1992) came to the same conclusion from their study of a number of firms which had adopted AMTs. They noted that (1) a significant proportion of companies had increased productivity, (2) fewer appear to have increased flexibility, and (3) many firms reported failure, gaining neither productivity nor flexibility benefits from their AMTs.

The difficulties that many organisations encounter in their adoption of AMTs are largely related to a lack of understanding, by managers and researchers alike, of the effects that AMT investments can have on a specific organisation. Company size, ownership and industry sector are useful characteristics which may help to explain key differences and patterns of management practices. The significant effects of these variables on aspects of company operations in previous studies support our focus on these variables with regard to AMT adoption. In 1989, research studies addressing the planning and implementation of AMTs were conducted in Australia (Sohal, Samson et al. 1991) and the United Kingdom (Sohal 1994). The results of the Australian survey indicated a number of significant relationships between both company size and ownership and AMT management practices. Larger companies were found to be more likely to invest in AMT and Australian owned companies invested significantly less and were more likely to invest to overcome skill deficiencies. In addition, surveys on quality management practices of Australian (Eisen, Mulraney et al. 1992) and Canadian (Kohse 1994) manufacturing firms indicated that company size and industry sector were key determinants in the use of QM practices.

In 1993 the study on the planning and implementation of AMTs referred to above was repeated in Australia and extended to New Zealand. This forms the empirical basis of this paper. Initially analysis has focussed on a direct comparison of New Zealand and Australian AMT management practices (Sohal, Putterill et al. 1994). The main conclusion was that there were few differences between the two countries except for differences with respect to the speed of investment and the nature of investment. However, the effects of company size, ownership and industry sector on AMT investment were not investigated in the comparison of the two countries because the number of firms responding to the survey was not sufficiently large enough to perform the statistical analyses required.

The identification of the "best practices" in technology management requires research which addresses how different types of companies manage their AMT investments and which management approach is more successful.

OBJECTIVES

The central objective of this paper is to empirically gauge the influence of company size, ownership and industry sector on the process of AMT adoption. This objective arose out of some more general questions and perceptions regarding AMT adoption. These are listed below.

Company size

- Do larger companies perceive themselves to have different strategic requirements and anticipate different benefits and difficulties from investing in AMT compared to their smaller counterparts?
- Does the large capital expenditure associated with many AMT investments deter smaller companies from investing and what are the implications?
- Are AMT decision making processes in small companies different from large companies?

Ownership

- Are foreign owned companies more aggressive or competent in their investment and implementation of AMTs?
- Do foreign owned companies have different expectations from an AMT investment?

Industry sector

- Are AMTs applicable to all industry sectors?
- Are the benefits of AMTs similar across industry sectors?
- Are certain industries 'leading the way' in the adoption of AMTs?

THE AMT SURVEY

The research instrument comprised a postal questionnaire which focussed on the four stages involved in AMT investments:

- proposal generation
- proposal assessment
- implementation of the selected technology; and
- post implementation audit.

During September and October 1993, questionnaires were mailed to manufacturing companies in Australia and New Zealand. Seventy five Australian and fifty seven New Zealand based companies (both representing a response rate of 20%) responded giving a total of 132 Australasian companies. The respondents were the personnel most actively involved in the planning and implementation of AMT investments in their organisation. They ranged across several management levels from CEOs to Production or Information Systems managers.

PROFILE OF COMPANIES SURVEYED

Only the profiles by company size, ownership and industry sector are included. Other profile characteristics can be provided upon request.

Company size

Figures 1 and 2 show the size of companies by annual sales revenue and by number of employees. For analysis of the effects of company size, the grouping of the companies into small, medium and large is as shown in Figure 1. Annual sales is used in this paper as the measure of company size. As is to be expected, there is a significant relationship between companies with large annual sales and a high number of employees.

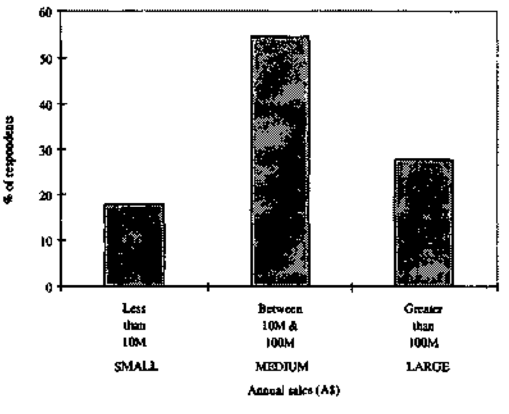

Figure 1: Sample classified by annual sales

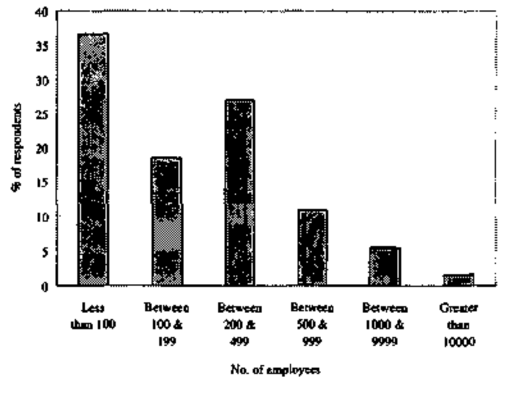

Figure 2: Sample classified by no. of employees

Ownership

Most of the companies in the sample are Australian or New Zealand owned (71%) (see Figure 3). However, there are enough companies in the sample to establish the effects of foreign ownership on the investment processes. American and British ownership each account for around 10% of the respondents, 3% of companies reported Japanese ownership and the remaining 5% indicated 'other' ownership, primarily Asian.

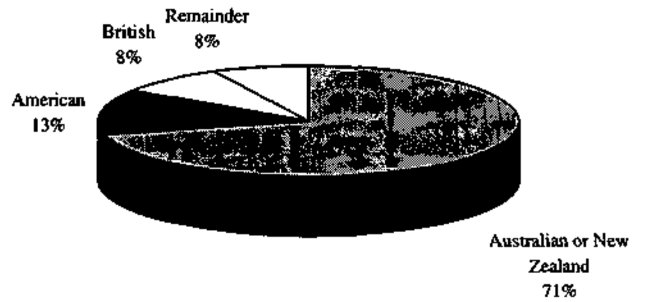

Figure 3: Sample classified by ownership

Classification by industry

The classification of the sample by industry sector is shown in Figure 4. The companies were widely distributed across a number of industries. However, the metal manufacturers, food and chemical industries were particularly well represented. The sample has been regrouped into broader industry categories so that there are enough respondents in each group to allow statistical testing. This regrouping is also shown in Figure 4.

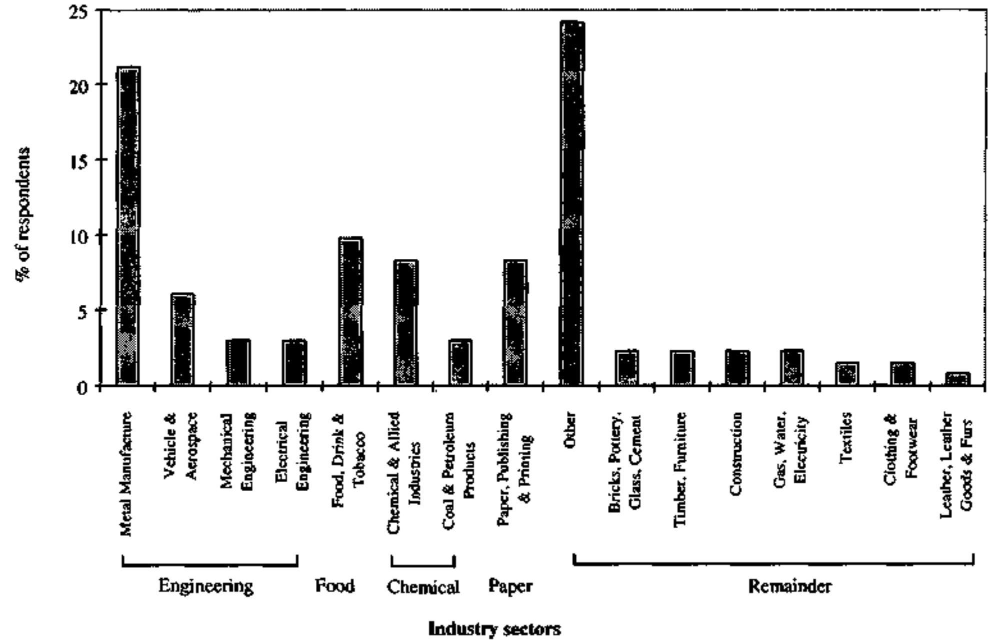

Figure 4: Sample classified by industry sector

AMT ADOPTION: SURVEY RESULTS

This section briefly reports the survey responses for the key management areas of the AMT investments that will be analysed in terms of company size, ownership and industry sector. While the raw responses of the management processes are interesting in themselves, detailed discussion is not included here as these were reported and discussed in Sohal, Maguire and Putterill (1994).

Nature and size of the investment

Figures 5, 6 and 7 show the nature of the AMT investments made by Australasian companies. The technologies were divided into computer hardware, computer software and plant and equipment and the respondents indicated the investments made in each of these three areas.

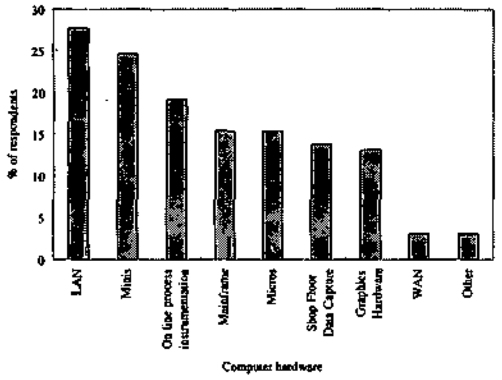

Figure 5: Nature of investments in computer hardware

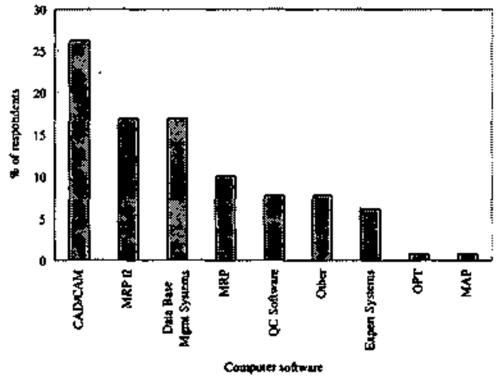

Figure 6: Nature of investments in computer software

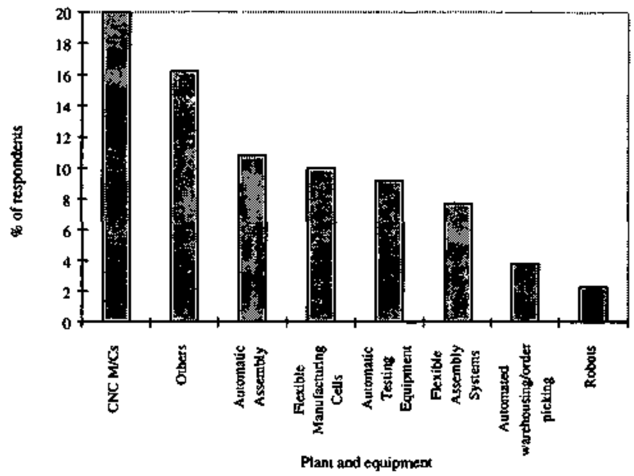

Figure 7: Nature of investments in plant and equipment

The size of the single largest AMT investment in the last three years is shown in Figure 8. Because over half (54.3%) of the respondents indicated that their company's largest investment was less than half a million dollars, this variable was regrouped into smaller and larger investments to enable statistical analysis.

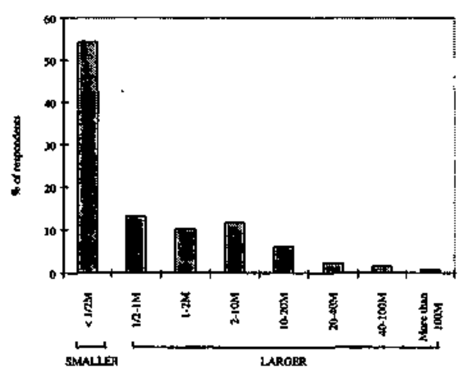

Figure 8: Size of the largest AMT investment in the last three years

Generation of the AMT investment idea

Figure 9 shows the area from which the AMT investment idea was generated. Over half (54.5%) of the respondents indicated that the investment idea was in part generated from the production function.

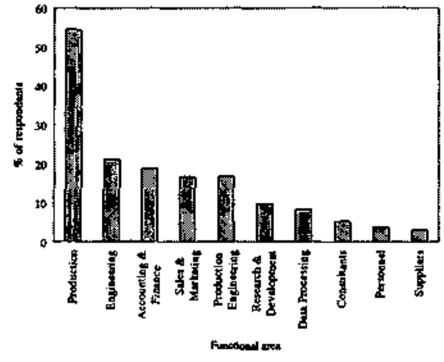

Figure 9: Generation of investment idea classified by functional area

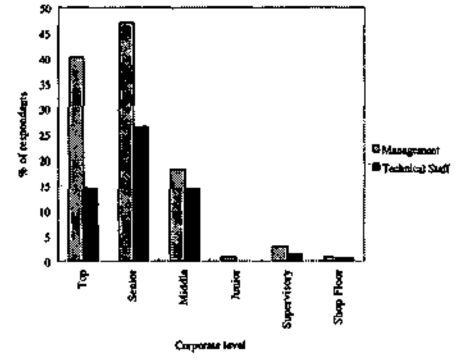

Figure 10: Generation of investment idea classified by management and technical level

The management and technical levels involved in the generation of the AMT investment idea is shown in Figure 10. The figure shows clearly that the generation of AMT investment ideas is top-down, with both top and senior management and technical levels providing the main drive in the generation of investment ideas.

Project teams

Over three quarters (77.3%) of the companies established a project team in the development of the AMT investment idea. Figure 11 shows the functional areas that were involved in those project teams. Personnel from production and accounting and finance were particularly well represented on these teams.

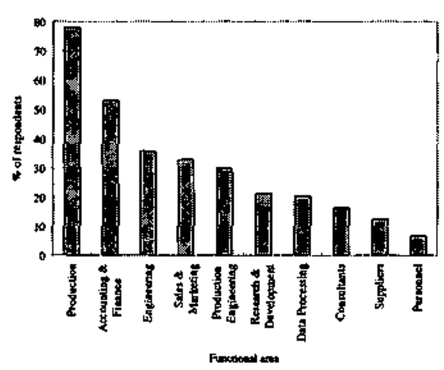

Figure 11: Involvement in project teams classified by functional area

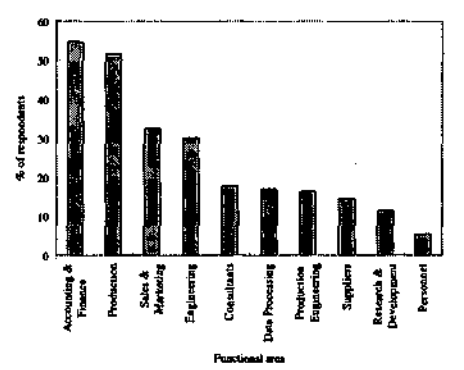

Figure 12: Management involvement in AMT proposal assessment

Involvement in AMT assessment

Figure 12 shows the extent of management involvement from different functional areas in the assessment of the AMT investment proposal. As for the project teams, management from accounting and finance and production were the main participants involved.

Elapsed time in decision making and implementation

The time that Australasian companies took to decide to invest is shown in Figure 13. The majority of companies took between three and 24 months to decide to invest. The elapsed time has been regrouped for statistical analysis into less than three months, between three and six months and more than 6 months.

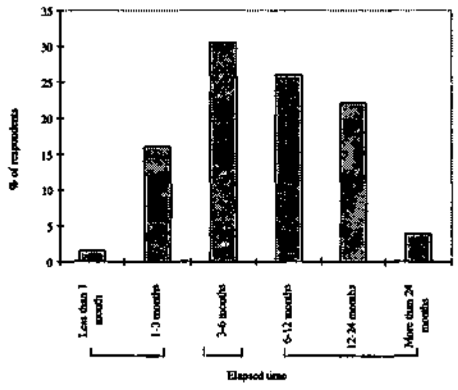

Figure 13: Elapsed time in deciding to invest

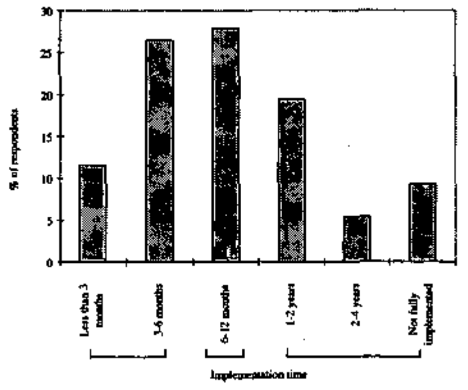

Figure 14: Time taken to implement the investment

Figure 14 shows the time taken to implement the investment. The sample responses have been regrouped into less than six months, between six to 12 months and greater than 12 months. Each of these groupings reflect approximately one third of the sample.

Expected benefits of AMT investment

The anticipated benefits of AMT investment were assessed by the respondents indicating the importance of each anticipated benefit on a five point Likert scale. Based on the mean scores, the benefits have been ranked in order of importance and are shown in Table 1.

ANTICIPATED BENEFITS	Rank	Mean score μ	Std. Dev. σ
Improved quality	1	1.854	1.121
Reduced costs	2	1.861	1.039
Obtaining competitive advantage	3	1.864	1.042
Increased throughput	4	2.107	1.230
Increased flexibility	5	2.164	1.428
Better mgmt control	6	2.258	1.226
Increased sales	7	2.470	1.230
Improved response to variation in product volume	8	2.595	1.382
Improved integration of manufacturing information systems	9	2.647	1.350
Improved response to variations in product mix	10	2.681	1.455
Reduced work in progress	11	2.708	1.368
Improved integration of information systems across functions	12	2.786	1.351
Improved workforce attitudes	13	2.815	1.157
Improved working environment	14	2.966	1.295
Reduced changeover/setup times	15	2.974	1.506
Improved ability to respond to variations in suppliers 'lead times	16	3.224	1.409
Overcoming skill deficiencies	17	3.233	1.179
Improved mgmt attitudes	18	3.250	1.264
Enhanced company image	19	3.311	1.339
Reduced product development time	20	3.319	1.428
Improved ability to implement engineering changes	21	3.353	1.286
Widening product range	22	3.376	1.484
Improved ability to respond to engineering changes	23	3.470	1.310
Overcoming production mgmt skill deficiencies	24	3.470	1.263
Better working relationships	25	3.526	1.099
Improved ability to respond to variations in suppliers' quality	26	3.595	1.285

Table 1: Anticipated benefits at the time of assessment

Scores based on a Likert scale: 1='great importance'; 5='no importance'

Anticipated risks and difficulties

Table 2 shows the anticipated risks and difficulties and the corresponding experienced risks and difficulties of AMT investment. Again, the responses are based on a five point Likert scale and the risks and difficulties have been ranked in order of importance.

RISKS AND DIFFICULTIES	Anticipated			Experienced		
	Rank	Mean score μ	Std. Dev. σ	Rank	Mean score μ	Std. Dev. σ
Disruptions during implementation	1	2.437	1.135	1	3	1.086
Adverse effect on workflow	2	2.805	1.171	3	3.316	1.016
Failure to achieve financial targets	3	3.043	1.281	6	3.395	1.128
Problems with interconnection of equipment	4	3.125	1.234	8	3.447	1.201
AMT skill deficiencies	5	3.278	1.181	2	3.242	1.146
Prod mgmt skill deficiencies	6	3.345	1.112	4	3.361	1.099
Lack of integration of Mgmt Info Systems	7	3.379	1.235	7	3.441	1.16
Lack of integration across functions	8	3.439	1.234	5	3.394	1.197
Opposition by workforce	9	3.608	1.259	10	3.917	1.131
Opposition by staff/mgmt	10	3.684	1.243	9	3.811	0.967
Obsolescence of technology	11	3.687	1.259	11	4.065	0.964

Table 2: Anticipated and experienced risks and difficulties with the AMT investment

Scores based on a Likert scale: 1='great importance'; 5='no importance'

ANALYSIS

The effects of company size. ownership and industry sector were assessed across all areas of AMT adoption. Statistical analysis to track the effects, relationships and differences consists of simple cross-tabulation analysis and chi-square tests between groups. Several questions use Likert scales to indicate level of importance or effect and comparison of the different groups via the Mann-Whitney U test (for two groups) and one-way ANOVA with Duncan's multiple range post-hoc test, confirmed by the nonparametric Kruskall-Wallis H test (for three or more groups) is the appropriate statistical analyses in these cases. Many variables have been regrouped to enable large enough group sizes to ensure statistical validity. In all statistical tests used in this paper, the probability of a Type I error (saying a difference exists when it actually does not) is less than 0.05. All references to significant relationships or differences between groups indicate that $P<0.05$. Detailed discussion of these relationships is not included in these proceedings due to space restrictions. Copies of the detailed discussion can be provided upon request.

The effects of company size and foreign ownership on AMT adoption

Summaries of the statistically significant relationships from the effects of company size and ownership are provided in Tables 3 and 4 respectively. In these tables the "+" and "-" indicate positive and negative effects respectively.

AMT ADOPTION CHARACTERISTIC			SIGNIFICANT EFFECT OF COMPANY SIZE
Nature and Size of the Investment	Investment in Computer Hardware	*On line process instrumentation*	+
		Shop floor data capture	+
	Investment in Computer Software	*Quality Control Software*	+
	Investment in AMT Plant and Equipment	*Investment in Automatic Assembly*	+
	Size of the investment		+
Generation of the AMT Investment Idea	From Top Management		+
	From Senior Management		-
	From Middle level Technical Staff		+
Project Teams	Likelihood of establishment of a Project Team		+
	Involvement from Accounting & Finance management		-
Elapsed Time in Decision Making and Implementation	Time taken to decide to invest		+
	Time taken to implement AMT project		+
Involvement in AMT Assessment	Total number of functional areas involved		+
	From Production Engineering management		+
	From Accounting and Finance, Engineering and Suppliers' technical staff		+
Anticipated Risks and Diffifculties	Opposition by workforce		+
Involvement in AMT Implementation	From Production Engineering management		+
Implementation of a AMT Training Program			+

Table 3: Summary of significant effects ($p<0.05$) of company size on AMT adoption

AMT ADOPTION CHARACTERISTIC			SIGNIFICANT EFFECTS OF FOREIGN OWNERSHIP
Nature and Size of the Investment	Investment in Computer Hardware	*Local Area Networks*	-
		Wide Area Networks	-
Generation of the AMT Investment Idea	From Top Management		+
	From Senior Management		-
Involvement in AMT Proposal Assessment	Involvement from Accounting & Finance management		-
Expected Benefits of AMT Investment	Obtaining competitive advantage		+
	Increased throughput		+
	Increased Sales		+
	Improved Management Attitude		+
	Improved Quality		+
	Improved Integration of Information Systems across Functions		+
Anticipated Risks and Difficulties	Disruptions during Implementation		+
	Problems with inter-connection of equipment		+

Table 4: Summary of significant effects (p<0.05) of foreign ownership on AMT adoption

The effects of industry sector on AMT adoption

Across all areas of AMT adoption there were six statistically significant cases of inter-industry variation:

1. Between industry sectors in terms of top management involvement in the investment idea generation. Analysis of the odds ratios indicates that the AMT investment idea is less likely to be generated by management of companies associated with the chemical industry sectors.
2. Between the industry sectors in terms of the importance of an "improved working environment" as an anticipated benefit of the AMT investment at the time of the proposal assessment. The chemical industry sectors regard an "improved working environment" as being very important while the "remainder" industry sectors regard it as the least important of the five industry groups.

3. The chemical industries are also significantly different from the manufacturing/engineering industries, also placing less importance on the benefit of "improved ability to implement engineering changes". Overall, the manufacturing/engineering industries put the highest importance on this benefit compared to the other groups.
4. Between the industry sector groups in terms of "increased throughput" as an anticipated benefit. The food industries are significantly different from the other four industry groups, placing much less importance on the benefit of "increased throughput".
5. The food industries are significantly different from the chemical, manufacturing/engineering and "remainder" industries in regard to the benefit of "reduced change-over/setup times". The food industry regarded this benefit as much less important than the other three groups.
6. Between the industry groups in terms of the benefit of "improved ability to implement engineering changes". The food industries are significantly different from the manufacturing/engineering industries and the "remainder" industries, placing much less importance on this benefit.

CONCLUSIONS

The main conclusion of this study is that the effects of company size and ownership on AMT adoption are significant in a number of key technology management areas. The effects of industry sector, however, are fewer. A useful framework for discussing this conclusion is to group the effects, or lack thereof, of company size, ownership and industry sector under the management issues to which they relate.

AMT Investment Activity

Larger companies are making more and larger investments. Smaller companies must attempt to emulate this level of activity as the benefits of AMT investments are relevant to small and large companies alike. Undoubtedly smaller companies have difficulty in securing the financial resources to invest and this does point to a potential inadequacy of the traditional financial appraisal of AMT investments. If there is a genuine opportunity for a company to significantly improve long term profitability through the adoption of AMTs, then it is imperative that, irrespective of company size, there are mechanisms in place that allow the investment to proceed.

AMT Decision and Implementation Duration

Larger companies take longer to decide to invest and implement their AMT investment. If larger companies have the financial resources to invest in AMTs, then some of those resources must be redirected to shortening the decision and implementation time. A key benefit of "market responsiveness" from an AMT investment is considerably undermined if the investment and implementation decisions take a long time.

AMT Initiative

Much of the drive to invest in AMT is significantly influenced by top and senior management irrespective of ownership, company size or industry sector. With the exception of the chemical industry, which reported less initiative of top management in the generation of AMT investment ideas compared to the other industry sectors, top and senior management are actively involved in the development of AMT investments.

Cross-Functional Involvement

The involvement of Accounting and Finance in the proposal assessment of AMT investments in foreign owned companies is higher than in Australasian owned companies. Similarly, the inclusion of Accounting and Finance in AMT project teams is higher in smaller companies. Given the limited scope of traditional cost-accounting in relation to AMT investments it is understandable that many companies are not involving Accounting and Finance personnel in AMT investment decisions. However, it is precisely because of the multi-dimensional nature of AMT investments that demands that all functional areas are involved. If the financial procedures for appraising AMT investments are to be redesigned/refined in order to accommodate the broader strategic issues of AMT investment then active involvement of all areas is essential.

AMT Implementation

Many of the differences between small and large companies can be attributed to smaller companies not having formalised procedures and processes in place and simply having fewer employees compared to the larger companies. For example, the reported differences of small companies being less likely to have project teams, less likely to implement a training program, less involvement from technical staff and less involvement from production or engineering management may simply reflect informal involvement and operating procedures. Smaller companies often do not have employees specialising in certain job areas such as technical staff and the need for specific project teams in smaller companies is either impossible or inappropriate. Also, the fact that smaller companies anticipate less opposition by the workforce in the adoption of AMTs suggests that informal channels of communication and awareness regarding the investment do exist. However, it is imperative that both small and large companies appreciate the importance of active involvement from all levels and all areas in the adoption of AMTs and move to establish formal operating procedures that ensure this involvement.

Benefits and Difficulties of AMT Investment

Australasian companies rate the anticipated benefits of increased throughput and sales more highly than foreign owned companies. Overall, Australasian firms had higher expectations from the AMT investment. This clarifies the difference in the post-implementation difficulties experienced between Australasian and foreign owned companies, with Australasian companies reporting adverse effects on workflow and bottlenecks. Perhaps in anticipating increased throughput, Australasian companies are, to a certain extent, "let down" by the throughput performance and hence the workflow difficulties. In either case, anticipating workflow requirements and planning accordingly during the AMT implementation is a key factor for successful adoption of new technology. Furthermore, the focus by Australasian companies on throughput and sales is perhaps misdirected given that the major benefits of AMTs are flexibility and responsiveness.

IMPLICATIONS FOR MANAGERS

The fact that some key differences based on ownership and company size have been identified is a reflection of the way things are, not the way things have to be. It is essential that companies should seek to achieve the "best practice" process of AMT adoption. If smaller companies are showing the best practices of AMT adoption in terms of decision making time, then larger companies should attempt to learn and change accordingly. Similarly, if the anticipated benefits and difficulties of AMT adoption by foreign owned companies are more realistic than those of Australasian companies, then Australasian companies should seek to change their perceptions. The real worth of exploring these effects of company size, ownership and industry sector is that managers and researchers alike can learn how different organisations approach similar AMT problems in different ways. Then the challenge is for managers to choose the best practice and effectively assimilate it into their operations. Managers should use information from all sources (not just direct competitor information, but from a range of different types of companies) and "fit" the best practices to their unique operation. It is hoped that this paper has provided information along these lines and it will be interesting to assess in the future if the effects of company size, ownership and industry sector do change as companies continue to learn from each other.

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