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The Adoption of Advanced Quality Practices and its Impact on Manufacturers

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Presently, the manufacturing sector faces unprecedented levels of competition in both the domestic and international markets. This competition is mainly as a result of rapidly expanding international trade, gradual removal of protection, substantial reforms in labour markets and industrial relations, rapid technological changes and discerning customers. Intense global competition requires manufacturers to deliver products with higher quality in a shorter time. Simultaneously, owing to new technological innovations, the complexity of the products is increasing. In Australia, the impact of this intense competition and structural changes appear to be having negative effects on the manufacturing sector. This paper discusses the quality and reliability (Q & R) practices and associated drawbacks of Australian manufacturers and presents the findings of an investigation of the challenges Australian manufacturers are currently facing. The results reported in the paper are based on the data collected from a survey using the standard questionnaire. The study was driven by a conceptual model, which relates advanced quality practices to manufacturing performance and manufacturing difficulties.Evidence indicates that Q & R is the main competitive factor for Australian manufacturers. Design capability and on time delivery (OTD) came second. Results show that Australian manufacturers in general are facing some manufacturing difficulties. The relationship between advanced quality practices and company performance and manufacturing difficulties are explored. It is found that the companies who have more emphasis on advanced quality practices have fewer problems in manufacturing practices. Moreover, companies who have actively implemented the advanced quality practices have managed to improve the quality of the product continuously. The results validate the proposed hypothesis and lend credence to current thinking that improvement in Q & R is a vital tool for competitive advantage.

Keywords: Product quality, Reliability, Questionnaire survey, Australian manufacturers, manufacturing performance

1. Introduction

The globalisation of the marketplace and the rapid improvements in information flow capabilities, have increased competition worldwide. There are unprecedented pressures on companies to improve their operational efficiency for enhanced competitiveness and overall business performance.

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Such pressures include competition from foreign products, new product introduction by competitors, rapid technological innovation and shorter product life, unanticipated customer shifts, and advances in manufacturing and information technology (Browne et al., 1995). Under the new circumstances, the organization must deliver a reliable product, or service, on time and ensure that customer requirements are satisfied. In a bid to cope with market demand, companies now look beyond cost. Speed, quality and flexibility are being emphasized as means of responding to the unique needs of customers and markets (Yusuf et al., 2004).

Organisations can build competitive advantage through superior manufacturing, but sustaining the competitive advantage over time requires comparable skills in continual improvement of quality and reliability of existing product and developing a continual stream of quality new products. The increasing pace of technological change and the accelerating globalisation of business has meant that competitive advantage for many companies now lies in their ability to effectively implement on-going product and process innovations. This progressive accumulation and sharing of knowledge fosters the process of organisational learning that is the essential engine for the continuous improvement process. Hence, long-term competitiveness is increasingly dependent on how well a company can continuously improve its product quality and reliability by fostering organizational learning and utilising individual and group knowledge within and outside the company.

The demands on product quality and reliability have changed over the period. The end users have higher expectations of the product performance in terms of both functionality and quality even for inexpensive products. Product quality and reliability is taken for granted. Connected with this is the change in warranty. There is a trend to extended warranty periods. This change is partly because of legislation and partly because of competition. For example, any electrical and electronic item must have one-year warranty (legislation) in Australia but 3-5 years of warranty is not uncommon (competition). While in the past warranties covered only the repair or replacement of defective components, currently in many cases of a complaint the product is simply exchanged for a new one, or the money is returned.

Quality has evolved from inspection, through quality control and quality assurance, to feedback from customers. This has transformed organisations from an inefficient environment with heavy reliance on inspection and hierarchical control, to one employing teamwork, paying attention to customer needs and satisfaction, getting quality right first time and continuously improving processes (Al-khalifa and Aspinwall, 2000). The 1990s have seen the quality revolution spreading beyond manufacturing and many organisations are forced to change their old strategies and management styles and develop better ways to allocate available resources in order to remain competitive.

The manufacturing sector plays an important role in the Australian economy. Presently, the manufacturing sector face unprecedented levels of competition in both the domestic and international markets. Globalisation and gradual reduction of tariffs put the companies under further competition. The impact of this intense competition and structural changes appear to be having negative effects on the manufacturing sector. Manufacturer's contribution to GDP is continually falling and it currently employs considerably fewer people than before (ABS, 2001).

The focus of this study is to analyse and evaluate current manufacturing and quality and reliability practices in Australia, in order to recognise the problems faced and to suggest a way forward. A conceptual model of advanced quality practices as determinants of manufacturing competitiveness and business performance was proposed. Also, the relationship between the advanced quality practices and attainment of competitive and manufacturing performance was explored.

2. Theoretical Framework

The general hypothesis being tested in this study is that product quality and manufacturing performances of the companies are influenced by advanced quality practices like Q & R estimation during design, use of field failure and manufacturing data, effective communication, awareness of customer requirements etc. The framework also postulated that the advanced quality practices might be influenced by contextual factors such as the firm size, ownership, type of goods produce, innovation pace in the company etc.

3. Methodology

As the study was designed to cover as wide a range of the heterogeneous manufacturers population as possible, a questionnaire was used as the basis for data collection. The carefully designed questionnaire of the survey reported in this paper was (1) based on a literature review, and preliminary information obtained from the pilot study - in order to address the relevant concerns and status of the industry; (2) pilot-tested by ten experts (seven academics and staff from two companies); and (3) improved based on the opinions obtained from these experts.

Having designed the survey form, a pilot testing was conducted using two companies in Melbourne. The piloting was carried out using face-to-face interviews with respondents. Based on their responses, certain modifications were made to the questionnaire. The modified questionnaire was further tested by seven academics, comprising of Ph.D. students in the related field and faculty members, at Melbourne University. In addition, careful reference was made to the literature of manufacturing strategy (Hayes and Wheelwright, 1984; Hill, 1985) and the global manufacturing research group survey and methodology (Rho and Whybark, 1990). The response scale varied; most were likert scales (1-

5 point scales), others were rankings, and some were requests for percentage estimates or counts, such as product yield rate.

The improved questionnaire was mailed to a cross-section of selected manufacturers all over Australia. A total of 1000 manufacturers were randomly selected, although the authors ensured that they were true manufacturers, not importers. Manufacturers mostly comprised of mechanical, electrical and electronic product manufacturers. The sample was selected so that small, medium, and large manufacturing firms as well as local, foreign and jointly owned firms were represented. Demographic representation was also taken into consideration. Quality managers were requested to complete the questionnaire, as the task of dealing with the quality and reliability issues is a quality manager's major responsibility. In order to increase response rate, a covering letter was sent to each respondent explaining why the research was being carried out and emphasising the fact that they could remain anonymous. The questions asked were also kept very simple and the participants were offered access to the survey results, if they so wished.

Among 1000 questionnaire sent, 40 were returned because whether the recipient changed the address or closed the business. Some of the respondents informed that they are no longer in manufacturing and started importing from overseas. One hundred and sixty-five responses were received from the survey with an overall response rate of 17.2%. This response rate compares favourably with the response rates of McDougall et al. (1994) at 11%; Sharma (2003) at 11.42%, Reed at el. (2002) at 7%, Vaughan and Sutcliffe (1996) at 12.5%, Gilgeous and Gilgeous (2001) at 15.4%, Walley et al. (1994) at 12% and Koch and McGrath (1996) at 6.5% and similar to responses reported by Yusuf and Adeleye (2002) at 18.16%, Yusuf et al. (2004) at 18.17%, Sohal et al. (2001) at 18%. Most of the questionnaires were completed by the quality managers and the rest were completed by senior level managers (such as the manufacturing manager, production manager etc) dealing with Q & R in their company.

Statistical techniques such as descriptive analysis, analysis of variance (ANOVA), cross tabulation etc. were used for analysing the data. Reliability tests were conducted for all variables studied. For example, competitive advantage factors had an F -statistic of 32.6 at p= 0.00 and a α coefficient of 0.621. Also, an F -value of 11.6 at p= 0.00 and a α coefficient of 0.895 were computed for measures of difficulties faced. As for the measures of advanced quality practices, F value 9.98 at p = 0.00 and a α coefficient of 0.791 were computed. Significant F -values indicate that each of the variables employed to measure a concept is unique. Also, minimum α value of 0.60 for such variables means that the variables converge and are good measures of the concept studied (Cronbach, 1951)**.** Results of the reliability tests are presented in Table 1.

Table1: Reliability of constructs

	Cronbach's Alpha	F statistic		χ^2 analysis	
	α	F value	p	χ^2	p
Competitive factors	0.621	32.62	0.000	118.5	0.000
Difficulties faced	0.895	11.60	0.000	191.69	0.000
advanced quality practices	0.791	9.98	0.000	151.36	0.000

4. Results and Discussions

4.1 Competitive advantage factors

Leading manufacturers in Europe, Japan, and the USA have been reported as focusing on certain broad categories of performance measures, namely: on-time delivery; product quality; customer satisfaction; employee morale; efficiency and utilisation; and product development (CIMA, 1996; Ittner and Larcker, 1998; Maskell, 1989). In this study, a list of competitive factors was prepared in the perspective of Australian manufacturers. The respondents were asked to indicate the level of agreement to the competitive advantage factors for their company. The respondents were asked to rate the importance of a list of factors that impact on the market success on a Likert scale ranging from 1 for strong agreement to 5 for strong disagreement.

The results are presented in Table 2. The overall finding was that the product Q & R and company reputation are thought to be the largest competitive factors for a company. Our discussion with people in some of the companies revealed that company reputation was also directly related to Q & R of product. Companies who deliver quality products have good reputations. To verify this, a cross tabulation between competitive factors product Q & R and company reputation was conducted and the result is shown in Table 3. A chi square value of 45 and significance value of 0.000 proved the complete dependency of these two factors. It may not be surprising that company reputation and product Q & R were ranked almost at the same level, since these are in fact complementary to each other. It can be concluded that product quality & reliability is the main factor for success. This result is in agreement with the similar study by Sohal at el. (1999). That study also found that the product quality is the main factor for success for Australian industries.

Following these is their design and manufacturing capability and time to market, with others much further behind, all fairly equal. Surprisingly, contrary to common belief, price ranked as relatively less important factor. There could be several reasons behind this. One of the reasons could be that, if the price was a factor for the customer, they were already sourcing in cheap markets. Australian manufacturers are not competing in these markets anymore. Only those who found other advantages in purchasing from local manufacturers such as lower transportation costs, better product quality, easier and direct communication, increased probability of getting quick replacement in case of faulty product, no import duty, shorter lead time etc. are sourcing in Australia. Another reason could be that, the manufacturers already have adjusted price to a tight level in the face of intense competition. This finding is in disagreement with the study of Sohal et al. (1999). Sohal et al. reported product price to be the second most important factor whereas the current study found it to be the least important factor. Probably the Australian manufacturers have adjusted the product price in the last 5 years and it is no longer as an important factor for them.

Table 2: Descriptive Statistics on competitive factors

	N	Mean	Std. Deviation
Marketing (CF1)	161	1.48	0.613
Company reputation (CF2)	161	1.54	0.642
Product quality and reliability (CF3)	157	1.78	0.811
Design and manufacturing capability (CF4)	160	2.01	0.897
Time to market (on time delivery) (CF5)	160	2.14	0.931
Price (CF6)	148	2.3	0.892

Table 3: Chi-Square Tests on company reputation and product Q & R

	Value	Asymp. Sig. (2-sided)
Pearson Chi-Square	45.193	.000
Likelihood Ratio	43.226	.000
Linear-by-Linear Association	33.520	.000
N of Valid Cases	161	

The above results suggest that market success is perceived to depend on capability to produce high performance reliable products. Conceptually, the strength of a firm's `foundation’ on a given dimension can be ascertained by `weighting' the reported degree of emphasis with the level of improvement in its recent history. Wood et al. (1990) demonstrate that good manufacturing performance seems to follow when a firm's intended competitive objectives (emphasis or importance) and its achievements (improvement or performance) are aligned. In a separate section companies were requested to indicate the degree of improvement in product Q & R in previous two years. An ANOVA analysis was performed to establish the relationship between product quality and reliability as a competitive factor and the quality improvement in last two years as shown in Table 4 and Figure 1. It can be seen that the companies consider Q & R as competitive factors have continuously improved product quality.

Table 4: ANOVA results of CF3 and quality improvement

Competitive factor	**Relationship with**	**F-value**	**Significance**
Product quality and reliability	Improvement in quality in previous 2 years	6.649877	0.0003

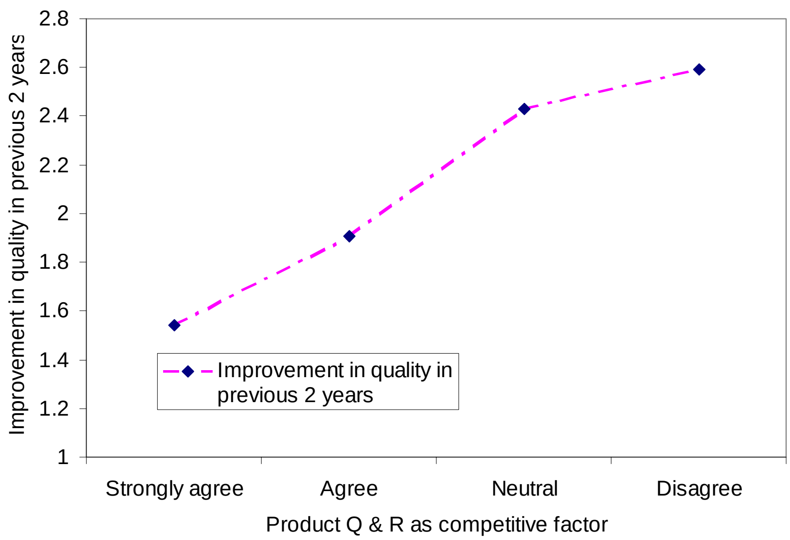

Figure 1: relationship between CF3 and improvement in quality in previous 2 years.

4.2 Difficulties facing by the companies

In the survey, respondents were asked to indicate whether or not their companies were experiencing problems in the areas listed in the questionnaire. They were requested to show the level of agreement to the problem areas between 1 and 5, where 1 is strong agreement and 5 is strong disagreement. The results are presented in Table 5.It is interesting to note that none of the suggested area has a mean score above 3.5, i.e. towards disagreement. This means that the participants are in general neither agreeable not disagreeable that they are facing problems in the areas mentioned. It can be translated as the companies are not comfortable or satisfied with current performance in these areas. It should be noted that companies in general have natural tendency not to disclose problems they have in the fear that would affect their business interest and would give competitors an advantage.

Table 5: Descriptive statistics on difficulties faced

	N	Mean	Std. Deviation
Product development (MD1)	146	3.08	1.133
Manufacturing process (MD2)	157	3.05	1.085
Quality assurance (MD3)	157	3.45	1.088
Product Reliability (MD4)	156	3.42	1.104
Failure analysis (MD5)	153	3.44	1.140
Product yield (MD6)	142	3.38	.995
Statistical evaluation of failures (MD7)	145	3.07	1.097
On time delivery (MD8)	159	3.10	1.233

4.3 Advanced quality practices

The respondents were requested to show the level of agreement to the advanced quality practices listed in Table 6 between 1 and 5. It can be seen that mean values of all these advanced quality practices are below 3 and mostly around 2. This means that most companies in general either practicing or agreeable with the advanced quality practices suggested in the questionnaire. The respondents provided strong emphasis to the initiatives like awareness of customer requirements, emphasis of quality during design, systematic review of contract and Q & R estimation during design.

Table: 6 Descriptive statistics of advanced quality practices

Advanced quality practices	N	Mean	Std. Dev.
Emphasis to quality during design (AQP1)	147	1.78	.781
Prediction of Q & R before manufacturing (AQP2)	145	2.00	.943
Awareness of customer requirements and priorities (AQP3)	159	1.67	.759
Systematic review of contract (AQP4)	153	1.96	.966
Awareness of design team about manufacturing capabilities and difficulties	146	2.01	.928
Effective communication during design of a new product (AQP6)	146	2.15	.992
Use of field failure and manufacturing data during design (AQP7)	142	2.11	1.004

4.4 Impact of advanced quality practices on manufacturing difficulties

It is important to know how the advanced quality practices affected company performance or how advanced quality practices and manufacturing difficulties (MD) are related. ANOVA statistics was carried out to investigate the influence of advanced quality practices on the difficulties companies are facing. The first initiative analysed was 'estimation of Q & R before manufacturing'. In the theoretical formulation it was assumed that advanced quality practices has influence on difficulties faced and other manufacturing and Q & R performance. The null hypothesis is that the advanced quality practices have no affect on difficulties i.e. means of difficulties related to agreement level of 'estimation of Q & R before manufacturing' (AQP2) are equal. The results are shown in Table 7. Only two respondents indicated 'strong disagreement' in advanced quality practices. Therefore, these responds can be considered as outlier. Eventually we did not take into consideration these values.

Table 7: ANOVA results of MDs and AQP2

Difficulties	**F-value**	**Significance**
Product development	1.291	0.280
Manufacturing process	5.862	0.001
Quality assurance	7.621	0.000
Product Reliability	4.460	0.005
Failure analysis	6.900	0.000
Product yield	5.647	0.001
Statistical evaluation of failures	11.166	0.000
On time delivery	4.802	0.003

It can be seen that other than product development, all the factors have significant F-vales (<0.05). Significant F-values rejected the null hypothesis that means are equal and suggests that means vary significantly. Significance value is so small that most are showing 0.000. Only product development is found to have no strong relationship with estimation of Q & R before manufacturing (sig. Value 0.28). It is understandable because product development depends on many factors (competitive pressure for example) and estimation of Q & R may not be directly related to this. However, the table shown above does not tell us how the difficulties faced are related to Q & R estimation. Means plot in SPSS was drawn to establish the relationship of Q & R estimation with difficulties, as shown in Figure 2. In general, F statistics establish that there is or is not a difference between group means, and means plots suggest where the difference may lie.

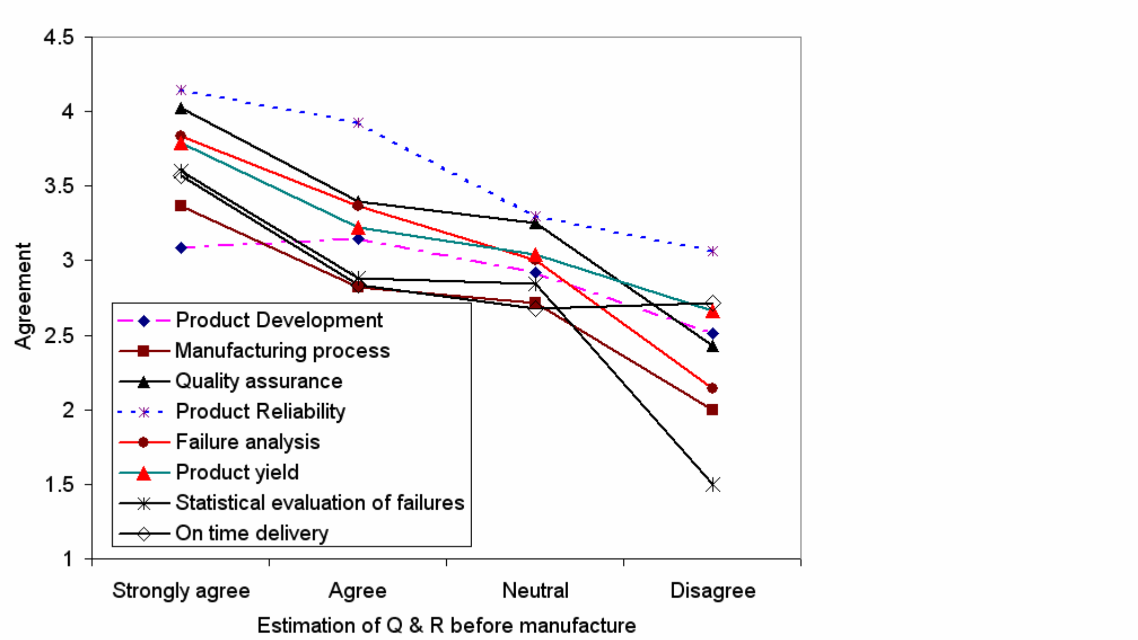

Figure 2: Relationship between manufacturing difficulties and estimation of Q & R before manufacturing

It can be seen that most of the difficulties are strongly (negatively) correlated with Q & R estimation. From this figure it is clearly established that companies emphasize Q & R at the beginning of manufacturing are not facing difficulties in general (mean value more than 3.5). Less the emphasize given to the Q & R estimation, more difficulties faced. All the constructs show similar trend of relationship. It can be seen that Q & R estimation has strong effect on statistical evaluation of failure and weak effect on on-time delivery. It is understandable because if the companies have estimation product Q & R at the beginning, they trace the product performance in the field and keeps records of warranty returns. Hence they have sufficient data for statistical evaluation. Related to this is quality assurance and manufacturing process. If the company have estimation of product Q & R, they generally have measures to minimize the predicted uncertainties or quality problems. On the other hand, if the companies do not have failure analysis at the beginning, they act only when problems come. This type of 'fire fighting' approach causes changes in manufacturing setting, reproduction etc. It will eventually affect manufacturing performance and quality assurance. It seems that OTD is less sensitive to the Q & R estimation during design. It seems contrary to the other results. Because the companies have difficulty in manufacturing and quality assurance should have similar difficulty in OTD. However, OTD also depends on other factors such as supply from vendors. Moreover, OTD is a relative measure and is often negotiable (with customer). The companies facing difficulty in OTD tend to seek more time during contract hence reduce the effect of OTD. Thus, it is understandable that OTD is not as strongly related as other difficulties.

The ANOVA results of advanced quality practice ‘effective communication’ (AQP6) and ‘use of field failure data’ (AQP7) are presented in Tables 8 and 9 respectively.

Table 8: ANOVA results of MDs and AQP6

Difficulties	F-value	Significance
Product development	1.744	0.161
Manufacturing process	8.145	0.000
Quality assurance	6.455	0.000
Product Reliability	2.768	0.044
Failure analysis	3.946	0.010
Product yield	2.286	0.082
Statistical evaluation of failures	8.442	0.000
On time delivery	5.081	0.002

Table 9: ANOVA results of MDs and AQP7

Difficulties	F-value	Significance
Product development	1.134	0.338
Manufacturing process	7.551	0.000
Performance of the product	3.746	0.013
Quality assurance	4.319	0.006
Product Reliability	2.780	0.044
Failure analysis	4.827	0.003
Product yield	4.110	0.008
Statistical evaluation of failures	3.640	0.015
On time delivery	2.902	0.037

From Table 8 it can be seen that means of most of the variables differ significantly ($p < 0.05$). However, no significant difference was reported in means of product development and product yield. Similarly, all variables except product development have significant F-value in Table 9. The means plots, as shown in Figure 3 and 4 respectively for AQP6 and AQP7, show the relationship of difficulties with AQP6 and AQP7.

From the figures it can be concluded that difficulties faced are closely related to the degree of emphasize placed on advanced quality practices. Companies placed more emphasize on these two advanced quality practices have fewer problems in manufacturing practices. From the figures it can also be seen that product development is not strongly related to the effective communication and use of field failure data. The reason for insignificant relationship of product development with estimation of Q & R during design has been explained earlier. The same reason is applicable here. Product yield also do not have statistical significant relationship with effective communication, as shown in Table 8. It is expected, as product yield may not be directly related to effective communication.

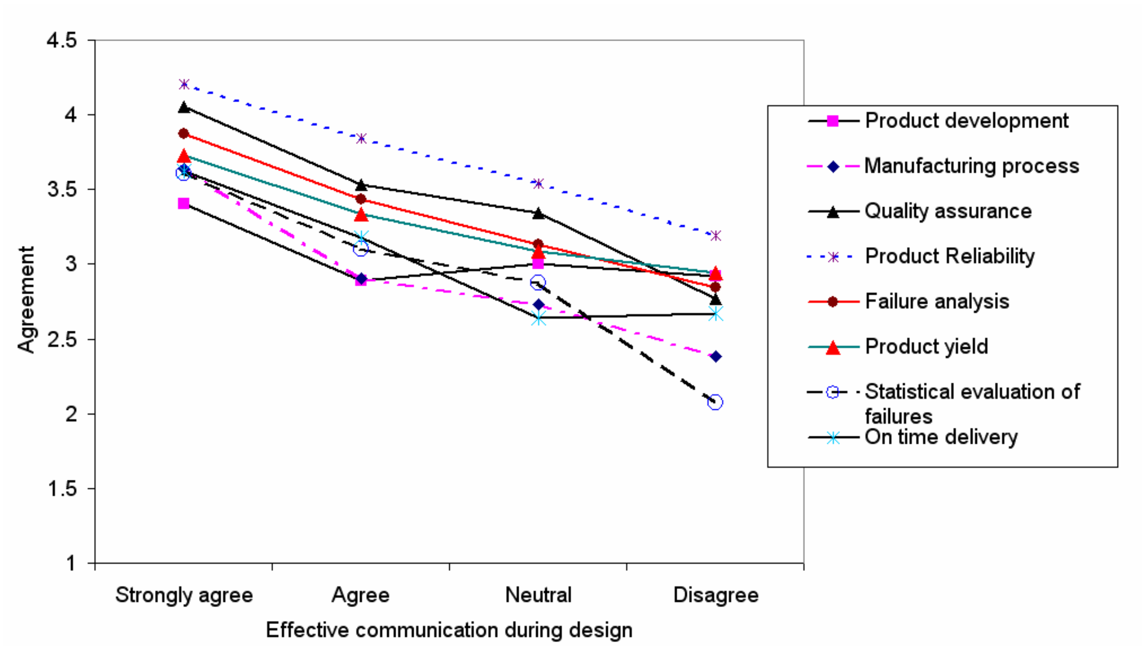

Figure 3: Relationship between manufacturing difficulties and effective communication

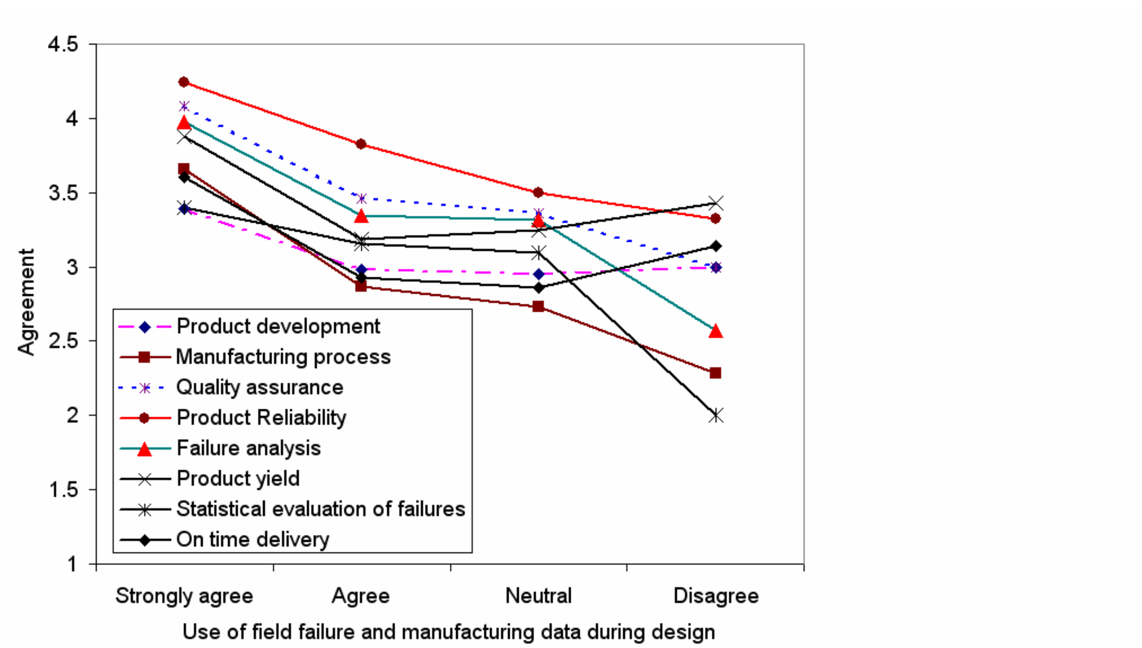

Figure 4: Relationship between manufacturing difficulties and use of field data

4.5 Impact of advanced quality practices in company performance

It is of interest how these advanced quality practices have contributed to the company performance. Product capacity utilization, product yield rate, on-time delivery, customer return rate (of faulty products), and quality improvement in previous 2 years were considered as performance measurement indices. The relationships of performance variables with AQP7, use of field failure data, are shown in Figure 5 and 6.

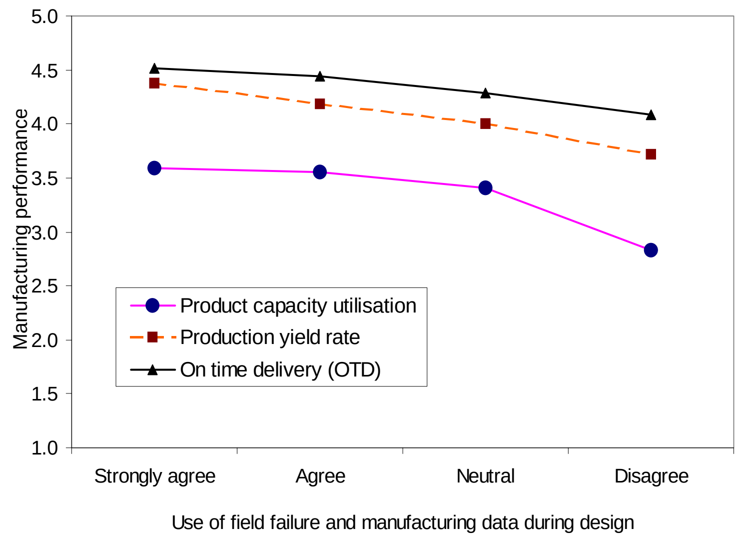

Figure 5: Relationship between AQP7 and manufacturing performance

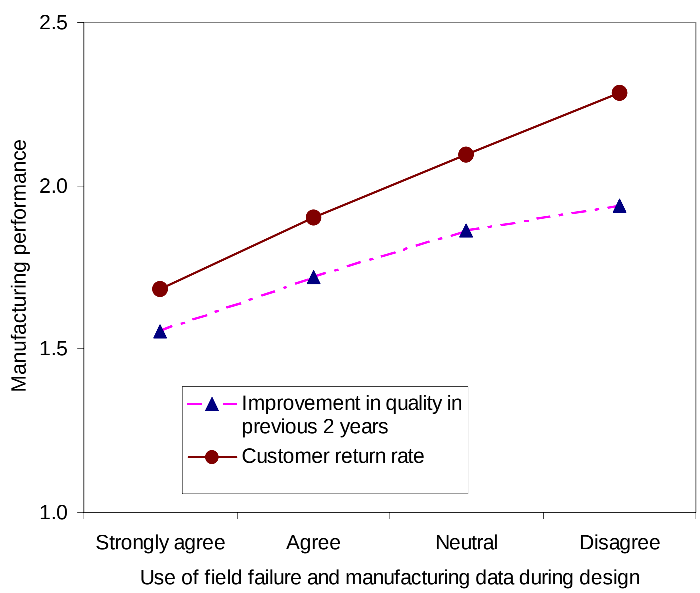

Figure 6: Relationship between AQP7 and Q & R improvement of the product

The companies use field failure data reported better product capacity utilization, product yield rate and on-time delivery. They also reported lower customer return rate and significant improvement in product quality. Similar results were also found for other AQPs. For example estimation of Q & R at the beginning resulted in better improvement in quality and less faulty product return as shown in Fig-7.

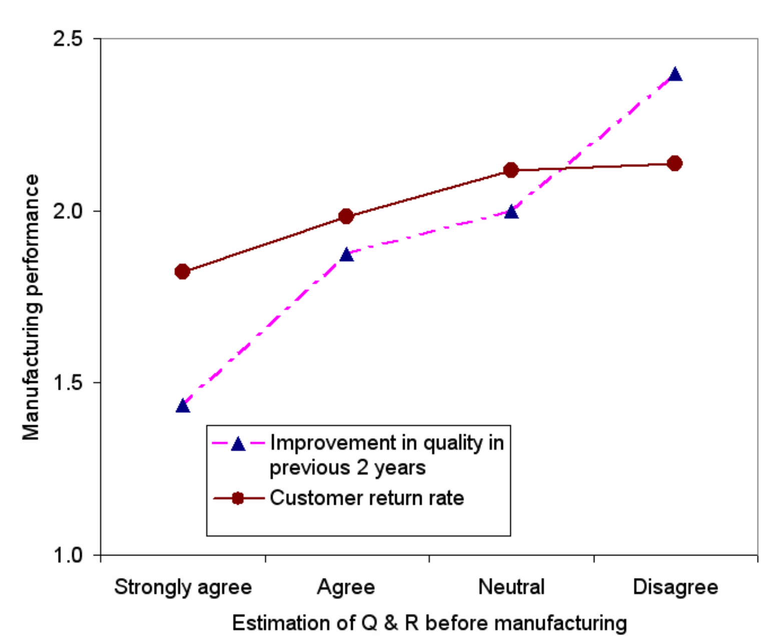

Figure 7: Relationship between AQP2 and Q & R improvement of the product

The survey results reported in this study provide empirical evidence that company performance and difficulties are strongly related to advanced quality practices initiated by the companies.

The results indicate that simultaneous pursuit of all advanced quality practices has the potential for higher levels of attainments on a broad range of performance measures.

4.6 Impact of contextual factors on advanced quality practices

ANOVA was carried out to test the dependability of advanced quality practices on contextual factors like firm size, ownership etc. The ANOVA results of advanced quality practices and company size (number of employees) are shown in Table 10.

From the table it can be seen that no significant relationship (sig.>0.05) is found between advanced quality practices and company size. Similar results were found for other contextual factors. It can be concluded that the advanced quality practices are independent of contextual factors considered in this study.

Table 10: ANOVA results of AQPs and number of employees

	F	Sig.
Emphasis to quality during design	.710	.493
Q & R estimation before manufacturing	.050	.952
Awareness of customer requirements and priorities	.854	.428
Systematic review of contract	.544	.581
Awareness of design team about man. capability and difficulty	.339	.713
Effective communication during design of a new product	.019	.982
Use of field failure and manufacturing data during design	.655	.521

5. Conclusions

Manufacturing is an important sector for the Australian economy. Statistics suggest that manufacturing sector has found competition and structural changes difficult to cope with, which is having an adverse effect on the rest of the economy. Under new challenges Australian companies are faced with the necessity of improving their performance and competitive capabilities.

The present study was undertaken to investigate the current manufacturing practices and their effectiveness and nature and extent of the problems faced by the Australian manufacturers in the face of new challenges. The study revealed that Q & R of the product is the most important competitive factor for the manufacturers. Australian manufacturers in general have difficulties in performing manufacturing practices. These difficulties found to have direct relationship with quality practices. Companies have more emphasize on quality practices have less problem in manufacturing practices. Moreover, companies who are implementing the advanced quality practices have managed to improve the quality of the product continuously.

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