Technology strategy in the Australian manufacturing industry: An empirical investigation of its position

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Abstract
A mail survey of manufacturing firms was conducted across Australia to investigate the degree of emphasis put by them on technology strategy. The study found that the emphasis on technology strategy ranked fifth from the top in a mix of six other organisational strategies. It is also perceived that the emphasis on technology strategy is going to increase further in the next few years but the ranking will remain unchanged. The study also investigated the level of effectiveness of technology strategy along with other strategies. The results indicate that technology strategy ranks the second after operations strategy in terms of its effectiveness in spite of its low emphasis relative to other organisational strategies. Within the technology strategy, in-house development of technology has received the highest level of emphasis followed by acquisition of new technology by firms which have adopted differentiation or focus generic strategies. The firms with cost leadership generic strategy, however, tend to put more emphasis on new technology acquisition. The respondents’ perceptions also suggest that in-house development of technology has been the most effective strategy in the past. An investigation of the relationship between technology strategy variables and organisational performance indicates that there are few significant correlations between sales growth in domestic market and use of CIM, FMS, and CNC machines. The correlations, however, are weak.

Introduction
Technology plays an important role in lowering the production/distribution costs, lowering the costs for buying and selling, and more precise targeting of customers to businesses (Chen, 2001). Technological change, globalisation, customisation and industrial restructuring have been the dominant features of the business environment in the last 10-15 years (Clegg and Clarke, 2001). Consequently, there has been a massive transformation in various business attributes during this period (Dow and Parker, 2001). To cope with the changing environment, gain and sustain competitive advantage, businesses worldwide including Australian businesses are involved in making strategic and operational changes. Organisational restructuring/downsizing/right sizing are some of the popular strategic initiatives. Efficiency improvement, cost cutting, improved communication among departments/sections/individuals and the establishment of an innovative culture have been the key objectives of this process.

Zairi (1994) argued that the key elements of competitiveness include the ’voice of the customer through current and future demands, and the voice of the process through establishing the organisational capability to deliver customer wants’. Literature also suggests that companies that compete effectively on time in terms of speeding new products to market, manufacturing just in time, and responding promptly to customer complaints etc. tend to be good at other business attributes. Some of those business attributes include assessment of customer requirements, product quality consistency, ability to exploit emerging markets, entering new businesses, generating new ideas and incorporating them in innovations (Stalk et al, 1992) which requires a good balance in the firm’s resources including appropriate technological choice.

In the context of changing customer expectations, technological discontinuities, and increasing environmental uncertainties, business managers have a big challenge of making a right strategic choice and setting their strategic priorities in order to allocate their resources to different functions in an efficient manner for business success. This view is consistent with the views of Bettis and Hitt (1995) who argued
that managers must develop new tools, new concepts, new organisation and the new mindsets to cope with the turbulent and chaotic environments leading to discontinuous change.

With growing competition in the domestic and international markets, more demanding and assertive customers, rapid advancement in technology, and changing government policies and laws, the business environment has changed dramatically in the last decade and is becoming more turbulent (Cravens et al, 2000, Jain, 1997). The use of technologies is not only reducing costs but also markedly improving the quality of products and services and enhancing the corporate image of the company to its customers (Robbins et al, 2003). Some of the approaches to low cost production are investment in flexible manufacturing systems (FMS), computer-aided design (CAD), computer-aided manufacturing (CAM) and robotics (Dodgson, 1989; Storey, 1994). Competitiveness has been argued to be a complex phenomenon related to four factors – internal economies, external economies, market structure, and competitive strategy (Toledano, 1994); while Fogarty (1994) considered information systems as a key to competitiveness. Different industries offer different opportunities and, as a result, successful strategies differ from one industry to another (Gilbert and Streb, 1988). Importance of different organisational functions at different stages of product life cycle (PLC) was discussed by Fox (1973). Consequently, different strategies may be needed at different stages of PLC. The study of Snow and Hrebiniak (1980) showed significant relationships among business level strategies, certain functional areas and performance.

As noted by Kabanoff (2001) from the Karpin Report, Australian organisations are generally not well placed for an era of globalisation and rapid technological change. The Karpin Report (1995: 184) discussed the importance of being able to seize the opportunity for Australia to reshape the focus of its business as more enterprising and entrepreneurial. The 1995 data on international comparison of machinery and equipment investment as a percent of GDP indicates that Australia’s performance in the international context is 8.7% which is little above the OECD average of 8.3% (Marceau and Manley, 2001). This is well above Canada, Germany, USA but below the level of Korea, New Zealand, Japan and Italy. The industrial indicators database prepared by OECD (1999) indicate that Australia is closer to OECD average in the services sector in terms of R&D investment as a percentage of value added but in the manufacturing sector it is well below the OECD average. Marceau and Manley (2001) noted that there has been a positive growth in knowledge-based service industries, investment in machinery and equipment, venture capital investment and high skilled jobs in Australia. However, there has been a decline in innovation rates in manufacturing businesses, R&D personnel and expenditure levels, low proportion of GDP compared to many other countries in manufacturing sector and the falling commitment of employers in staff training. It is also noted that in terms of export performance by sectors defined by technology intensity, Australia ranks fourth last in the high-technology sector and second last in the medium-high technology sector in the OECD countries.

Deloitte Touche Tohmatsu’s (1994) study revealed that customer service and quality are viewed as the top priority critical success factors by the Australian manufacturing industry for the immediate future. This study also reported that Australasia and Europe fall behind the US, Canada, and Japan in their ability to complement their own capabilities through integration with customers and suppliers. Dwyer and Mellor (1993) have also discussed the need to improve Australia's industrial performance. It is necessary to be able to adopt appropriate strategies to deal with competition successfully (Mia, 1996).

The review of the literature, thus, leads to the following issues:

- the choice of technology can affect almost every aspect of the business process including production such as the equipment, the level of personnel skills and training, scale of operation, space requirements, scheduling, tooling, safety, and maintenance (Martinich, 1997),
- there is a need to integrate technology strategy with operations strategy (Gaither, 1996; Martinich, 1997),
- businesses must have distinctive and purposeful technology strategies and they should be effectively implemented to be able to deal with the current business environment and challenges.
technology strategy has an important role in enhancing business coordination and integration and thereby improve performance,
level of emphasis on different organisational strategies is contingent on business strategy, product life cycle stage and other situational factors, and,
there is a need to overcome the issues related to productivity performance of Australian businesses.

Research questions
To address the issues summarised above, this research aims to investigate the following exploratory research questions in the context of Australian manufacturing industry:

Question 1a: What is the level of emphasis put by the Australian manufacturing industry on technology strategy?
Question 1b. Has the technology strategy been effective?

Question 2: Is technology strategy associated with organisational performance?

Key terminologies
Business (generic) strategies: Porter’s (1980) generic strategies are used for this research. They are cost leadership, differentiation, and focus. Cost leadership strategy is a business strategy which emphasises organisational efficiency so as to achieve cost advantage relative to competitors. Differentiation strategy is a business strategy which seeks to develop products or services viewed as unique in the industry. Focus strategy is a business strategy which attempts to establish a position of cost leadership or differentiation or both within a particular segment of a market.

Functional strategies: Seven key organisational functions have been identified based on a review of past research work (Hitt et al, 1982, Steiner, 1969). They are technology, marketing, research and development (R&D), operations, human resources (HR), financial, and organisational. Distinctive competencies relevant to each functional area have been identified in defining these functional strategies.

Technology strategy: A firm’s technology is defined as the knowledge, tools/equipment, people, procedures/techniques and activities used to transform organisational inputs into outputs (Samson and Daft, 2003, Martinich, 1997). For this research, technology strategy is defined in terms of firm’s involvement in developing technology in-house, acquisition of new technology, use of CIM, FMS and CNC machines.

Theoretical framework
A schematic diagram of the theoretical framework of this research is given in Figure I. The framework assumes that the emphasis on functional strategies is influenced by contextual factors such as the firm’s industry, type of goods produced, product life cycle stage, firm size, market type, etc.

Figure I – Theoretical framework
The framework also assumes that choice of strategies at functional level should have a match with the business strategy chosen by the firm as suggested by Hrebiniak (1990). It is also assumed that businesses are aware of the appropriateness of the organisational structure, the people and the culture to implement the chosen strategies. The framework also depicts that the right strategic choice at the business level and functional level may lead to improved business performance. The contextual factors also would influence the choice of business level strategy and business performance.

Method
A mail survey of manufacturing industry was conducted across Australia. CEOs were requested to complete the questionnaire, as they are involved in formulating and implementing strategies (Aguilar, 1967; Hambrick and Mason, 1984; Gopinath and Hoffman, 1995). KOMPASS database was used to select the sample. The sample consisted of small, medium, and large manufacturing firms. In the process of sample selection, attempts were made to include different industry groups within manufacturing for which purposive sampling method was used. Interviews of CEOs or senior managers were conducted for developing an understanding of practical aspects of strategy formulation and adoption and validating the study findings.

The generic strategies, product life cycle stage, type of goods produced, industry category were measured on a nominal scale. For measuring the strategic focus at functional level, 34 strategic variables relevant to organisational functions were listed in random order. The level of past use and future emphasis on strategic variables was measured using a 7 point rating scale. The respondents were also asked to indicate whether any of those strategic variables had been very effective in the past. Pre-testing of the questionnaires was completed before the survey was sent. To confirm the representativeness of the respondents, a check of non-respondents was carried out and some of the organisational attributes such as industry category, type of market, number of employees, etc. were compared with the attributes of the respondents. The chi-square test revealed no significant differences in any of these characteristics between respondents and non-respondents.

For testing the instrument reliability, a reliability index, Cronbach's coefficient was used. The alpha reliability calculated for different functional strategies ranged from 0.67 to 0.88. The alpha value for technology strategy is 0.67. Powell (1995) noted that typically alpha coefficients should fall within a range of 0.70 and 0.90 for narrow constructs and 0.55 to 0.70 for moderately broad constructs. Similar observations were made by Sproull (1995). Although the alpha value for technology strategy is on the low side, this is considered to be acceptable as the alpha value of 0.63 was considered to be acceptable in the work of Covin et al (1994) for the five items constructs. Other figures suggest a strong evidence of reliability in the constructs of functional strategies based on the comparison of alpha values with past studies (Hitt et al, 1982). The correlation analyses were carried out between the subjective and objective measures of performance such as market share and profitability to test the validity. The results confirmed an evidence of validity.

Results
Although the response (225 useable responses) rate from the survey was low with 11.42%, the figure is acceptable as the sample is representative of the population as discussed by Koch and McGrath (1996). Average return on assets (ROA) of the survey respondents was 16.5% per annum. 78.7% of respondents were involved in exports. The average proportion of sales being exported was 15%. About half of the exporters had exports less than 5% of sales. Generally the respondents were found to be keen in enhancing their exports, which is indicated by the average annual export sales growth of 27% against an average annual domestic sales growth of 14%.

The findings for each of the research questions are presented below.

Response to research questions 1a and 1b - The level of emphasis put by the Australian manufacturing industry on technology strategy and its effectiveness
The mean scores for the level of past use and future emphasis were calculated for each functional strategy using their respective strategic variables. The scale used for the measurement of past use was ‘1=not used at all to 7=highly used’, and that for future emphasis was ‘1=no emphasis at all to 7=high emphasis’.

The results suggest that technology strategy was the fifth most important strategy in the past. Operations strategy ranked first, R&D strategy second, marketing third, human resources fourth and so on. Although there seems to be an increase in overall emphasis on technology strategy in the future, the ranking of its importance will continue to be the same as in the past few years. Operations strategy will be a number one priority but human resources will receive the second top priority in future. However, in terms of effectiveness in the past, technology strategy was the second most effective strategy after operations strategy. This suggests that there was a need to improve efficiency, and thereby reduce the cost of operations for Australian manufacturing industry in order to be more competitive in the domestic and international markets. It is believed that technology has played an important role in cost cutting initiatives as a part of operations strategy. This provides some support to the contention that technology strategy should be well integrated with operations strategy.

An analysis of individual strategic variables under technology strategy suggests that Australian manufacturing industry have given more emphasis on in-house technology development. This is then followed by acquisition of new technology, use of computer integrated manufacturing (CIM), use of flexible manufacturing systems (FMS), and use of numerically controlled machines (CNC) (see table 1). It is also noted that the top two technology strategies ‘in-house development of technology’ and ‘acquisition of new technology’ have been very effective in the past. ‘Use of FMS’ has been found least effective. An analysis of emphasis on technology strategy variables by generic strategy suggests that in-house technology development has been the most important strategy for firms that have adopted differentiation or focus generic strategy but for the cost leaders acquisition of new technology has been the most important strategy (see table 2). This is perhaps because the cost leaders prefer to minimise the investment on in-house technology research.

<table>
<thead>
<tr>
<th>Technology strategy</th>
<th>Past use Mean [SD] (Ranking)</th>
<th>Future emphasis Mean [SD] (Ranking)</th>
<th>Past effectiveness Scores (Ranking)</th>
</tr>
</thead>
<tbody>
<tr>
<td>In-house technology development</td>
<td>4.75 [1.88] (1)</td>
<td>4.97 [1.75] (2)</td>
<td>41 (1)</td>
</tr>
<tr>
<td>Acquisition of new technology</td>
<td>4.58 [1.79] (2)</td>
<td>5.38 [1.54] (1)</td>
<td>32 (2)</td>
</tr>
<tr>
<td>Use of CIM</td>
<td>3.32 [2.03] (3)</td>
<td>4.05 [2.06] (3)</td>
<td>13 (4)</td>
</tr>
<tr>
<td>Use of FMS</td>
<td>3.07 [194] (4)</td>
<td>3.78 [2.07] (4)</td>
<td>7 (5)</td>
</tr>
<tr>
<td>Use of CNC machines</td>
<td>2.80 [2.21] (5)</td>
<td>3.17 [2.19] (5)</td>
<td>19 (3)</td>
</tr>
<tr>
<td>Mean score for Technology strategy</td>
<td>3.74 [1.34] (5)</td>
<td>4.30 [1.27] (5)</td>
<td>22.4 (2)</td>
</tr>
</tbody>
</table>

Note: For past use and future emphasis mean scores, standard deviation and the ranking are indicated.
Table 2: Level of emphasis on technology related strategic variables by generic strategy adopted

<table>
<thead>
<tr>
<th>Technology strategy</th>
<th>Cost leadership (n=41)</th>
<th>Differentiation (n=43)</th>
<th>Focus (n=29)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Mean [SD] (Ranking)</td>
<td>Mean [SD] (Ranking)</td>
<td>Mean [SD] (Ranking)</td>
</tr>
<tr>
<td>In-house technology development</td>
<td>3.90 [2.10] (2)</td>
<td>5.09 [1.86] (1)</td>
<td>4.65 [1.95] (1)</td>
</tr>
<tr>
<td>Acquisition of new technology</td>
<td>4.07 [1.86] (1)</td>
<td>5.00 [1.50] (2)</td>
<td>4.41 [1.99] (2)</td>
</tr>
<tr>
<td>Use of CIM</td>
<td>2.85 [1.90] (3)</td>
<td>3.44 [1.88] (3)</td>
<td>2.79 [1.86] (3)</td>
</tr>
<tr>
<td>Use of FMS</td>
<td>2.37 [1.59] (4)</td>
<td>2.88 [1.81] (4)</td>
<td>2.65 [1.72] (4)</td>
</tr>
<tr>
<td>Use of CNC machines</td>
<td>2.21 [2.07] (5)</td>
<td>2.68 [2.10] (5)</td>
<td>2.65 [2.11] (5)</td>
</tr>
<tr>
<td>Mean score for Technology strategy</td>
<td>3.10 [1.21] (6)</td>
<td>3.85 [1.23] (5)</td>
<td>3.43 [1.10] (5)</td>
</tr>
</tbody>
</table>

Note: For past use and future emphasis mean scores, standard deviation and the ranking are indicated.

Response to research question 2 – The relationship between technological strategy and organisational performance

The results of the correlation analyses among technology related strategy variables and objective measures of organisational performance such as export proportion, sales growth in domestic and export markets, domestic market share and profitability indicate that the correlations are generally weak and very few of them are significant (see table 3). Use of CIM, use of FMS, and use of CNC machines indicate a positive and significant correlation with sales growth in domestic markets. Acquisition of new technology has a positive and significant association with sales growth in export markets. This suggests that the increase in investment in technology such as CIM, FMS, and CNC is positively associated with the increase in sales growth in domestic markets and the increase in new technology acquisition is also going to have a positive impact in sales growth in export markets.

Table 3: Correlation coefficients (‘r’ values) – Technology strategy related variables and organisational performance

<table>
<thead>
<tr>
<th>Technology strategy variables</th>
<th>Proportion of exports in %</th>
<th>Sales growth in domestic market in %</th>
<th>Sales growth in export market in %</th>
<th>Domestic market share in %</th>
<th>Return on total assets in %</th>
</tr>
</thead>
<tbody>
<tr>
<td>In-house technology development</td>
<td>-0.04</td>
<td>0.04</td>
<td>-0.03</td>
<td>0.01</td>
<td>-0.06</td>
</tr>
<tr>
<td>Acquisition of new technology</td>
<td>-0.11</td>
<td>0.06</td>
<td>0.18*</td>
<td>-0.08</td>
<td>-0.08</td>
</tr>
<tr>
<td>Use of CIM</td>
<td>0.06</td>
<td>0.15*</td>
<td>0.02</td>
<td>-0.01</td>
<td>-0.04</td>
</tr>
<tr>
<td>Use of FMS</td>
<td>-0.04</td>
<td>0.20**</td>
<td>0.02</td>
<td>-0.08</td>
<td>0.05</td>
</tr>
<tr>
<td>Use of CNC machines</td>
<td>0.08</td>
<td>0.19**</td>
<td>0.08</td>
<td>-0.07</td>
<td>-0.06</td>
</tr>
</tbody>
</table>

Note: † stands for p < 0.10, * stands for p < 0.05, ** stands for p < 0.01 and *** stands for p < 0.001.

Multiple regression analyses are also carried out to investigate the level of explanatory power of these technology related variables with objective performance (see table 4). The results suggest that the
The coefficient of determination ($R^2$) in general is very low. For example, 5.8% of change ($R^2 = 0.058$) in sales growth in domestic markets is explained by these technology strategy related variables (CIM, FMS, CNC). Likewise, 5.1% of change ($R^2 = 0.051$) in sales growth in export markets is explained by investment in new technology acquisition. No evidence of relationship is found between financial performance (return on total assets) and technology related variables. This could be for two reasons – one is that the level of investment in technology is still very low and too early to see the positive impact on financial performance. The other is, may be the outcome of such investment is yet to be seen as this process needs a fair amount of time to train the employees in new technology and be able to successfully adopt/implement the technology as it involves some lag effect.

Table 4: Relationship between technology strategy variables and organisational performance ‘objective’ (results of multiple regression analysis ‘standardised coefficients - beta values’)

<table>
<thead>
<tr>
<th>Technology strategy variables</th>
<th>Proportion of exports in %</th>
<th>Domestic market share in %</th>
<th>Sales growth in export market in %</th>
<th>Sales growth in domestic market in %</th>
<th>Return on total assets in %</th>
</tr>
</thead>
<tbody>
<tr>
<td>In-house technology development</td>
<td>-0.003</td>
<td>0.046</td>
<td>-0.118</td>
<td>-0.030</td>
<td>-0.026</td>
</tr>
<tr>
<td>Acquisition of new technology</td>
<td>-0.141†</td>
<td>-0.085</td>
<td>0.221**</td>
<td>0.011</td>
<td>-0.075</td>
</tr>
<tr>
<td>Use of CIM</td>
<td>0.131</td>
<td>0.065</td>
<td>0.018</td>
<td>0.044</td>
<td>-0.033</td>
</tr>
<tr>
<td>Use of FMS</td>
<td>-0.08</td>
<td>-0.043</td>
<td>-0.060</td>
<td>0.124</td>
<td>0.143</td>
</tr>
<tr>
<td>Use of CNC machines</td>
<td>0.091</td>
<td>-0.087</td>
<td>0.066</td>
<td>0.137†</td>
<td>-0.066</td>
</tr>
<tr>
<td>Multiple R</td>
<td>0.196</td>
<td>0.127</td>
<td>0.225</td>
<td>0.241</td>
<td>0.144</td>
</tr>
<tr>
<td>$R^2$</td>
<td>0.038</td>
<td>0.016</td>
<td>0.051</td>
<td>0.058</td>
<td>0.021</td>
</tr>
<tr>
<td>SE</td>
<td>16.82</td>
<td>25.36</td>
<td>47.67</td>
<td>28.10</td>
<td>17.52</td>
</tr>
<tr>
<td>$F$</td>
<td>1.59</td>
<td>0.71</td>
<td>1.84</td>
<td>2.39*</td>
<td>0.71</td>
</tr>
</tbody>
</table>

Note: † stands for $p < 0.10$, * stands for $p < 0.05$, ** stands for $p < 0.01$ and *** stands for $p < 0.001$.

The investigation of relationship between technology strategy and business level generic strategies found that the firms which adopt a differentiation strategy tend to put more emphasis on technology than cost leaders do. Technology strategy is also found to be important by firms that adopt a combined strategy of cost leadership and differentiation strategy.

Discussion
This research investigated the relative importance given by the Australian manufacturing industry to technology strategy in a mix of other functional strategies. The results suggest that although level of importance given to technology strategy was not very high in the past with fifth ranking from the top in a mix of seven functional strategies, it has been perceived as a very effective strategy with number 2 ranking. It is also revealed that much of the technological efforts should have gone into process engineering such as process improvement or cost reduction rather than product engineering and product development. The findings also indicate that initiatives to develop in-house technology has been accorded the top emphasis in the past few years under technology strategy. This emphasis, however, is going to change to new technology acquisition rather than developing own technology in the future. Firms which adopt cost leadership are found to put more emphasis on new technology acquisition and not on in-house technology development, as opposed to the firms which adopt a differentiation or focus strategy. These findings are consistent with Porter’s (1980) contentions. Under the technology strategy, initiatives like in-house development of technology and acquisition of new technology, are also perceived as effective.

This research also investigated the relationship between technology strategy variables and organisational performance. The results suggest that the correlations are generally weak and very few of them are
significant. For example, use of CIM, FMS, and CNC machines are positively associated with sales growth in domestic markets and acquisition of new technology is positively associated with sales growth in export markets, but the level of explanatory power of these variables to the change in performance measures is very low. Therefore, although technology is a very important factor for business performance, there are other factors which also play a very important role in business success, and technology needs to be integrated in the entire business process. The investigation of relationship between technology strategy and business level generic strategies found that technology strategy was a very important strategy for firms which adopt differentiation strategy or the ones which adopt a combined strategy of cost leadership and differentiation strategy.

This research had to include all the strategic variables relevant to different organisational functions to investigate the relative importance of technology strategy in a mix of other functional strategies. Therefore, this study used a limited number of technology variables. To enhance the value of this study from the technology perspective and make it more useful for the managers involved in technology management, future research should consider more variables related to technology, such as web-based (internet) technology, technology research, etc. This will provide a useful framework to the practicing managers to make decisions on technology initiatives.

References
Chen, S. (2001), Strategic management of e-business, John Wiley & Sons: Chichester
Deloitte Touche Tohmatsu (1994), Stepping up Australia – Meeting the Global Challenge

Hrebiniak, L G. (1990), Implementing strategy, Chief Executive, Vol 57, 74-77, April


Kabanoff, B. (2001), The values of Australian organisations and their managers in ‘Business, work, and community: into the new millennium’, Oxford University Press, South Melbourne, Australia, edited by Dow, G. and Parker, R.


Mia, L. (1996), Intensity of market competition, Use of strategic management accounting and Business unit performance, Paper presented at a research seminar held at School of Accounting, The University of New South Wales, and supported by KPMG, April 26


Steiner, G. (1969), Strategic factors in business success, Financial Executives Research Foundation, NY


Toledano, S. H. (1994), The state of the Mexico, Business Mexico, Vol. 4, No. 4, 34-36, April