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TECHNOLOGY, MANUFACTURING PERFORMANCE AND BUSINESS PERFORMANCE AMONGST AUSTRALIAN MANUFACTURERS

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Abstract

In 1994, the Australian Manufacturing Council completed a comprehensive survey of Australian manufacturers. The survey sought information on elements of manufacturing strategy, manufacturing practices (e.g. benchmarking and people management), manufacturing performance (quality and timeliness) and business performance (sales growth, exports and market share). An aspect of manufacturing practice was the use of Advanced Manufacturing Technology (AMT). In this paper we report on the statistical links between the use of AMT, manufacturing performance and business performance amongst Australian manufacturers. Statistical estimates of the strength of these links depend on the assumptions made about the data. Our findings will disappoint those who hope or expect technology to be strongly associated with business success, the statistical evidence is equivocal. While noting that statistical association does not imply causation, we nevertheless suggest some plausible explanations of strong associations. More study of the ways in which human, social and organisational factors mediate the way in which technology affects organisational performance is required.

Keywords: Australia, manufacturing technology, manufacturing performance, statistical analysis

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1. INTRODUCTION

Manufacturers presumably introduce advanced manufacturing technology (AMT) for business reasons: to increase profits or to stay in business. This paper exploits an opportunity to investigate the statistical relationships between the use of various kinds of AMT's and manufacturing performance and business performance. The opportunity was provided by the Australian Manufacturing Council which published a report [1] based on a comprehensive survey of Australian manufacturers. The Council kindly made the survey data available to us.

This paper provides statistical measures linking the use of technologies with measures of manufacturing success and business performance. It notes that different assumptions about the data (which imply that different statistical treatments are appropriate) yield different conclusions.

It need hardly be said that high correlation does not imply causation. In a particular firm, it might seem obvious that the introduction of CAD/CAM led to shorter product development times. However, it is possible that the improvement was caused by a change in culture, a demanding customer or the introduction of JIT, and would have happened without CAD/CAM. The introduction of a new technology might reduce performance while the organisation initially struggles to acquire the requisite skills and knowledge i.e., there may be an appreciable lag between installing new technology and getting benefits from it. Some technologies might not provide maximal benefits until other departments, suppliers and customers change their practices or assumptions. Analogous to the strength of a chain being its weakest link; the benefits of new technology may be modest until the last process on the assembly line has been automated.

Researchers have been puzzled by the failure of huge investments in information technology to be manifest in profits [2]. There is an emerging view that very recently, dramatic increases in some firms' profits are attributable to their having adapted their structures, cultures and systems to fit the new information technology. Similar considerations might apply to manufacturing technology.

1.1 Scope

The kinds of advanced manufacturing technologies (AMTs), measures of manufacturing performance (called performance outcomes in the study) and measures of business performance considered in the study are listed in appendix A. The AMT's considered include direct technologies (such as NC and laser cutting); indirect technologies (CAD/CAE and MRP); what might be called philosophies such as JIT and TQM; and communication technologies (Local Area Networks (LAN's) and Electronic Data Interchange (EDI)).

Performance Outcomes were essentially measures of the factory's competence and include measures of unit costs, flexibility and safety. Business Performance include measures of domestic and export sales and market share in each of three financial years and, derived from these measures, growth figures over the three years.

1.2 Past Work

An automated factory processes and uses data as well as raw materials, parts and labour. A considerable advantage of AMT is the ability to keep information (such as a product design and orders) in electronic form for as long as possible before the firm incurs an irreversible expense by making it manifest in production. Dean, Yoon and Susman [3] noted that a common element of AMT is the use of computers to store and manipulate data. Data held electronically can be changed and distributed relatively cheaply. It is comparatively expensive to modify an already made product or to change an already promulgated production schedule. Computer based and controlled equipment allows scheduling and product changes to be specified through software instead of physically adjusting machinery settings. Such equipment can almost always capture data about the processes. This data can be transferred to computer systems and transformed into information which managers can use to monitor production more accurately and better understand the resources they control.

The reasons most often cited for introducing AMT are cost reduction, increased flexibility, product quality and less tangible considerations such as a need to provide better managerial control, remain competitive, enter a new market or to reduce dependence on an external supplier [4] [5] [6] [7]. Daim [8] gives a comprehensive review of the literature on this and many other aspects of AMT.

In a review of past empirical work, Zammuto and O'Connor [9] noted that studies of the relative success of AMT's indicate mixed results. Many studies reported success in terms of reduced lead times, reduction in costs, improved quality and increased machine utilisation (e.g., see Ingersoll Engineers [10], Goldstein [11], Bessant [12] and Ettlie [13]). However, other studies reported failure of firms to successfully exploit AMT's; most notably in terms of failing to exploit the potential benefit of increased flexibility [14] [15].

The installation of new technology does not automatically generate business benefits. Its end effects are mediated by myriad factors such as the organisational structure, people, systems, suppliers, customers and culture. These issues are discussed in a review article [16] in which two models are posited. The authors dismiss the first, deterministic, model which assumes that end effects are determined by technology (perhaps with minor, random variation). This model might be valid if the new technology was overwhelmingly superior to its old counterpart (such as the mechanical cash register). They suggest as more realistic a much weaker model in which the introduction of technology does no more than create new possibilities. The degree to which those possibilities are exploited depends on (is mediated by) myriad human and social factors and possibly also on chance (see Finney [17] and James [18]).

A number of recent studies have addressed (not always explicitly) various dimensions of mediation between AMT and performance. Gupta and Somers [19], in their study of 269 manufacturing organisations using factory automation (FA) technologies, found that the degree of integration of business functions significantly influenced the quantity and type of benefits accrued from using the technologies. Zammuto and O'Connor [9] conceptually addressed the affect of organisation design and culture on gaining the benefits of AMT's. Using a case study approach Thomas and Wainwright [20] highlighted that internal politics can have a significant mediating influence on the relationship between the use of AMT's and overall success of the investment. Ramamurthy [21] studied the effects of planning on the success of AMT's for 222 manufacturing firms and concluded that the quality of the planning system had significant moderating influences. Weill [22] exemplifies similar work done in Australia.

2. THE SURVEY DATA

In 1994, the Australian Manufacturing Council completed a survey of Australian and New Zealand manufacturers. The survey, designed to determine the extent and effectiveness of best practice amongst Australasian manufacturers, was valuable in that the sample size was large (962 Australian firms responded); the response rate was good for this kind of exercise (32%) and the responses were tested for reliability. A telephone survey of non-respondents indicated that there was little difference between them and respondents. It was also found that there was no evidence of "respondent fatigue" (answering later questions mechanically) or "respondent inattention" (respondents failing to notice a change in the questionnaire's requirements) [1] pp. 78-79.

The questionnaire sought information in the following areas:

1. Manufacturing Strategy (Planning, Manufacturing and Factory Operations)

2. Manufacturing Practice (Leadership, People, Customer Focus, Quality of Process and Product, Benchmarking and Technology)

3. Manufacturing Outcomes (Cost, Quality, Flexibility, Timeliness, Innovation and Competitiveness) and

4. Business Performance (Sales (domestic and export), Employment Levels, Market Share and Cashflow)

The questions relevant to this paper are listed in appendix A.

3. STATISTICAL ANALYSES

The object is to determine if there are any correlations between the use of various technologies and manufacturing or business performance. A critical issue is deciding which statistical techniques are appropriate, this varies with the four question styles found.

3.1 Ordinal Data

Most questions required responses on a Likert scale, for example questions PO1A-PO1K (which asked respondents to compare their performances with that of competitors) required responses of: much higher, higher, on par, lower, much lower and don't know.

Such responses comprise ordinal data (see Siegel [23] pp 21-29 for definitions). Strictly speaking, parametric statistics (such as the mean and variance) are meaningless for ordinal data and tests based on them (e.g. the t-test) should not be used.

The Mann-Whitney test is appropriately used to determine whether two sets of ordinal data have different medians. Although this test is generally less powerful than the t-test (an analogous tool for interval data) it does have two comparative advantages: it does not require interval data; and it does not assume that responses are normally distributed.

Siegel [23] firmly opines that treating ordinal data as interval data is a serious conceptual error with possibly serious consequences. Treating the data as ordinal is a conservative approach. The probability of a type I error (rejecting a true hypothesis) is comparatively large and; the probability of a type II error (accepting a false hypothesis) is small. Conversely, treating the data as interval is non-conservative. The probability of a type I error (rejecting a true hypothesis) is comparatively small and the probability of a type II error (accepting a false hypothesis) is comparatively large.

3.2 Interval Data

Some questions (e.g. PO3A - number of levels of management) yielded uncoded integer answers.

3.3 Grouped Data

Some questions coded a range of outcomes as a single digit. For example, question PO8A coded defect rates of <0.1%, 0.1-0.49%, 0.5-1.99% etc as 1, 2, 3 etc.

Some questions, especially those on business outcomes, sought data such as total sales. Presumably, to preserve confidentiality, these raw figures were converted to single digit codes each of which signified a range.

In the business outcomes section, respondents were asked their sales and market share in each of three years. To relate technology use to these figures would be to relate it to company size rather than business success. We converted the raw data into year by year changes in total sales, export sales and market shares (see appendix A). Note that subtracting ranges increases group width and coarsens the data.

It is traditional to represent grouped data by the group's midpoint. This was not always possible, for example the "rightmost" class of question P08A was a defect rate of more than 5%. It would have been inappropriate to use a mid-point of 52.5%. We graphed the data and estimated the mean of points above 5% by extrapolation.

Note that representing an interval by its midpoint might bias statistical tests as well as reducing their power [24].

4. ANALYSES

Questions TE1A to TE1S asked about the use and utility of various technologies; responses were: not used, negative contribution, no contribution, marginal contribution, reasonably significant contribution, major contribution.

The responses were used to dichotomise the sample into organisations that used a particular technology and those who did not thus, subjective impressions of utility were avoided. The Mann-Whitney or t-test was then used to determine, for each measure of manufacturing performance and business outcomes, whether there was a statistically significant difference between users and non users of each technology.

The results are shown in tables 1 and 2. A "*", "**" or "***" indicates that a difference has been detected at the 0.05, 0.01 or 0.001 level respectively. A "-" sign indicates that the relationship is negative; for example, in table 1, average factory hours are less for respondents using advanced cutting techniques than non-users.

The subjective interpretation of the tables is affected by the way in which rows and columns are sequenced. One might hope to create blocks dense with asterisks by resequencing the rows and columns. This was attempted with very little success. We chose instead to group technologies as follows (refer to appendix A for the codes):

- Direct (F, G, H, C, E, J, K, L, I)
- Design (A, B)
- Indirect (D, O, S, P, Q, R)
- Communication (M, N)

4.1 Results

The statistical associations between the use of technologies, measures of organisational performance and measures of business are shown in tables 1 and 2.

4.2 Discussion

The initial discussion is based on the outcomes and performance measures on the left hand side of these tables, later individual technologies are considered.

4.2.1 Technological Competence

Many technologies are associated with relative technological competence. This is not surprising - respondents are evaluating the performance of units for which they are largely responsible.

4.2.2 Dependability

This group comprises: customer satisfaction, delivery in full on time to our customers and order to delivery time. This group is not strongly associated with technology, inspection and JIT being modest exceptions.

4.2.3 Cost

This comprises several elements. Technology is perceived as having remarkably little effect on internal costs including the cost of quality. The most striking effects are that CAD, CAE and TQM *increase* quality costs. This may mean that the cost of correcting poor quality is made more explicit and tangible. This might be a good thing in that errors are found and fixed before goods leave the factory.

			Advanced cutting technologies apart from lasers F	Simple pick and place robots G	More complex robots H	Computer numerically controlled (CNC) machines C	Materials working lasers E	Automated guided vehicles J	Automatic inspecting and testing performed on incoming materials K	Automatic inspecting and testing performed on final product L	Automated storage and retrieval I	Computer-aided design (CAD) and/or computer-aided engineering (CA A	CAD output used to control manufacturing machines (CAD/CAM) B	Flexible manufacturing cells (FMC) or systems (FMS) D	Total Quality Management (TQM) O	Value Adding Management (VAM) S	Just-in-Time (JIT) P	Manufacturing Resource Planning (MRP, MRPII) Q	Computer Integrated Manufacturing (CIM) R	Local area computer network (LAN) for technical data M	Electronic data interchange (EDI) N
	Relative technological competitiveness	PO7F	*	**	*	**	***	*	**		**	**		*	*	*		**	***	**	*
	Order to delivery time	PO1I							**	*							*				
	Customer Satisfaction	PO7A																	*		
^	Delivery in full on time to our customers	PO8J																			**
	Materials costs per unit of product	PO1A							**		*										
	Labour costs per unit of product	PO1B		*	**						*										
	Overhead costs per unit of product	PO1C																			
	Marketing, distribution and admin. costs per unit of product	PO1D					*														
	Total cost per unit	PO1E								*								-			
^	Cost of quality (error, scrap, rework and inspection) as a percentage of total sales	PO8C										***			**					**	
	Number of end items	PO1H										*			-						-
^	Average hours per week the factory schedules production	PO3A	–	***	*					***	*	***			***				*	***	***
^	Percentage capacity lost due to breakdowns and other unplanned downtime	PO3B		*						*	*	***			**	**		***		*	*
	Productivity	PO7D		***	***			*	*	**	*			*	***	**	***	**	**	**	***
	New product introduction lead time	PO1G	**				**	**	***	**		*					**		**		*
	Average process changeover time	PO7B							*			-							*		
^	Ratio of annual sales to average total stock (Stock Turns)	PO8F	-	-								-	-	–				-			
	Finished product defect rate	PO1F													-						-
^	Defects as a percentage of production volume	PO8A		**		*						***	**		*						
^	Warranty claims cost as a percentage of total sales	PO8B				*					*	**	***	**	**					***	
	Lost time due to accidents per year per employee	PO1J																			-
	Lost time due to industrial disputes	PO1K																			-
	Employee moral	PO7C			*			**	***	**	**			**		*		**	***		
	Cashflow (Pre capital investment)	PO7E													**	*		*	**		***

Table 1: Statistical tests (Predominantly Mann Whitney U tests)

*	P<0.05
**	P<0.01
***	P<0.001
^	T - tests calculated using the midpoint of the censored interval data

		C	E	F	G	H	J	K	L	I	A	B	D	O	P	Q	S	R	M	N
		CNC machines	Materials working lasers	Advanced cutting technologies apart from lasers	Simple pick and place robots	More complex robots	Automated guided vehicles	Automatic inspecting and testing performed on incoming materials	Automatic inspection and testing performed on final product	Automated storage and retrieval	CAD and/or CAE	CAD output used to control manufacturing machines (CAD/CAM)	Flexible manufacturing cells (FMC) or systems (FMS)	TQM	JIT	MRP, MRP II	Value Adding Management (VAM)	CIM	LAN	Electronic data interchange (EDI)
Change in total sales 1990/91 - 1991/92	BP2TD 92/91-91/90																			
Change in total sales 1991/92 - 1992/93	BP2TD 93/92-92/91		*			*	*		*				*	*						
Change in total sales 1990/91 - 1992/93	BP2TD 93/92-91/90				*	*			*				*	**		*				
Change in export sales 1990/91 - 1991/92	BP2ED 92/91-91/90														*	*				
Change in export sales 1991/92 - 1992/93	BP2ED 93/92-92/91												*	*					*	
Change in export sales 1990/91 - 1992/93	BP2ED 93/92-91/90										***		***	***	*	**			**	
Percentage of total sales from "new" products (those produced for less than 5 years	PO2	*		***	*	***	**				*	***	**		**	***	*	*		
Change in market share 1990/91 - 1991/92	BP3MSD 92/91-91/90														*					
Change in market share 1991/92 - 1992/93	BP3MSD 93/92-92/91																			
Change in market share 1990/91 - 1992/93	BP3MSD 93/92-91/90																			

Table 2: t-Test Statistics - Business Performance

4.2.4 Internal Factors

The number of end items is affected by few technologies. This is surprising, the short setup times of advanced technology should enable a larger range of end products. Technology has a significant effect on productivity. It is not obvious how managers estimated productivity, perhaps the best guess is that they thought in terms of labour output.

Surprisingly, technology is associated with increased hours of production. Competitive pressures or the need to recoup spending on technology may have forced managers to exploit assets better by operating for more hours. New technology may have made "lights out" manufacturing easier to organise (the authors are aware of at least one example).

Curiously, unplanned loss of capacity is strongly associated with several indirect technologies. We suspect that the link between downtime and e.g. MRP and TQM is that using these methods makes participants more like to formally record and remember unproductive time. Competitive pressures may have reduced the slack in the system.

4.2.5 Flexibility

The group comprising new product introduction lead time, average process changeover time and stock turns imperfectly reflects flexibility. Clearly, reductions in new product introduction lead times are associated with several direct technologies, an interesting instance is automated inspection of incoming materials. Perhaps an impediment to new product development is being sure that purchases were of the quality specified. Curiously, technologies are associated with *fewer* stock turns, i.e. higher inventories- a symptom of *lower* intrinsic flexibility.

4.2.6 Quality

Contrary to expectations, quality is negatively correlated with technology, especially with CAD. There are several possible reasons for this. In a more demanding environment, the expectations of internal and external customers may have risen. Philosophies such as benchmarking, ISO9000 and TQM entail recording quality deviations and may perhaps result in more defects being detected and fixed before leaving the factory. Statistics on defect rates may be being demanded by higher levels of management. Lower finished product defect rates are weakly associated with technology.

The least easily explain finding is that *higher* warranty costs are strongly associated with some technologies. Perhaps this reflects changing times and that some arms of the Australian regulatory and judicial system are able to direct firms to compensate buyers of faulty products.

4.2.7 Employees

Respondents, with perhaps biased views, thought that higher employee morale was associated with some technologies.

4.2.8 Business Performance

The associations between business performance and technology are set out in table 2. The change in export sales between 1990/91 and 1992/93 is positively associated with several technologies. There are myriad possible reasons for this. Exporting firms are entering a more competitive market. Achieving competitive costs and quality may not be possible without some sophisticated machinery. Some advanced technology requires a high volume to be economic and may compel broaching foreign markets. Exporters might, on average, be more cash rich and better able to experiment with AMT. It does seem significant that many technologies are associated with new products. Please note that this table is formed from groups which were initially rather wide and that "subtracting" doubles the class width. To represent classes by their midpoint may bias test results.

4.2.9 Individual Technologies

We now consider the effects of particular technologies where these are marked.

- Automatic inspection of incoming materials and of outgoing products seem to have marked, beneficial association with several measures. The former is very strongly associated with order to delivery time, new product introduction lead time and employee morale, the latter with *longer* factory schedules and superior new product introduction lead time. Automated inspection machinery is presumably cheaper than machinery which manipulates metal and may be a cost effective investment.

- CAD/CAE has a marked, negative association with several measures: it is associated with *increased* costs of quality, *longer* factory schedules, *more* breakdowns, and *more* defects. This is hard to explain, perhaps those who have adopted CAD/CAE are still learning about it or have introduced it to help cope with extant problems. CAD linked to machinery is associated with increased warranty claims.

- TQM, JIT, VAM and CIM are all associated with higher productivity. TQM is also associated with longer schedules, MRP/MRPII with increased downtime and CIM with improved cash flows.

- Communications technologies (LAN and EDI) are associated with longer schedules and improving productivity. LAN is associated with increases in warranty costs, EDI with improved cash flows.

5. CONCLUSION

The analysis does not demonstrate that AMT in general is associated with, let alone generates, manufacturing or business success. The statistical evidence that users of manufacturing technology do better than non-users is muted at best. The most striking conclusions are that automated inspection techniques, TQM, LAN and EDI seem to have strong effects, mostly beneficial and that CAD/CAE has strong negative effects. Note that table 1 contains 456 cells and that, if the data was purely random, one would expect to find 18 cells with a single star and 5 with a double star.

The implementation of advanced technology is a complex process whose success depend on myriad aspects of the organisation's structure, systems (formal and informal), culture and environment. Statistical comparison of inputs and outputs is a fairly crude tool which gives no insight into how firms adopt to and exploit new technology. In current terminology, the critical research issue is to clarify the mediating mechanisms. It may be wrong to assume that new technology is a driving variable, perhaps demands for new and better products or reduced costs drive the demand for its introduction. The authors are engaged in a research project on the implementation of manufacturing technology which involves interviewing production and general managers. Some tentative insights are emerging.

The data used in this paper was obtained by a survey. Surveys have several intrinsic difficulties. This survey was long (about 275 responses were required from "the CEO or a member of the senior management team familiar with all the site's operations" [1] p 86). Although responses were tested for consistency and fatigue, responses to later questions may not have been answered with great care. We have already noted that some questions had to be answered in a counter-intuitive way. Some questions required data that competent executives *ought* to have at hand. Bias may have been present, few of us like to commit to paper facts which imply that we have made poor decisions.

Respondents were asked to consider a site as the unit about which units were asked. Sites may not have been homogenous in their use of technology. The effects on the site of small scale use of technology might have been swamped by other factors. We note that there may be a considerable lag between the introduction of new technology and obtaining benefits and that, in a large organisation, one site could carry the cost of new technology while a different (supplied) site or customer obtains the benefits.

APPENDIX A: QUESTIONS ASKED

The questions from AMC [1 pp 95-98] relevant to this paper pertain to:

Technologies Used

Respondents were asked which technologies they used and each technology's contribution to the respondent's organisation's competitive position.

TE1A. Computer-aided design (CAD) and/or computer-aided engineering (CAE)
TE1B. CAD output used to control manufacturing machines (CAD/CAM)
TE1C. Computer numerically controlled (CNC) machines
TE1D. Flexible manufacturing cells (FMC) or systems (FMS)
TE1E. Materials working lasers
TE1F. Advanced cutting technologies apart from lasers
TE1G. Simple pick and place robots
TE1H. More complex robots
TE1I. Automated storage and retrieval
TE1J. Automated guided vehicles
TE1K. Automatic inspecting and testing performed on incoming materials
TE1L. Automatic inspecting and testing performed on final product
TE1M. Local area computer network (LAN) for technical data
TE1N. Electronic data interchange (EDI)
TE1O. Total Quality Management (TQM)
TE1P. Just-in-Time (JIT)
TE1Q. Manufacturing Resource Planning (MRP, MRPII)
TE1R. Computer Integrated Manufacturing (CIM)
TE1S. Value Adding Management (VAM)

Use and Appropriateness

Two questions asked whether the respondent's core technology was appropriate (TE2A) and fully utilised (TE2B).

Performance Outcomes A

Respondents were asked whether their performance on each of the following dimensions was much higher, higher, on par with, lower or much lower than major domestic and international competitors:

PO1A. Our material costs per unit of product are
PO1B. Our labour costs per unit of product are
PO1C. Our overhead costs per unit of product are
PO1D. Our marketing, distribution and administration costs per unit are
PO1E. Our total cost per unit of product is
PO1F. Our finished product defect rate is
PO1G. Our new product introduction lead time is
PO1H. Our number of end items is
PO1I. Our order to delivery time is
PO1J. Our lost time due to accidents per year per employee is
PO1K. Our lost time due to industrial disputes is

Performance Outcomes B

Respondents were asked the following: PO2.In 1992-93, what was the percentage of total sales from 'new' products (ie those produced for less than 5 years)?

PO3(a) On average, how many hours per week (maximum of 168 hours) does your factory schedule production?

PO3(b) How much capacity (in percent) do you lose due to breakdowns and other unplanned downtime?

PO4 How many levels, from the most Senior Manager to the production operator, exist at your site?

PO5(a) On average, how many days of induction training would each new production operator receive?

PO5(b) On average, how much ongoing training would the following employees receive per year?

- Senior Management
- Middle Management/Supervisors
- Production Operators

Unfortunately and inexplicably, the answers to some questions (e.g. PO2) have been recorded as ranges, not in their original form.

Performance Outcomes C

Respondents were asked to estimate their site's current performance level for each of the following performance measures on a scale of 1 -5. Unfortunately, for some questions a score of 5 was good, for others it was poor.

PO7A. Customer Satisfaction
PO7B. Average process changeover time
PO7C. Employee morale
PO7D. Productivity
PO7E. Cash flow (Pre-capital investment)
PO7F. Relative technological competitiveness

Performance Outcomes D

PO8A. Defects as a percentage of production volume
PO8B. Warranty claims cost as a percentage of total sales
PO8C. Cost of quality (error, scrap, rework and inspection) as a percentage of total sales
PO8D. Research and development as a percentage of total sales
PO8E. Employee education and training expenditure as a percentage of pre-tax average payroll
PO8F. Ratio of annual sales to average total stock (stock turns)
PO8G. Proportion of production operators involved in:
PO8H. Process improvement/problem solving teams
PO8I. Self-managing and/or cellular work teams
PO8J. Quality circle/employee involvement groups
PO8K. Delivery in full on time to our customers
PO8L. Average age of core equipment
PO8M. Ratio of quality control inspectors to direct production operators

Business Outcomes

Business success was elucidated through the following questions.

BP2TD 92/91-91/90:	change in total sales 92/91-91/90
BP2TD 93/92-92/91:	change in total sales 93/92-92/91
BP2TD 93/92-91/90:	change in total sales 93/92-91/90
BP2ED 92/91-91/90:	change in export sales 92/91-91/90
BP2ED 93/92-92/91:	change in export sales 93/92-92/91
BP2ED 93/92-91/90:	change in export sales 93/92-91/90
BP3MSD 92/91-91/90:	change in market share 92/91-91/90
BP3MSD 93/92-92/91:	change in market share 93/92-92/91
BP3MSD 93/92-91/90:	change in market share 93/92-91/90

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