



INVESTMENT DECISIONS IN AUSTRALIAN
MANUFACTURING

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ABSTRACT

In 1996 the author conducted structured interviews with managing directors and production managers of manufacturing companies. The objectives were to ascertain the criteria firms used to make investment decisions in manufacturing technology; how (and how well) they managed the introduction of new technology; whether (after implementation) they had experienced unanticipated effects from new technology and what factors impeded or assisted its implementation. This paper discusses past work, describes the methodology, suggests a way of grouping criteria and gives some preliminary findings. The most important finding is that tangible criteria dominate decisions but that considerable intangible benefits are usually experienced.

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INTRODUCTION

Motivation

The research was motivated by:

- The observation that, although there are parallels between implementing computer systems and new manufacturing technology (the latter can be regarded as a special kind of computer), the former problem has generated a quite disproportionate literature.
- Decisions on manufacturing technology may have implications and ramifications throughout the firm (even for suppliers and customers) which cannot be adequately captured by purely financial criteria. For example, a major investment in manufacturing might incur a large fixed cost; markedly reduce variable costs; markedly increase capacity, output quality and various kinds of flexibility; change the skills required of the workforce and the demands on suppliers; allow the simplification of scheduling and organisational structures or open new markets. The intangibles may be much more important than the tangibles.

Outline

In 1996 the authors started a research project whose objectives included finding out why Australian firms invested in manufacturing technology (broadly defined), how they implemented the decisions and how (if at all) they evaluated their decisions and processes. To this end we have interviewed 16 managing directors or production managers of manufacturing companies (the interviews continue).

The Selection Process

The selection of interviewees was inevitably biased. We obtained from a commercial source a list of 800 manufacturing businesses and wrote to the managing director of a random selection requesting an interview. Very few (3%) responded and we made followup phone calls to the managing director. We obtained interviews in about 10% of cases.

Some companies evidently and rationally do not want staff to waste time talking to academics. Executives in firms which are finding conditions difficult are unlikely to bare all to an interviewer. On the other hand, some executives feel a duty to cooperate and others welcome a chance to have a broad ranging conversation whose topic is their (usually considerable) achievements. Fewer than 1% of managing directors were women.

The Economic Context

The adoption of free market philosophies in many economies is well documented. Relevant changes for Australian manufacturers are:

- Australia appears to have two economies in that some sectors (tourism, entertainment, computing and telecommunications) are growing quite strongly but traditional sectors (retailing and traditional manufacturing) are static at best.

- The reduction in tariffs from about 20% to 5%. Most interviewees agreed that tariff reduction was inevitable and a good thing for the country as a whole however painful it might be to individual companies. It has lead to greater competition from imports in most industries. Several interviewees echoed the thoughts of a textile manufacturer who opined that it was pointless competing with Chinese T-shirt manufacturers. Australian companies must compete by exploiting a more highly trained workforce, a more advanced technological base and better infrastructure to make more sophisticated products and to be more responsive.
- The variable Australian dollar. The recently rising \$A makes it more difficult to export profitably and makes imports cheaper and more competitive. The need to forecast exchange rates causes disproportionate problems in planning and the acquisition of capital goods from overseas.

Current Manufacturing Technology

Most current investment in manufacturing technology is in computerised machinery (Advanced Manufacturing Technology or AMT). The modern factory processes data as well as metal. Computerised machinery not only does what its electromechanical forebears did (and does it more quickly and accurately) but collects, stores and processes data. Exploiting this data may improve managerial control and planning.

A more subtle advantage is the ability to defer the time at which a design stored electronically on a CAD system has to be made manifest in metal and the time at which a customer's order has to be produced. To make a physical prototype incurs costs and implies that subsequent modifications become much more expensive. To actually make a customer's order implies that the customer has lost the opportunity to modify the order cheaply.

Investments in both direct and indirect technologies were included. The former are dominated by processing (numerically controlled machinery and robotics); the latter includes production scheduling software and monitoring and design and testing equipment.

PAST WORK

Many authors and a huge literature have contributed to the understanding of criteria governing decisions on investing in manufacturing technology. Several themes are evident:

1. How do firms make decisions on investment in manufacturing technology, how successful are such decisions and by what criteria should they be judged?
2. How effective are the subsequent implementation processes?
3. How should they make such decisions and how should implementation processes be managed?
4. The development of models and methodologies (often implemented as software packages or spreadsheets which purport to help managers use the methods espoused).

Underlying many of the above points is research directed to identifying, proritising and organising relevant criteria.

The Literature

An important issue in evaluating the success of an AMT investment is the criteria used to assess success, presumably business success. Should success be assessed on the basis of the firm's own criteria or on some external, objective criteria? In practice, how many firms compare the objectives with the achievements?

Amongst papers identifying criteria used by manufacturers when evaluating manufacturing investment proposals are: Kolli and Parsaei (1992) Giffi, Roth et al. (1992) Small and Chen (1995) McGaughey (1994). Nonas, Johansson et al. (1990) stress the need to consider the impact of technical change on the workforce (and social systems) and community. Gold (1989) stresses the critical role played by senior management, the need to take a long term view and the inadequacy of purely financial measures.

Many authors provide worksheets, Analytical Hierarchy Process models or computer packages which purport to help managers evaluate manufacturing investment proposals. Most of these methods allow managers to place weights on traditionally intangible factors. Dhavale (1995) recommends a scoring model which can include non-tangible factors. MacStravic and Boucher (1992) used a computer package to combine consideration of tangible and intangible factors. Putrus (1991) stresses organisational goals. Sullivan (1986) provides an AHP approach implemented as a computer package which allows the user to incorporate non-financial criteria. Badiru, Foote et al. (1991) notes the need to consider multiple criteria and provides a spreadsheet implementing an AHP model. In a case study Oeltjenbruns, Kolarik et al. (1995) used AHP methods implemented in a microcomputer program to combine consideration of tangible and intangible factors. Badiru and Raman (1992) provide an expert system advising on the implementation of robots, which takes into account the ramifications for the non-manufacturing parts of the organisation. However, Wilner, Koch et al. (1992) report that their respondents were largely satisfied with traditional, financial evaluative techniques and Davis (1992) found that an apparel company was predominantly concerned with cost savings. A model categorising risk exposure is given by Hottenstein and Dean (1992) who used a sample of 22 firms to categorise the risks inherent in AMT investment.

Geppert (1989) notes the important practical issue of the new equipment's compatibility with existing systems. If the production line comprises a sequence of machines, upgrading one machine may not improve some measures of performance such as throughput. Major benefits of investment may not appear until all machines have been upgraded. Somewhat similar views are advanced by Van Blois and Andrews (1983). Howie (1984), in discussing the requirements of the factory of the future with a systems emphasis, stresses the need for communications and the need to integrate manufacturing functions with management information systems.

Rolland (1985) opines that the full exploitation of new technology (a prerequisite to competitive products and prices) requires that "executives become systems thinkers", radically change their organisations' cultures, and eliminate batch processing and thinking based on it. Bessant (1993) emphasises that the failure of some AMT implementations may be attributable to a failure to consider strategic factors. Honeycutt, Siguaw et al. (1993) assert that adopting Flexible Manufacturing Systems increases flexibility and that this change has ramifications throughout the organisation especially for its competitive position and strategy. Beatty (1993) unsurprisingly finds that firms which plan for AMT are more likely to have successful implementations. Shani, Grant et al. (1992) note that the implementation of AMT is likely to induce a large change in the organisation's structure and culture. The slow rate of introduction of such systems and sometimes disappointing results may be attributable to failure to consider the effects on and of sociotechnical systems. Thomas and Wainwright (1994) note "a range of organisational and management problems

which prevent many organizations from gaining advantage" from CIM. They examine implementation "as a social and political process, in which strategic objectives are sometimes obscured by functional, professional and individual interests". Organisational implications are also discussed by Duimering, Safayeni et al. (1993) who again point out that new technology embedded in old structures and systems is unlikely to be fully exploited.

How successful are these decisions and implementations? Project success is discussed by Bessant (1994). Zairi (1992) finds that successful AMT implementation is partly attributable to the competence and support of AMT suppliers. Beatty (1992) studied the implementation of CAD/CAM technology, again finding that social and organisational factors materially affected success. Saraph and Sebastian (1992) note that "US firms are, however, experiencing a 50%-75% failure rate when implementing AMT, mainly due to their neglect of critical human resource factors" and that "Managers must consider these factors and devise workforce strategies that are consistent with the AMT environment. The introduction of AMT in the organization has the potential to radically change the individual and social environment of the workplace". Maguire, Putterill et al. (1994) note that Australasian managers found it difficult to say whether their firms' AMT investments had been successful or not.

Is it possible to improve the models now available? Models (some of which are merely categorisations) of and methods for managing the investment and implementation process have been proposed by several writers.

de Haan and Peters (1993) undertook a Delphi study to determine expert opinion as to the critical factors relevant to investing in AMT.

THE INVESTIGATION

The Questionnaire

A copy of the questionnaire used with managing directors is available from the author; a variant was used with production managers. Some questions were, in practice, dropped because they proved to be irrelevant. The questionnaire covered the following areas:

- A background section sought information about the company, in particular what it made, its ownership structure (a public company, private company, partnership or family business) its size, whether it was profitable or not and what the outlook was.
- The identification of a particular investment decision worth discussing (we preferred to discuss an investment which had taken place in the last two years) and the interviewee's role in the decision. In some cases it was possible to repeat the interview with a second investment.
- The criteria used to decide amongst investments and whether a particular investment proposal should proceed. Tangible and intangible criteria were sought. Under the former we sought details of the methods used (ROI, NPV, payback period etc), hurdles and some elucidation of how the associated forecasts of cash flows were obtained. We asked whether intangible criteria were considered (we suggested improved quality, greater variety, shorter delivery times, simplification of processes and structures, strategic and competitive advantage, and better information and managerial control).

- The implementation of the new technology, in particular: whether there was a project team or whether it was considered a routine part of the production manager's job, the involvement of consultants, suppliers, customers and the workforce.
- The human aspect. Did the investment entail stress or change for the workforce, in particular, did the interviewee see a need to change e.g. from theory X to theory Y?
- A retrospect. We asked whether the project's ramifications had been thought through; for unanticipated factors which helped or hindered the implementation; whether there had been a formal post implementation review; whether the investment had been successful or not and whether it had been fully exploited.

Responses

Some of the most interesting responses are given here.

The companies interviewed varied markedly in size (A\$1M to \$500M turnover), style (the bigger companies especially were professionally managed but smaller companies' managers seemed to exhibit more enthusiasm) and industry sector. The sectors covered included petroleum exploration and production, food, textiles (woven, non-woven and dying), pharmaceuticals, several general engineering firms, vehicle makers, printers, a newspaper, a prefabricator of hotel room fittings and a car components maker. Most companies had at least flirted with exports.

Triggers An idea is often discussed for months prior to it being seriously considered. Why does the idea suddenly get managerial attention?

Skilled tradespeople can nurse old machinery to produce varied output of competitive quality. Their retirement may force a firm to resort to NC machinery to produce the same quality and variety.

Two firms had to invest in a new factory. The first, successful, firm did so because the signing of an abnormally large order meant that it had to triple its output. The second firm, a food manufacturer, did so partly because it found it increasingly difficult to meet quality and hygiene requirements in an old factory and partly because a new owner had a somewhat suitable empty building and could sell the fairly well located old factory for a modest profit.

Tangible Criteria Used For almost all respondents, the first criterion was financial. Most used some kind of cash flow analysis, most commonly discounted rate of return. Most large firms had hurdles (a payback period of three years and a ROI of 30% was typical) and tended to express success in terms of high rates of return. This is partly attributable to large firms' formal systems. Senior managers require quantitative estimates of an investment proposal perhaps because they need to compare different, otherwise hard to compare, proposals from different business functions.

Smaller firms' decisions give the appearance of being forced on them, typically by demand outgrowing their capacity or (in two cases) a foreseen need to meet a competitor's superior or cheaper product. In large companies, decisions are filtered by cash flow considerations (whatever the private reasoning of the proposer) whereas smaller companies seem to be more influenced by outgrowing old capacity and the need to preserve competitive advantage.

Attitudes to investments are affected by firm size. A small firm's bad investment decision might be fatal whereas a large firm's portfolio of projects insures it against disaster.

Intangible Criteria When investment decisions are made, intangible criteria are not given much weight but almost all respondents mentioned, with approbation, the intangible benefits experienced when the new machinery is installed. The frequencies of kinds of intangible benefits are summarised in table 1.

Table 1. A summary of intangible criteria

Criterion	Times mentioned	Interviewees' comments
Higher quality	10	A prerequisite to survival especially in exporting or meeting competition from imports.
Flexibility	4	
Shorter delivery times	5	Including better delivery performance (assisted in one case by use of EDI).
Better managerial information and control	4	Automatic collection of statistics.
Simplified structure, scheduling and/or processes.	7	Moving from MRP to JIT, flatter structures.
Environmental friendliness	2	Being able to use a mechanical instead of chemical process.
Reduced dependence	2	Eliminating outsourcing and associated delay and uncertainty.
Working environment	2	Safer (fewer compensation claims) and more scope for workgroups.

ANALYSIS

After considering existing models, we arrived at a framework (fig 2) based on Earl (1989 p 170 Table 8.2).

Figure 2. A Framework for Assessing New Production Technology

Aspect	Goals	Challenges	Measurement techniques
Cost and capacity	Efficiency and satisfying demand	Choosing the right IRR and accurate forecasts	NPV and forecasting
Flexibility	Rapid reaction to the market and minimal costs of flexibility.	Forecasting and implementing the kinds of flexibility required, e.g. new product development, switching between products etc (Upton (1994) is especially interesting).	Measures of responsiveness such as those implicit in Time Based Competition and the cost of flexibility
Quality	Minimal internal and external quality costs	Internalising the TQM philosophy	Customer satisfaction, external and internal costs of quality
Organisational	Simple structures and procedures	The replacement of MRP scheduling by JIT. Minimising the hidden factory. Simplifying interfaces between other functions, external parties and the factory. Changing cultures to align with new production technologies.	Indirect costs and overheads. Reaction times. Measures of staff satisfaction.
Strategic and Competitive	Domination of existing markets and entry to new markets	Exploiting advantages given by new technology	Strategic planning techniques. New business proposals.

EXAMPLES OF TECHNOLOGY

We saw and discussed many interesting technologies. Some cases are worth mentioning. One job shop had acquired a mixture of machinery some of which could be numerically controlled. The proprietor had not bothered to exploit NC capability partly because he wanted apprentices to gain experience.

A maker of woven garments employed an artist who "painted" designs on a 17inch computer screen. Once a design had been agreed on, the design could be transferred from the design computer to a knitting machine. When the right coloured wools had been loaded, the design could be knitted with little further human intervention.

A third manufacturer had invested \$A3.5M in a sequence of eight machines acquired from eight different sources. He was having predictable difficulty integrating the machines. When the

machines work together, he will reap enormous benefits; in particular, he will stop using environmental sensitive chemicals.

CONCLUSIONS

Australian manufacturing is amazingly diverse. It was personally rewarding and fascinating to see vibrant businesses, learn about a variety of manufacturing processes one did not know existed and be privy to the justification of investment decisions.

The most striking conclusion from this preliminary research is that intangible benefits are given little formal attention in decisions on investments in manufacturing technology; proposals must be justified in terms of financial criteria. However, after the decision is made, the intangible benefits are much appreciated.

Small manufacturers have a different, less formal, approach. Some proprietors affect to "suck it and see" or pretend to work in casual, even slapdash ways. Such affectations imperfectly conceal some acute intelligences. In some cases forecasting was based on managers keeping up-to-date through a wide range of contacts.

Because it is hard to predict, than the changing exchange rate is more of a worry than reductions in tariffs.

The introduction of new technology coincides with and probably speeds movements from "theory X" to "theory Y" and increases in product quality.

We propose to modify our interview structure and do interviews in at least 40 companies. We would like to interview different participants in the one decision.

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