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A conceptual model for manufacturing performance improvement

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ABSTRACT

Purpose: Important performance objectives manufacturers sought can be achieved through adopting the appropriate manufacturing practices. This paper presents a conceptual model proposing relationship between advanced quality practices, perceived manufacturing difficulties and manufacturing performances.
Design/methodology/approach: A survey-based approach was adopted to test the hypotheses proposed in this study. The selection of research instruments for inclusion in this survey was based on literature review, the pilot case studies and relevant industrial experience of the author. A sample of 1000 manufacturers across Australia was randomly selected. 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.
Findings: Evidence indicates that product quality and reliability is the main competitive factor for manufacturers. Design and manufacturing capability and on time delivery came second. Price is considered as the least important factor for the Australian manufacturers. Results show that collectively the advanced quality practices proposed in this study neutralize the difficulties manufacturers face and contribute to the most performance objectives of the manufacturers. The companies who have put more emphasize on the advanced quality practices have less problem in manufacturing and better performance in most manufacturing performance indices. The results validate the proposed conceptual model and lend credence to hypothesis that proposed relationship between quality practices, manufacturing difficulties and manufacturing performances.
Practical implications: The model shown in this paper provides a simple yet highly effective approach to achieving significant improvements in product quality and manufacturing performance. This study introduces a relationship based 'proactive' quality management approach and provides great potential for managers and engineers to adopt the model in a wide range of manufacturing organisations.
Originality/value: Traditional ways of checking product quality are different types of testing, inspection and screening out bad products after manufacturing them. In today's manufacturing where product life cycle is very short, it is necessary to focus on not to manufacturing them first rather than screening out the bad ones. This study introduces, for the first time, the idea of relationship based advanced quality practices (AQP) and suggests AQPs will enable manufacturers to develop reliable products and minimize the manufacturing anomalies. This paper explores some of the attributes of AQP capable of reducing manufacturing difficulties and improving manufacturing performances. The proposed conceptual model contributes to the existing knowledge base of quality practices and subsequently provides impetus and guidance towards increasing manufacturing performance.
Keywords: Conceptual model; Advanced Quality Practices; Manufacturing performance; Product quality; Questionnaire survey

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1. Introduction

The globalization 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. 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. Under the new circumstances, the organization must deliver a reliable product, or service, on time and ensure that customer requirements are fulfilled.

The demands for product quality and reliability have changed over the period. Customers expect high quality product with increasing functionality even in inexpensive products [1]. Matching with the increasing customer demand, there is a trend of increasing warranty period. For example, any electrical and electronic item must have one-year warranty in Australia but 3-5 years of warranty is not uncommon. 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 prediction of product and process failure at design stage, monitor predicted quality and reliability throughout the product life cycle and feedback from the customers. This has transformed organizations 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 [2]. Organizations can build competitive advantages through superior manufacturing, but sustaining the competitive advantage over time requires comparable skills in continual improvement of quality and reliability (Q & R) of existing products and developing a continual stream of quality new products. A company can continuously improve its product Q & R by fostering organizational learning and utilising individual and group knowledge within and outside the company.

The manufacturing sector plays an important role in the Australian economy. Presently, the manufacturing sector faces unprecedented levels of competition in both the domestic and international markets. Globalization and gradual reduction of tariffs have put the companies in 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 [3]. Australia's unsatisfactory industrial performance has been a matter of increasing concern [4]. Literature also reported the inadequate quality level of Australian products. Sohal et al. [5] showed that Nippondenso, one of the leading automobile parts manufacturers in Australia, struggled to compete with its parent company in Japan. Nippondenso Japan is able to provide higher quality components at lower prices.

In view of increasing concern over Australian manufactured goods, the authors have been motivated to conduct a study to understand the current manufacturing practices of Australian companies and identify manufacturing practices that provide best manufacturing performances. To the best of the authors' knowledge, no such study has been conducted in the new circumstances. There is a need to investigate the nature and extent of the problems confronting manufacturers in the face of new challenges.

A conceptual model of advanced quality practices (AQP) as determinants of manufacturing competitiveness and performance is proposed. It is also hypothesized that adoption of proposed AQPs would reduce the effects of manufacturing difficulties. Results validated the model proposed. Investigation shows that the AQPs are positively correlated with manufacturing performance and negatively correlated with manufacturing difficulties.

2. Conceptual model

A pilot study on some Australian manufacturers was conducted earlier [6]. In that study the following key observations can be made:

- Product Q & R is the main competitive factor for Australian manufacturers. However, manufacturers are facing problems to improve their product Q & R. They do not have an effective programme in place to improve the quality of product.
- Manufacturing is under increased time-constraint. Most of the companies surveyed have problem in on-time delivery in full.
- Product price is the least important factor among the factors considered in this study, as long as manufacturers can deliver quality product on time.

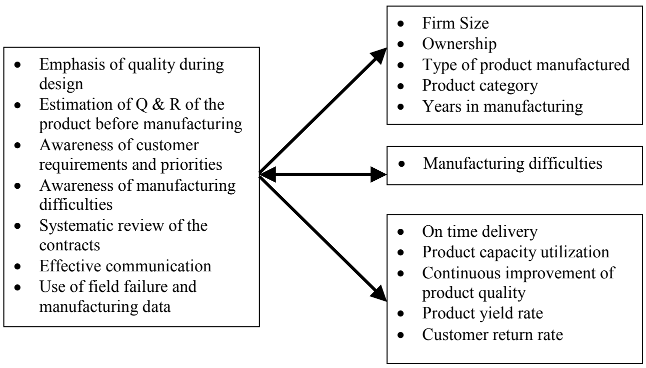

Fig. 1. Theoretical framework

From the pilot study, it is clear that the Australian manufacturers are facing difficulties in coping with the intense competition due to the changing circumstances. They are facing difficulties in some of the manufacturing areas as well as manufacturing performance measures. In this study a conceptual model is formulated which proposes that adoption of certain advanced quality practices can neutralize the manufacturing difficulties and can help improving the manufacturing performances. The model comprise of the following hypotheses:

H1: The simultaneous pursuit of AQPs can neutralize the potential negative impacts of manufacturing difficulties.

H2: The product Q & R and manufacturing performances of the companies are influenced by AQPs like Q & R estimation during design, use of field failure and manufacturing data, effective communication, awareness of customer requirements etc.

H3: The framework also postulated that the AQPs might be influenced by contextual factors such as the firm size, ownership, type of goods produce, innovation pace in the company etc.

The schematic diagram of the theoretical framework of this research is presented in Fig. 1.

3. Research method for questionnaire survey

3.1. The questionnaire and its distribution

A questionnaire was designed which sought to test the hypotheses proposed. The selection of research instruments for inclusion in this survey was based on literature review, the pilot case studies and relevant industrial experience of the authors. To ensure that the questionnaire was relevant and valid, it underwent rigorous evaluation by the research team and was pilot-tested by ten experts (seven academics and staffs from two manufacturers). Finally some improvements were made based on the opinions obtained from these experts.

The questionnaire contained two major sections. The aim of the first section was to build up a profile of the manufacturing companies for later comparisons. This section comprised of the questions related to number of employees, annual revenue, category and type of the product manufactured, introduction of new products per year etc. The second part contained questions covering areas of manufacturing practices; namely, competitive factors, manufacturing difficulties, and advanced quality practices. Manufacturing performance was determined across different measures. The response scales varied; most were in Likert scales (1-5 point scales). For instruments measured on 1-5 Likert scales, 5 stands for strongly disagree, least important or strongly deteriorated whereas 1 implies strongly agree, most important or strongly improved. As well, a 3 stands for modest or neutral. For the performance measures, like production capacity utilization, product yield rate, customer return rate of faulty product and on time delivery, respondents were requested to mention the current level as a percentage.

For the mail survey across Australia, a total of 1000 manufacturers were randomly selected. Demographic representation was taken into consideration in selecting the companies. 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. 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.

3.2. Response and data analysis

A response rate of 17.2% was obtained. This response rate compares favourably with the response rates of McDougall et al.[7] at 11%; Reed at el. [8] at 7%, Vaughan and Sutcliffe [9] at 12.5%, Walley et al. [10] at 12% and Koch and McGrath [11] at 6.5%. 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, CEO etc) dealing with Q & R in their company.

It was critical to ensure the content validity and reliability of the questionnaire. Validity generally determines whether the measuring instrument is indeed measuring what it purports to measure and reliability refers to consistency [12]. Content validity is a judgement, by experts, of the extent to which a question truly measures the concept it was intended to measure. Content validity cannot be determined statistically; it only can be determined by experts and by the reference to the literature [13]. It was mentioned earlier that the questionnaire was vigorously tested by several academic experts for its content validity. It was also tested by experts in industry. Validity of the questionnaire was thus demonstrated.

Standard procedure to statistically determine the instrument reliability is the determination of Cronbach's coefficient alpha. Moreover, data reliability requires that instruments measuring the same construct should be sufficiently different from other instruments. That means, although the questions should be consistent, they should not be repetitions of the same question. The *F*-test in reliability analysis is used to measure the uniqueness of the variables. Reliability tests were conducted for all the variables studied as a measure of the internal consistency of the research instruments employed to measure concepts. All the constructs had significant F and α values. Competitive advantage factors (CF) had an *F* -statistic of 32.62 at $p \approx 0.00$ and a α coefficient of 0.621. Also, an F -value of 11.6 at $p \approx 0.00$ and a α coefficient of 0.895 were computed for measures of difficulties faced (DF). As for the measures of AQPs, F value 9.98 at $p \approx 0.00$ 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 and not the repetition of the same variable. Also, minimum α value of 0.60 for such variables means that the variables are internally consistent and are good measures of the concept studied [14].

Statistical techniques such as descriptive analysis, factor analysis, analysis of variance (ANOVA) and cross tabulation were used for analysing the data.

4. Results and analyses

This section discusses a number of the key findings from the survey.

4.1. Competitive priorities

Determining competitive priorities of manufacturers is considered one of the key elements in manufacturing strategy

[1,15]. However, not much research has been devoted to measurement of these priorities [16]. In this study it was attempted to identify competitive priorities especially under the new circumstances. Similar to the pilot study, 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.

In rank order the importance of competitive priorities are shown below (the mean scores are shown in the brackets):

1. Company reputation (1.48)
2. Product quality and reliability (1.54)
3. Design and manufacturing capability (1.78)
4. On time delivery (2.01)
5. Price (2.14)
6. Marketing (2.3)

The proportions of respondents for each factor are shown in Figure 2. It is evident that company reputation ranked number one closely followed by product quality and reliability. This result is slightly different from the findings of pilot study. To clarify this we consulted a few respondents. Our discussion with them revealed that company reputation was directly related to Q & R of their products. Companies who deliver quality products generally have good reputations. To verify this, a cross tabulation between product Q & R and company reputation was carried out in SPSS. 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 (1.48 and 1.54 respectively), since these are in fact complementary to each other. It can be concluded that product quality & reliability is the main competitive factor for the manufacturers. This result is in agreement with the similar study by Sohal at el. [17]. That study also found the product quality as the main success factor for Australian industries.

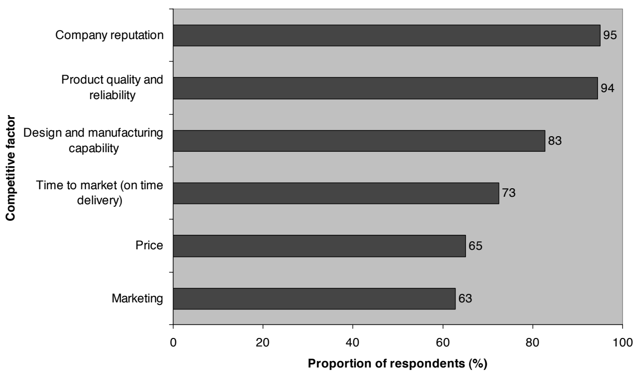

Fig. 2. Competitive priorities of Australian manufacturers

It is generally thought that Australian manufacturers are unable to compete foreign products because of its high labour and production cost. Surprisingly, contrary to common belief, price ranked as the least important factor. This finding is in disagreement with the study of Sohal et al. [17]. Sohal et al. reported product price to be the second most important factor whereas the current study found price to be the least important factor. Probably in the changing circumstances competitive priorities have been changed. Kim [18] reports that companies' competitive priorities change over the period to match the changing circumstances. We have talked to a few respondents regarding this issue. One of the automotive component manufacturers informed us that they export components to India and Korea. His opinion is that if high quality and durability can be assured, people are ready to pay higher. For many products, manpower cost is very insignificant compared to the total production cost.

Competitive priorities of Australia was compared with that of world's leading industrial countries [18] in order to place the results in a wider international context. The results are shown in Table 1. In Kim's study quality and reliability were considered as separate factors. However the authors found that quality and reliability are closely interrelated; hence these two were considered as one factor in the present study. It can be seen that other than Japan, all countries placed product quality and reliability on top of the competitive priority list (although Australia put company reputation on top, it was shown earlier that this is highly correlated with product Q & R). It may seem unusual that Japan placed price as number one competitive factor. Kim [18] reported that five years earlier Japan also considered product quality and reliability as the main competitive factor. Japanese manufacturers believe that they have attained sufficient level of product quality and reliability and now they need to emphasise on cost reduction to increase the market share. However, product reliability still is the 2nd most important competitive factor for Japan. As most of the leading manufacturers consider product quality and reliability as the main competitive factor, it can be concluded that the world market is a battle of quality (and reliability). Companies must produce high quality product in order to capture a market share in the competitive market.

Table 1
Comparison of competitive priorities (degree of importance)

	US	Europe	Japan	Australia
1	Conformance quality	Conformance quality	Low price	Company reputation
2	Product reliability	Product reliability	Product reliability	Product quality and reliability
3	On-time delivery	On-time delivery	On-time delivery	Design and manufacturing capability
4	Low price	Low price	Fast delivery	On time delivery
5	Fast delivery	Fast delivery	New products speed	Price

4.2. Difficulties facing by the manufacturers

To validate the findings of pilot study under wider Australian context, respondents of the questionnaire survey were asked to indicate whether or not their companies were experiencing problems in a list of manufacturing areas. Similar to the pilot study, 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. In rank order the significance of manufacturing difficulties are shown below (the mean scores are shown in the brackets):

1. Manufacturing process (3.05)
2. Statistical evaluation of failures (3.07)
3. Product development (3.08)
4. On time delivery (3.1)
5. Product yield (3.38)
6. Product Reliability (3.42)
7. Failure analysis (3.44)
8. Quality assurance (3.45)

The mean scores for all the variables are between 3 and 3.5. This means that collectively the participants are neither agreeable not disagreeable that they are facing problems in the areas mentioned. This result looks different from findings of the pilot study. 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. However, if we look into the respondents for each factor separately, a better picture can be observed. Figure 3 shows the proportions of the companies who said that they do not have difficulties in the suggested areas. Only for product reliability and quality assurance more than 50% respondents said that they did not have difficulties. For all other factors, more than 50% respondents either agreed or remained neutral about the manufacturing difficulties.

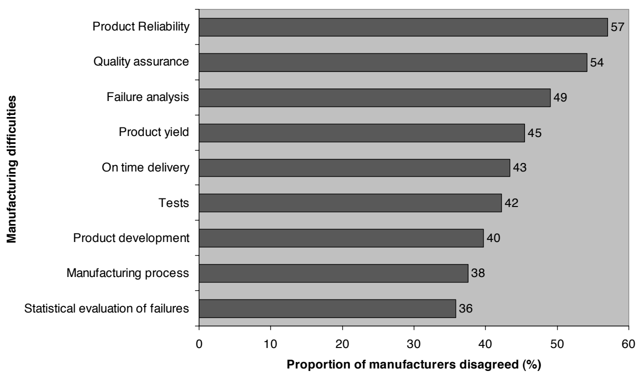

Fig. 3. Manufacturing difficulties: proportion of respondents

In order to test whether the variables used to measure the manufacturing difficulties can together be used as composite measure of manufacturing difficulty, a factor analysis in SPSS was carried out. Factor analysis resulted in two factors. 'On time delivery' fell in one group (factor 2) and all other variables fell in another factor. This indicates that on time delivery does not measure item measured by other variables. In fact on time delivery does not depend on manufacturing process only. It depends on other factors as well such as supply from vendors. Moreover, OTD is a relative measure and is often negotiable (with customers). The companies anticipate 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 manufacturing difficulties. Eventually on time delivery was removed as a measure of 'manufacturing difficulty'. Factor analysis was re-run excluding OTD and all the items grouped into one factor. The results are shown in Table 2. High factor loadings indicate the strength of relationship. Kaiser-Meyer-Olkin (KMO) measure of sampling adequacy of 0.872 and significance value of 0.00 was achieved which validates the factor model derived.

Table 2.
Factor model of manufacturing difficulties

Manufacturing difficulties	Factor loading with Manufacturing difficulties
Failure analysis	0.819
Quality assurance	0.808
Tests (screening, stress, environmental, accelerated etc)	0.759
Product Reliability	0.759
Product yield	0.754
Statistical evaluation of failures	0.717
Product development and design	0.678
Manufacturing process	0.676

4.3. Advanced quality practices

In the theoretical formulation it was proposed that attainment in some advanced quality practices can reduce the impact of manufacturing difficulties identified during pilot study and eventually contribute to the better manufacturing performances. Traditional ways of checking product quality and reliability are different types of testing and inspection. Traditionally, to meet the customer requirements, companies focus on screening out bad products after manufacturing them. Screening does not guarantee that a component will not fail in the field. It simply shifts the responsibility for assuring reliable product from manufacturer to the customer. So, it is necessary to focus on not to manufacturing them first rather than screening out the bad ones [19]. This study proposes that attainment of the suggested AQPs will enable manufacturers to develop reliable products and minimize the manufacturing anomalies.

The respondents were requested to show the level of agreement to the AQPs between 1 and 5. The results are listed below according to rank order (mean values are shown in brackets):

1. Emphasis to quality during design (1.78)
2. Q & R estimation before manufacture (2.00)
3. Awareness of customer requirements and priorities (1.67)
4. Systematic review of contract (1.96)
5. Awareness of design team about manufacturing capabilities and difficulties (2.01)
6. Effective communication during design of a new product (2.15)
7. Use of field failure and manufacturing data during design (2.11)

The mean values of all these AQPs are below 3 and mostly around 2. This means that most companies in general either practicing or agreeable with the AQPs suggested in the questionnaire. The manufacturers provided strong emphasis to the practices like awareness of customer requirements, emphasis of quality during design, systematic review of contract and Q & R estimation during design.

In order to test whether all these variables collectively measure one thing, a factor analysis was carried out and the results are presented in Table 3. The results show that all the variables grouped in one factor, which indicates that variables used, are adequate to measure the AQP. A KMO measure of sampling adequacy value of 0.819 and significance value of 0.00 validates the factor model derived.

Table 3.
Factor models of advanced quality practices

Advanced quality practices	Factor loading with AQP
Emphasis to quality during design (AQP1)	0.814
Q & R estimation during design (AQP2)	0.770
Effective communication during design of a new product (AQP3)	0.750
Use of field failure and manufacturing data during design (AQP4)	0.729
Systematic review of contract (AQP5)	0.702
Awareness of customer requirements and priorities (AQP5)	0.627
Awareness of design team about manufacturing capability and difficulty (AQP6)	0.571

4.4. Testing hypothesis 1

It is important to know how the AQPs are related with manufacturing difficulties reported earlier and how they affect the company performance. In the theoretical formulation it was assumed that AQP can neutralize manufacturing difficulties and improve manufacturing and quality performances. So the null hypothesis is that the AQPs have no effect on manufacturing difficulties and manufacturing performances. ANOVA statistics was carried out to investigate the influence of AQPs on the difficulties companies are facing. First, an ANOVA was carried out for manufacturing difficulties and one of the AQPs 'Q & R estimation during design'. The results are shown in Table 4.

Table 4.
ANOVA results of manufacturing difficulties and AQP2

Difficulties	Relationship with	F-value	Significance
Product development	AQP2	1.291	0.280
Manufacturing process	AQP2	5.862	0.001
Quality assurance	AQP2	7.621	0.000
Product Reliability	AQP2	4.460	0.005
Failure analysis	AQP2	6.900	0.000
Product yield	AQP2	5.647	0.001
Statistical evaluation of failures	AQP2	11.166	0.000
On time delivery	AQP2	4.802	0.003

It can be seen that other than product development, all the factors have significant F-vales (<0.05). 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. Large F-values rejected the null hypothesis that means are equal and suggests that means of manufacturing difficulties significantly vary with attainment levels of AQPs. Significance value is so small that most are showing 0.000. Although Table 4 shows that there are significant relationships between manufacturing difficulties and AQP2, the pattern of the relationships cannot be realised from the Table. Means plot in SPSS was drawn to observe the relationship of Q & R estimation with difficulties, as shown in Figure 4.

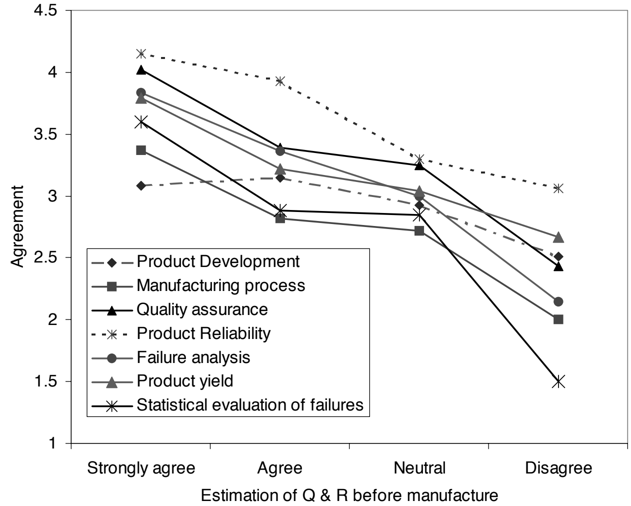

Fig. 4. Relationship between AQP2 and estimation of manufacturing difficulties

It can be seen that the manufacturing difficulties are strongly correlated with Q & R estimation. Less the emphasize given to the Q & R estimation, more difficulties manufacturers faced. All the variables measuring the AQPs show similar trend of relationship.

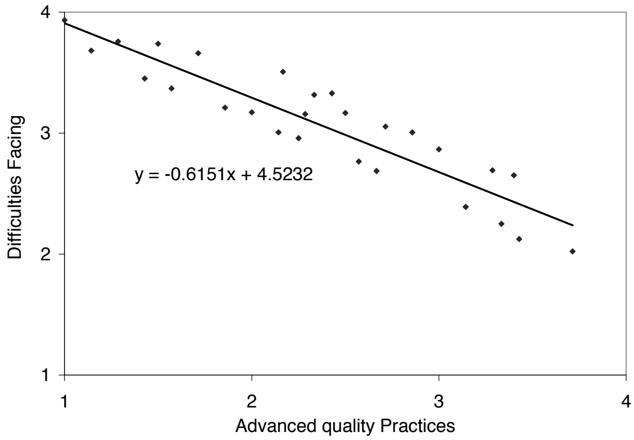

Fig. 5. Relationship between AQP and manufacturing difficulties

As the factor analysis showed that all the variables used to measure the manufacturing difficulties collectively measure one thing, scores of all the variables were summed and averaged. Similarly average score was derived for the variables used to measure AQPs. In order to establish the relationship between the composite measure of AQPs and composite manufacturing difficulties, an ANOVA was carried out. The results are shown in Figure 5. It is evident that AQP and manufacturing difficulties are linearly but negatively related. The manufacturers who place more emphasise on AQPs are likely to have less manufacturing difficulties. *F* value of 2.2 and significance value 0.001 was also achieved which proves that the relationship is statistically significant. The equation for the relationship is shown in the figure. Although true mathematical relationship is not possible as these measures are ordinal, the strength of relationship is evident from the expression. Hypothesis 1 is thus validated with minor modification in the measure of manufacturing difficulties.

4.5. Testing hypothesis 2

Literature [20] reported that important performance objectives sought to fulfill each company's manufacturing strategy were achieved through the use of appropriate practices and supporting enablers. In this study it was proposed in the conceptual formulation that attainment in AQPs can improve the company performance. 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. Good manufacturing performance seems to follow when a firm's intended emphasis or importance and its achievements (improvement or performance) are aligned [21]. As shown in Figure 1, 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. An ANOVA analysis was performed to establish the relationship between AQP and manufacturing performance indices as shown in Table 5. All performance measures except product capacity utilization have high F values, which indicate the strong relationships between AQP and manufacturing performances. Statistically significant ($p<0.05$) relationship exists between AQP and improvement in quality and number of faulty products from customers. AQP also has close relationship with on time delivery. However, product capacity utilization has poor relationship with AQP probably because it depends on many factors other than AQP. Hence, product capacity utilization is dropped as a measure of manufacturing performance.

Table 5.
ANOVA relationship between manufacturing performance and AQP

Manufacturing Performance	Relationship with	F	Sig.
Improvement in quality in previous 2 years	AQP	2.310	0.001
Product capacity utilization	AQP	0.816	0.715
Production yield rate	AQP	1.385	0.140
Customer return rate	AQP	2.260	0.003
On time delivery (OTD)	AQP	1.542	0.060

Although Table 5 shows significant relationship between manufacturing performance and AQP, the pattern of relationship cannot the understood from the table. Means plot in ANOVA shows the pattern of these relationships. Results showed that AQPs are positively related to quality improvement, on time delivery and product yield rate and negatively related to customer return of faulty products. This means that the companies who practice AQPs have higher attainment in quality improvement, product yield rate and on-time delivery and experience lower warranty claims and return of faulty products from customers. However, these plots are not shown here for the purpose of parsimony. The results validated hypothesis 2. However, little change was made in the measure of manufacturing performance.

4.6. Testing hypothesis 3

ANOVA was carried out to test the dependability of AQPs on contextual factors like firm size, ownership, age of the manufacturer and engagement in specific type or category of product. The ANOVA results are shown in Table 6. From the Table it can be seen that no significant relationship (sig.>0.05) is found between AQPs and contextual factors. It can be concluded that the AQPs are independent of contextual factors considered in this study. Hypothesis 3 is thus rejected.

Table 6.
ANOVA results of composite AQP and Contextual factors

	Relationship with	F	Sig.
Number of employees	AQP	0.347	0.707
Product Category	AQP	1.642	0.197
Years in business	AQP	1.765	0.175
Product type	AQP	0.419	0.658
Ownership	AQP	0.199	0.819

5. Conclusions

Manufacturing is an important sector for the Australian economy. A pilot study has found that manufacturing performance of Australian manufacturers is not satisfactory and also they are facing some difficulties. A theoretical model was proposed to overcome the drawbacks. The present study was undertaken to examine the proposed model and to identify the best competitive factors and quality practices that contribute to the product quality and manufacturing performance improvements. The study revealed that Q & R of the product is the most important competitive factor for the manufacturers. Product price has become an unimportant factor for manufacturers and the world market has become a battleground for quality and reliability.

This paper explores some of the attributes of advanced quality practices capable of reducing manufacturing difficulties and improving manufacturing performances. The attributes include emphasis to quality during design, product quality and reliability estimation before manufacture, awareness of customer requirements and priorities, systematic review of contract, awareness of design team about manufacturing capability and difficulty, effective communication during design of a new product, use of field failure and manufacturing data during design.

In order to enable a focused analysis, the variables used for manufacturing difficulties and AQPs were reduced into single principal component through factor analysis. A factor analysis showed that except on time delivery, all the dimensions used can measure collectively the manufacturing difficulty. On time delivery, however, found not to be directly related to the manufacturing alone. Similarly, dimensions used for AQPs proposed are able to measure a single item.

Thereafter, ANOVA was carried out to establish relationship between these two factors and between composite AQP and manufacturing performance measures. Results show that AQPs are able to neutralize and reduce the difficulties manufacturers face and contribute to the most performance objectives of manufacturers. The companies who have more emphasize on AQPs have less difficulties in manufacturing practices. These practices have also resulted significantly better performance in product quality and company performance.

This study also investigated whether contextual factors have any impact on level of emphasise on AQPs. The results did not indicate any significant relationship between AQPs and contextual factors.

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