QUALITY MANAGEMENT PRACTICE: UNIVERSAL OR CONTEXT DEPENDENT? AN EMPIRICAL INVESTIGATION

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January 2000

Submitted in partial fulfilment of the requirements for the degree of

DOCTOR OF PHILOSOPHY

LONDON BUSINESS SCHOOL
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ABSTRACT

Quality management has often been advocated as being universally applicable to organisations and organisations activities. This universal stance is part of the emergence of a new paradigm in Operations Management based on the assumption that the adoption of best practice in a wide range of areas leads to superior performance (the best practice paradigm). This is in contrast with the manufacturing strategy contingency approach in which the field of Operations Management has been strongly rooted from its inception, which advocates internal and external consistency between manufacturing strategy choices (the strategic choice paradigm). In addition, as quality management has matured, more recent rigorous academic studies have raised doubts as to the universal validity of its set of practices. Despite these tensions, there is still little empirical research conducted in quality management aimed at shedding light on the question: Are quality management practices contingent on a plant's manufacturing strategy context? This study investigates this question by examining, via case based research, the use of quality management practices across plants representing a range of different strategic contexts in the UK electronics industry. By selecting plants mature on quality from a single very competitive industry and controlling for process technology, the study aimed to isolate the effects of a plant's strategic context on quality management practice.

Overall, the results suggest that although a few practices seem to be universally applicable, several others are strongly contingent on a plant's strategic context. The study also identifies mechanisms by which a plant's strategic context affects quality management practices. At a more general level, the study lends support to the existence of links between a plant's manufacturing strategy and the pattern of use of best practices. This finding is in agreement with the contingency view of the strategic choice paradigm and in contrast with the universalistic approach of the best practice paradigm.

ACKNOWLEDGEMENTS

A few years ago, departing from an Engineering/Operational Research approach to Operations Management, I decided to embark on a journey towards Operations Management research addressed from a managerial perspective. This decision was fuelled by a personal desire to contribute more strongly to real-world problems. I was then willing to trade-off the intellectual elegance of my thus far disciplinary rooting for increased relevance. Having reached the end of the journey, I am pleased to have realised that such a trade-off does not necessarily have to exist. This journey, although undertaken alone, was made easier by many, at different levels.

At the scientific level, I am grateful to my thesis advisor, Christopher Voss, whose experience and wisdom have helped me to keep focusing on the forest whilst tending to the trees, especially towards the later stages of my work. His depth of knowledge across the whole of the Operations Management area, both content wise and methodology wise, have allowed me great freedom which, I believe, has very much enriched my work. I have also learned a great deal from Chris about scholarship and the meanders of the academic profession. I consider myself privileged to have received such an outstanding introduction to research.

Kate Blackmon's advice at the early stages and her understanding of the insecurities facing a junior researcher helped steer my route. Challenging discussions with Terry Hill and his crystal-clear views on manufacturing strategy have also contributed to shaping my thoughts on the research topic at the early stages. Towards the middle of the journey, Mark Frohlich's insights on the practicalities of conducting field research and his great knowledge of the electronics industry were valuable. My thanks go also to Pär Åhlström for having facilitated access to the plant where I carried out the first case study and for his advice on collecting data in the field. Jim Short's constructive comments as part of my PhD transfer committee also deserve to be mentioned.

I have to thank Alastair Nicholson for facilitating access to another of the plants in my research sample. His passion for conducting relevant research for the service of real world managers was a source of inspiration and has left its seeds for the future.

At an institutional level, I am grateful to Fundação para a Ciência e Tecnologia and the Universidade Católica Portuguesa (Portugal) who kindly sponsored my PhD studies.

The scientific journey inherent to a PhD is inevitably intertwined with a personal one. At this level, friends and colleagues - too many to mention - have made this journey immeasurably more pleasurable.

Finally, my warmest gratitude goes to my parents who have always supported me at all levels. I dedicate this thesis to them.

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Volume B comprises the appendices holding individual case data and some pieces of individual case analysis, all referenced in the main thesis volume in hand. These appendices are distinguished from the ones included in the main thesis volume in hand by exhibiting the prefix "B" in their labels. The appendices are as follows:

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1. INTRODUCTION

As the title of the study indicates, its main subject is Quality Management. As such, this introductory chapter begins by stating the definition and scope of quality management as it is addressed in the study. Next, it briefly introduces the question that is investigated in the study. The chapter closes by presenting a road map for the study and the chapters to follow.

1.1 DEFINING QUALITY MANAGEMENT

Total Quality Management (TQM) was born more than a decade ago with the core ideas of W. Edwards Deming, Joseph Juran, Philip Crosby and Kaoru Ishikawa. Since then it has become an all pervasive management philosophy finding its way into most sectors of today's business society. Along this path, TQM has come to mean different things to different people (Watson and Korukonda, 1995), to such an extent that it begs the question: Is there such a thing as TQM? Hackman and Wageman (1995) answer this question affirmatively. They defend that TQM exhibits convergent validity, since there is substantial agreement among the movement's founders about the key assumptions and practices of total quality management. Furthermore, they also attribute discriminant validity to TQM arguing that, as espoused by the movement's founders, TQM philosophy and practice can be reliably distinguished from other strategies for organisational improvement.

Accepting that there is such an approach as TQM, it is necessary to distinguish between its different constituent practices (or activities). Practices are the observable facet of TQM, and it is through them that managers work to realise organisational improvements. The focus of the present study is on the set of practices associated with the TQM approach. As such, it takes a continuous perspective, as opposed to a discrete perspective, of quality management practice.

That is, organisations are viewed as adopting quality management practices individually, with no attempt being made to classify organisations as having adopted the full total quality management approach or not. Indeed, when dealing with an integrated management philosophy the appropriate question may not only be whether organisations adopt it but how they adopt it (Westphal et al., 1997). The term Total Quality Management (TQM) is intentionally avoided from here onwards, to reinforce the point that total quality management is not viewed as a closed, self-contained, yes/no program. Instead, the terms "quality management" (QM) and "quality management practice" are used.

The present study addresses QM in manufacturing operations and the unit of analysis is the plant. In the manufacturing sector, the plant constitutes the strategic business unit for implementing quality strategies (Ahire et al., 1996) and it is at the plant level that specific QM practices and performance occur (Flynn et al., 1995a). Although QM can be applied to all organisational functions and processes, the focal point of the present study is the production related processes. Additionally, as will be elaborated in more detail in subsequent chapters, the present study concentrates on the content of mature QM programs. It does not address the *process* of implementation of QM practices.

Several studies have tried to synthesise the vast QM literature and identify the key QM practice dimensions. Associated instruments to measure these dimensions were developed and empirically tested via survey research. Table 1-1 compares five major studies and provides an approximate correspondence between the QM practice constructs that were identified. As shown in the table, there is substantial agreement as to the set of constructs classified under the QM umbrella. These constructs are all present in the frameworks used for the national quality awards, such as the Malcolm Baldridge National Quality Award in the U.S. and the European Quality Award in Europe. The main purpose of the frameworks is self-assessment and education, and they can be seen as business excellence frameworks rather than strictly quality related. They are based on a broader definition of quality, and as such include aspects not encompassed by the constructs in Table 1-1.

The definition of QM practice that is adopted in the study is a synthesis of the constructs shown in Table 1-1, and includes the following practice constructs: Product Design/Introduction, Zero Defects, Real Time Feedback, Off-Line Feedback, Workforce Management, Supplier Involvement and Customer Focus. Appendix 1 gives the exact definitions for these practices. As shown in Table 1-2, each of these practices appears in at least three of the studies considered in Table 1-1. Because Benchmarking is only considered in two studies, it is not included. Top Management Leadership refers mainly to facilitating and sustaining the organisational change necessary to implement QM. Since the present study focuses on mature QM, thus not addressing the *process* of implementation of QM practice, Top Management Leadership is not included either. Some aspects of it are considered later in the study as a means to assess the degree of maturity of a plant in terms of QM. The precise definitions used in the present study refer to the plant level, and draw most closely on the definitions developed by Flynn et al. (1995a). The main difference is that Flynn et al's (1995a) construct SPC/Feedback is desegregated into two finer constructs, Real Time Feedback and Off-Line Feedback. Note that since there is a strong similarity between the several practice constructs defined in the literature, the choice of one particular study as the basis for the precise definitions is not crucial. Flynn et al.'s (1995a) study was chosen because it is situated at the plant level and received strong empirical support.

1.2 QUALITY MANAGEMENT: THE UNIVERSALS VS. IT-ALL-DEPENDS

Since its inception, the field of QM has been led mainly by practitioners. Like other recent management philosophies, QM has acquired a strong prescriptive stance with practices often being advocated as being universally applicable to organisations and organisations activities. This trend is part of the emergence of a new paradigm in Operations Management based on the assumption that the adoption of best (world class) practice in a wide range of areas leads to superior performance and capability. Voss (1995) calls it the best practice paradigm. This paradigm focuses on the continuous development of best practice on all areas within a company. In fact, the last two decades have been characterised by the introduction of a wealth of new management practices typically portrayed as being universally applicable (e.g., MRP, TQM, TPM, JIT). The universal orientation of QM has been pointed out as contrasting with the contingent approach of management theory in general (Dean and Bowen, 1994). In particular, the field of Operations Management has been strongly rooted from its inception on a manufacturing strategy contingency approach. Voss (1995) calls this the strategic choice paradigm. The assumption of this paradigm is that internal and external consistency between manufacturing strategy choices increases performance (e.g., Woodward, 1965; Hayes and Wheelwright, 1979a; Hill, 1985; Ward et al., 1996). Internal consistency refers to the coherence between the different elements of a manufacturing strategy; external consistency refers to the match between this set and the wider strategic context (e g., marketing strategy). This is in stark contrast with the universal approach of the best practice paradigm.

Despite these tensions between the universal vs. it-all depends perspectives, there is still little empirical research in QM conducted at the intersection of the two paradigms and aimed at shedding light on the question: Are QM practices contingent on a plant's strategic context?

To address this question, this study sets out to empirically investigate whether QM practices are contingent on a plant's manufacturing strategy context (testing); and if so, to explain how a plant's strategic context affects these practices (explaining). Further justification of the relevance of the research question and its contribution to current knowledge is given in Chapter 3, after the literature has been reviewed (Chapter 2).

Table 1-1. Comparison between five major instruments for measuring the degree of use of quality management practices.

		Flynn et al. (1995a)	Ahire et al. (1996)	Anderson et al. (1995)	Powell (1995)	Saraph et al. (1989)
Main literature base	Practitioner and empirical literature which reports on practices in actual use in the US and Japan.		Literature on quality management, organisational behaviour and general operations management. Conceptual literature and actual practices of organisations as evidenced through various case-studies and empirical research.	Deming's works.	TQM literature.	Theoretical work of quality gurus, including Deming, Juran, Crosby and Ishikawa
Survey sample	706 respondents (plant managers, supervisors, workers) of 42 US manufacturing firms (>100 employees) from the machinery, electronics and transportation components industries.		371 US manufacturing plants (>100 employees), single industry (motor vehicle parts and acessories); single respondent (plant manager).	41 US manufacturing firms (>100 employees) from the machinery, electronics and transportation components industries. Multiple respondents (plant managers, supervisors, workers).	54 US manufacturing and service firms (>50 employees); single respondent (CEO or senior quality manager).	162 respondents (top quality manager and or general manager) of 89 divisions of 20 US manufacturing and service firms (>1000 employees); 1 or 2 respondents per division
Level of analysis	Plant		Plant	Plant	Business unit	Business unit
Dimensions of quality management practices	Infrastructure	• Top management support	•Top management commitment	•Visionary leadership	•Executive commitment •Adopting the philosophy	•The role of management leadership and quality policy •The role of the quality department
	Infrastructure	•Customer relationship	•Customer focus		•Closer to customers	
	Infrastructure	•Supplier relationship	•Supplier quality management		•Closer to suppliers	•Supplier quality management
	Infrastructure	•Workforce management •Work attitudes	•Employee involvement •Employee empowerment •Employee training	•Internal co-operation •Employee fulfilment •Learning •Continuous improvement	•Training •Employee empowerment •Open organisation	•Training •Employee relations
	Core	•Process flow management •SPC/feedback	•SPC usage •Internal quality information usage	•Process management	•Process improvement •Flexible manufacturing •Zero defects mentality •Measurement	•Process management •Quality data and reporting
	Core	•Product design	•Design quality management			•Product/service design
			•Benchmarking		•Benchmarking	

Table 1-2. Approximate correspondence between practice constructs adopted in the study and the constructs in Table 1-1.

This study	Flynn et al. (1995a)	Ahire et al. (1996)	Anderson et al. (1995)	Powell (1995)	Saraph et al (1989)
Product Design/Introduction	Product Design	Design Quality Management	-	Flexible Manufacturing	Product/Service Design
Zero Defects	Process Flow Management	-	Process Management	Zero Defects Mentality	Process Management
Real Time Feedback	SPC/Feedback	SPC usage	Process Management	Process Improvement, Measurement, Flexible Manufacturing	Process Management, Quality Data and Reporting
Off-Line Feedback	SPC/Feedback	Internal Quality Information Usage	Process Management	Process Improvement, Measurement	Quality Data and Reporting
Workforce Management	Workforce Management	Employee Involvement, Employee Empowerment	Internal Co-Operation, Continuous Improvement	Employee Empowerment, Open Organisation	Employee Relations
Supplier Involvement	Supplier Relationship	Supplier Quality Management	-	Closer to Suppliers	Supplier Quality Management
Customer Focus	Customer Relationship	Customer Focus	-	Closer to Customers	-

1.3 ROADMAP OF THE STUDY

The present study is organised as follows. Chapter 2 reviews the literature in QM and lays the theoretical foundations for the study. Drawing on the review of the literature, Chapter 3 defines the study's objective - to empirically investigate whether QM practices are contingent on a plant's manufacturing strategy context (testing); and if so, to explain how a plant's strategic context affects these practices (explaining). Chapter 4 puts forward a general research design to address the research question. This design is based on the examination of the use of QM practices across a spread of strategic contexts, and will underpin the subsequent chapters. Chapter 5 defines "strategic context". Chapter 6 describes the methodology used in the study prior to the data reduction and analysis stages. It proposes to address the research question by conducting case-studies in the UK electronics industry representing a spread of strategic contexts. Chapter 7 describes the process of reduction of case data, in preparation for the deeper stages of analysis to follow. Chapter 8 describes the analyses of case data that were performed to answer the research question. Finally, Chapter 9 presents the contribution of the study, addresses its limitations and identifies issues for future research.

2. LITERATURE REVIEW

This chapter reviews the literature in the Quality Management (QM) area which is relevant for the present study. The review addresses the QM literature associated with the field of management, and takes a primarily Operations Management standpoint. Within Operations Management, the focus is on manufacturing operations with service specific literature being excluded. Other discipline-specific literature (e.g., information systems, health care, etc.) is not addressed. Technical and analytical quality topics (e.g., quality control statistical techniques, cost models, etc.) are also excluded, as is the literature specifically related to quality standards (e.g., ISO9000) and quality awards (e.g., the European Foundation and Baldridge quality awards). Finally, the emphasis is on the broad field of QM, without individual and specific coverage of the different components of QM (e.g., Statistical Quality Control, Zero Defects, Workforce Management, etc.). Ahire et al. (1995) provide a detailed review of the literature on the several components of the QM approach. This is the only substantial literature review in the field. It provides a thorough synthesis of articles published from 1970 to 1993.

The review in hand organises the literature along five research themes which are deemed relevant for the progress of knowledge in the field and to the topic of this study: the definition of product quality, the impact of QM on firm performance, QM in the context of management theory, the implementation of QM and contextual factors affecting QM. The review of these research streams revolves around the issue of whether QM practices are universally applicable. The objective of the review is not exhaustive and descriptive coverage of the literature, but instead the synthesis of the main research findings and identification of the main issues for future research. In addition, it lays out the theoretical foundations for the present study.

2.1 DEFINING PRODUCT QUALITY

Before reviewing the literature which has a more direct bearing on the issue of whether QM practices are universally applicable, it is of benefit to reflect on the meaning of quality. Given that the focus of the study is on manufacturing operations, I address the definition of quality with respect to tangible products as opposed to the quality of services.

Research in this area has been unable to arrive at a single definition of product quality. At best, several alternative definitions were proposed. Garvin (1984) identified five major approaches to the definition of quality and the disciplines in which they are rooted (see Table 2-1). The transcendent approach views quality as "innate excellence". Although quality cannot be defined precisely, it is both absolute and universally recognisable. The product-based approach defines quality as a weighted sum of the amounts of the desired attributes in a product. User-based definitions view quality as the degree to which the product satisfies the preferences of individual consumers. The manufacturing-based approach equates quality to conformance to engineering specifications. For the value-based approach a high quality product is one that provides performance at an acceptable price or conformance at an acceptable cost. Reeves and Bednar (1994) also identify similar definitional approaches to quality, and conclude that a global definition of quality does not exist; rather, different definitions of quality are appropriate under different circumstances. According to these authors, one should focus upon the fundamental nature of an organisation's output and then use a definition of quality suitable for that output (Reeves and Bednar, 1994).

Table 2-1. Alternative approaches to the definition of product quality.

Approach	Definitional variables	Underlying discipline
Transcendent	Innate excellence	Philosophy
Product-based	Quantity of desired attributes	Economics
User-based	Satisfaction of consumer preferences	Economics, Marketing and Operations Management
Manufacturing-based	Conformance to requirements	Operations Management
Value-based	Affordable excellence	Operations Management

Source: Garvin (1984).

Another important realisation is that quality seems to be a multidimensional construct (Garvin, 1984; Hjorth-Anderson, 1984). Empirical evidence of the multidimensionality of the quality construct has been provided by Stone-Romero et al. (1997). Garvin (1984, 1987) proposed eight dimensions of product quality:

(1) *Performance*: the product's primary operating characteristics.
(2) *Features*: attributes that supplement the product's primary operating characteristics.
(3) *Reliability*: the probability of a product failing within a specified time period.
(4) *Conformance*: the extent to which a product's design and operating characteristics meet predetermined standards.
(5) *Durability*: the amount of use a product offers a consumer before the product deteriorates.
(6) *Serviceability*: how fast, how easily, and with what degree of courtesy and competence repairs are performed.
(7) *Aesthetics*: how a product appeals to the five senses.
(8) *Perceived quality*: reputation, image, or other inferences regarding the attributes of a product.

Garvin's (1984, 1987) eight quality dimensions are a robust framework for research, covering a wide range of products and markets. However, in some cases we may need to consider other quality dimensions, or aggregate/ desegregate some of Garvin's basic dimensions to fit the particular situation being addressed. Reeves and Bednar (1994) state:

> "The quality construct space is so broad and includes so many components that there would be little utility in any model that tried to encompass them all. Consequently, the challenge is not to formulate one definition or model that attempts to account for all possible variables." (Reeves and Bednar, 1994, p. 441)

Given that the construct space for quality is not bounded, it may be better understood by measuring limited aspects of its total meaning (Reeves and Bednar, 1994).

The importance of recognising the multidimensional nature of quality cannot be overstated. First, the relative strategic importance of the different quality dimensions varies across products and industries. An organisation will only achieve competitive advantage through quality if there is a match between the importance that the markets assign to the individual quality dimensions and the organisation's performance along those individual dimensions (Garvin, 1984). A good level of aggregate performance over the several quality dimensions may provide a feeble advantage if an organisation does not do well on the dimensions of quality critical to its markets. Second, different quality dimensions exhibit different relationships with other competitive variables such as cost and delivery dependability. For example, regarding cost, improved conformance quality may lead to reduced costs, while improvement in the performance dimension may imply reduced conformance and increased costs (Maani, 1989). Third, provision of different quality dimensions poses different demands on different organisational functions (e.g., marketing, design, manufacturing, purchasing) and may require different organisational practices (e.g., QM practices) depending on the quality dimension in question (Flynn et al., 1995a). For example, while the design function and associated design practices are bound to influence most quality dimensions, the manufacturing function and practices will probably be limited to influencing conformance quality.

2.1.1 Conclusions and further research

Most research to date has treated quality as an unidimensional construct and has not taken the necessary care to clearly state the definition of quality used (Stone-Romero et al., 1997). These definitional difficulties may be responsible for conflicting results reported in the literature linking quality to outcomes such as market share, cost and profits (Reeves and Bednar, 1994). Therefore, correctly addressing the definition of product quality is paramount. In this connection, three main points should be considered in future research:

(1) Quality is a multidimensional construct, and as such, research studies must use multidimensional measures of quality.

(2) There is no single definition of quality. One must focus upon the fundamental nature of an organisation's output and use a definition of quality encompassing the relevant dimensions for that output. Garvin's (1984) eight quality dimensions are a good starting point for choosing the right dimensions.

(3) Given the unbounded nature of the quality construct, a single measure of the quality construct should not be aimed for. Instead, there is the need to develop conceptual frameworks and measuring methods for *specific* domains of the quality construct (Reeves and Bednar, 1994).

2.2 THE IMPACT OF QUALITY MANAGEMENT ON FIRM PERFORMANCE: THE QUALITY-PERFORMANCE MODEL

One aspect which is relevant to the issue of whether QM practices are universally applicable is the extent to which those practices have an impact on firm performance. In recent years, a new paradigm has emerged in Operations Management underpinned by the assumption that best (world class) practice in a wide range of areas will lead to superior performance and capability. Voss (1995) calls it the best practice paradigm. This paradigm focuses on the continuous development of best practice on all areas within a company and it is supported by research that shows strong linkages between adoption of best practice and operating performance (e.g., Clark and Fujimoto, 1991; Oliver et al., 1994). QM comprises a wide set of best practices and it is considered a key element of the best practice approach to achieving and sustaining competitive advantage. Effective QM is seen as supporting, and also as being supported by, the other dimensions of best practice (e.g., JIT).

This section reviews the literature rooted on the best practice paradigm addressing the impact of QM on firm performance. Figure 2-1 depicts the model underlying this body of literature. The model variables are:

1) *Quality Management Practice*: QM practices (for example, as defined in Appendix 1).

2) *Internal Process Quality*: A measure of process variability (before final inspection). Low process variability equates to a high internal process quality.

3) *Product Quality Performance*: Product quality (after final inspection) measured, for example, along Garvin's (1987) eight quality dimensions. Note that "Product Conformance Quality" is a different construct from "Internal Process Quality". Provided final inspection is effective in detecting defective units, it is possible to have a good product conformance quality with a low internal process quality. In this case, the consequences of low internal process quality would be reflected in the operational performance.

4) *Operational Performance* (excluding quality): Manufacturing performance including cost, productivity, delivery dependability, delivery speed, inventory turnover, etc.

5) *Business Performance*: Financial measures of business performance (e.g., return on inventory, return on sales, sales growth).

The quality-performance model shows the several routes by which QM practice may impact on quality, operational and business performance. QM proponents argue that the set of QM practices reduce the manufacturing process variability (thus increasing Internal Process Quality and subsequently Product Conformance Quality), for example by using statistical process control. Moreover, all other product quality dimensions will also be improved, for example by using design and customer minded QM practices. Garvin (1984) showed how, in turn, Internal Process Quality and Product Quality Performance could impact on Operational and Business Performance. He proposed two main routes for the effect of quality on Business Performance: the Manufacturing Route and the Market Route (Figure 2-1).

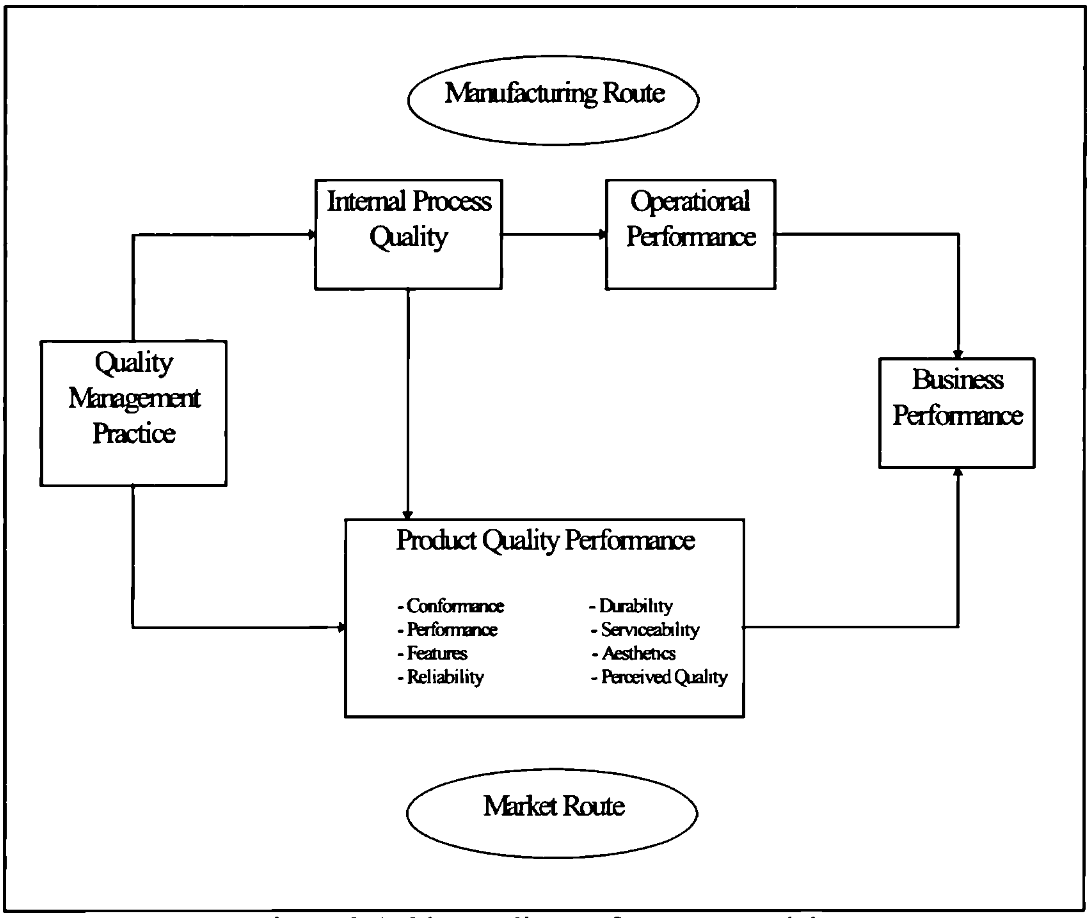

Figure 2-1. The quality-performance model.

In the *manufacturing route*, improved internal process quality, meaning fewer defects, scrap and rework, results in improved operational performance (e.g., lower manufacturing costs, higher productivity, more dependable processes), and subsequent improvement in terms of manufacturing related order-winners and qualifiers. These in turn lead to improved business performance.

In the *market route*, improvements in product quality lead to increased sales and larger market shares, or alternatively, less elastic demand and higher prices. If the cost of achieving these gains is outweighed by the increases in contribution received by the firm, higher profits will result. Larger market shares can improve business performance directly and can also lead to indirect experience based cost savings and further gains in profitability. Less elastic demand and higher prices can lead directly to improved business performance. Finally, improved product quality can lead to lower warranty and product liability costs, resulting in lower service costs and improved business performance.

The quality-performance model delineates possible mechanisms by which increased quality (internal process and product) *may* lead to increased operational and business performance. However, it should not be taken for granted that the final result of these mechanisms will always be increased performance. That is, quality may not always be free. As Karmarkar and Pitbladdo (1997) analytically demonstrate with their quality models, the costs and benefits of quality depend on whether the issue is performance or conformance quality, and on the nature of the market environment (for example in terms of market size and structure, e.g., perfect competition vs. monopoly vs. oligopoly). These authors argue that quality improvements should be assessed by the return on the investment made as any other productivity enhancing or cost reducing initiative, and present examples of situations where an increase in performance quality or conformance quality may not necessarily lead to a net benefit.

The following sections review empirical evidence on the several relationships depicted in the quality-performance model.

2.2.1 The impact of quality performance on operational and business performance: Empirical evidence

This section reviews empirical evidence on the relationship between quality performance (internal process quality and product quality) on operational and business performance. In one of the most frequently cited studies, Phillips et al. (1983) used the PIMS database (Buzzell and Gale, 1987) to test a model relating product quality to cost, market share and business performance. Business performance was measured using the commonly accepted measure of return on investment (R.O.I.) while quality was measured in the PIMS database as perceived quality. Their results indicated that higher perceived quality was related to higher market share and lower costs. They also found that higher market share and lower costs were associated with higher R.O.I.. A few years later, Capon et al. (1990) tried to summarise many other studies conducted after the work of Phillips et al. (1983) relating quality, as well as various other factors, to business performance. Capon et al. (1990) used meta-analysis to examine a total of 320 published studies of factors affecting financial performance. Out of those 320, they found twenty studies that related quality to business performance. In those studies there were 104 positive, versus eight negative, relationships between quality and financial performance (the authors do not indicate how quality and financial performance were measured for any specific study).

Recently, there have been more rigorous empirical studies with the explicit goal of testing relationships between quality and operational and business performance. Sluti (1992) in his path analysis study of 184 manufacturing firms in New Zealand, found that improved conformance quality had mixed results when related to operational and business performance. Quality performance did not have a significant impact on business financial performance, yet the relationship between quality and production/operations outcomes was significant. Significantly affected operational performance measures included process utilisation, process output, production costs, WIP inventory levels, and on-time delivery. The survey study of Maani, Putterill and Sluti (Maani et al., 1994; Sluti et al., 1995), involving 184 New Zealand manufacturing companies, used Structural Equation Modelling to find a significant and strong relationship between conformance quality (a composite measure combining internal process quality and product conformance quality) and operational performance of manufacturing (including work in progress inventory, unit cost, productivity and on-time delivery). The effect of conformance quality on business performance (measured by the return on sales) via the mediating effect of operational performance was significant but weak. Madu et al. (1995) compared 146 manufacturing firms in the US and Taiwan based on a survey of middle managers. They found a significant relationship between predictors of quality performance (customer satisfaction, employee satisfaction and employee service quality) and perceived business performance. White (1996) meta-analysed previous studies which provided empirical evidence of relationships between conformance quality, cost, delivery speed, delivery reliability, product flexibility and business performance. In what concerns the relationships involving conformance quality, he found strong support for the beneficial influence of conformance quality on cost, and less strong but still positive support for its beneficial effects on delivery speed, delivery dependability, and business performance.

In summary, research to date suggests that:

-internal process quality has a significant and strong effect on operational performance.

-internal process quality and product quality have a weak and not always significant effect on business performance.

2.2.2 The impact of quality management practice on performance: Empirical evidence

While the above research examined the relationship between quality performance and operational and business performance, other researchers have worked further upstream in the quality-performance model by studying the relationship between QM *practice* and performance (internal process quality, product quality, operational and business performance). Much of the literature to date has been descriptive, and evidence of links between QM practices and performance has in the most part been anecdotal. Only recently there have been more elaborate efforts to substantiate these relationships. This section does not intend to be an exhaustive coverage of all of the literature, but rather concentrates on major rigorous empirical studies directly addressing the impact of QM practices on performance. These studies use sophisticated data collection and analysis approaches to move beyond description to inference. The emphasis is on manufacturing contexts, although one of the addressed studies covers a mix of manufacturing and service organisations. Two points deserve mention when aggregating the studies' results. First, the studies do not all exactly use the same definition of QM practice: some use the whole set of practices defined in Appendix 1, others use a subset. Second, different instruments are used to measure QM practice. Nevertheless, there are no major incompatibilities between the definitions and instruments used and all of them exhibit content validity. Given that the selected studies were all undertaken with the necessary methodological care and rigour, it is felt that they can nevertheless be jointly used to address the broad issue of the impact of QM practice on performance.

Flynn et al.'s (1995a) exploratory study of 41 manufacturing firms at the plant level, investigated the relationship of specific QM practices to quality performance and competitive advantage. Their framework clarifies the role of practices by dividing them into core (product design process, process flow management and statistical control and feedback) and infrastructure practices (top management support, customer relationship, supplier relationship, workforce management and work attitudes). Infrastructure practices create an environment supportive of the use of core practices. In terms of core practices, they found that process flow management, and statistical control/feedback had a significant impact on internal process quality, while "perceived quality market outcomes" (an aggregate perceptual measure including all of Garvin's (1987) eight dimensions of quality) was primarily related to statistical control/feedback and the product design process. Both performance measures were related to a perceptual measure of competitive advantage. In terms of infrastructure practices, top management support and workforce management were the most important, with supplier relationship and work attitudes also related to some of the core quality practices and quality performance measures.

Anderson et al. (1995) explored the impact of practices associated with the Deming Management Method on quality performance (an aggregate measure including conformance, serviceability and a general customer satisfaction item). The study used the same data sample as the Flynn et al. (1995a) study, but a different practice-performance model. Based on a previous articulation of a theory of QM underlying the Deming Management Method (Anderson et al., 1994), the model hypothesises that "*visionary leadership* contributes to the creation of a *co-operative and learning organisation* to facilitate the implementation of *process management practices*, which, when implemented, support *customer satisfaction* and organisational survival through sustained *employee fulfilment* and *continuous improvement* of processes, products, and services". While the model captures the impact of part of Flynn et al.'s (1995a) infrastructure (visionary leadership, learning and co-operation) on some of their core practices (process management), it reverses the causality relationship between these and a second component of infrastructure (continuous improvement and employee fulfilment). Anderson and colleagues found evidence that again top management support was the most important variable in its role of supporting the use of the other QM practices, that internal co-operation improved process management, process management contributed to continuous improvement, and employee involvement impacted on quality performance. No significant relationship was found between continuous improvement and quality performance. Overall, this model, based on the Deming Management Method, seems to have less power than Flynn et al's in describing the relationships between different QM practices and the impact of these on quality performance.

Powell (1995), drawing on the resource approach and other theoretical perspectives, empirically examined QM as a potential source of sustainable competitive advantage. The study was based on surveys and on-site interviews with CEOs and senior quality executives of 54 manufacturing and service firms, and concluded that QM can produce competitive advantage (measured by perceptual data): firms with a high use of QM practices ("TQM firms") outperformed firms with a low use of these practices ("non-TQM firms"). His results suggest that QM success appears to depend critically on executive commitment, open organisation and employee empowerment - imperfectly imitable QM features (intangible resources). And less upon such QM staples as quality training, process improvement, and benchmarking - imitable QM tools and techniques (tangible resources). According to Powell, although firms may find the latter indispensable to a fully integrated QM initiative, they apparently do not produce business performance advantages in the absence of the intangibles. Powell also found that whether or not several tangible practices significantly contributed to performance depended on industry.

Powell further posits that although QM can produce competitive advantage, *it may not be necessary for success.* According to him, "adopting the vocabularies, ideologies, and tools promoted by the QM gurus and advocates, matters less than developing the underlying resources that make QM implementation successful". He adds that the intangibles appear to produce success with or without formal QM adoption. However, this last assertion, in what concerns QM tools and techniques, remains to be proved. Powell's study did not assess the quality performance of the firms involved. In the study, the best performers (in terms of perceived competitive advantage) had a significantly higher degree of adoption of the intangible practices than the worse performers, but a non-significantly different degree of adoption of tangible practices. This leaves scope for an alternative explanation. Intangibles are indeed necessary to support and enhance the effects of QM tools and techniques on quality and business performance. But they might not be sufficient: firms only adopting the intangible practices may not achieve a good quality performance, and consequently not achieve a good business performance. What may be difficult to imitate may not only be the intangible practices per se, but its integration with the tangible practices. This alternative explanation is consistent with Flynn et al's (1995a) result that *both* core practices (which include some of Powell's tangibles) and infrastructure practices (which include all of Powell's intangibles) lead to quality performance and this in turn to competitive advantage. The utilisation of the path analysis technique and the inclusion of measures of quality performance in Flynn et al's study have allowed it to capture the indirect effects of infrastructure on quality and business performance through the core quality practices.

Picking up on Powell's results, Dow et al. (1999) examined whether all QM practices contribute to increased quality performance (mainly, conformance quality). Based on data from a survey of 698 manufacturing sites in Australia and New Zealand, they found that only workforce commitment, shared vision and customer focus practices were significantly related to quality performance. These three practices would fall under Powell's (1995) intangibles category, but again the research design that was used did not allow for the identification of potential indirect effects of the intangibles on performance through the core quality practices. Dow et al. (1999) suggest that the fact that some of the practices were found not to be significantly related to performance could be the result of these practices being context dependent.

Samson and Terziovski (1999), in a survey study of 1024 manufacturing sites in Australia and New Zealand, found a significant relationship between the use of QM practices and operational performance (a mix of customer satisfaction, employee morale, productivity, conformance quality and on-time delivery). Some but not all of the QM practices were strong predictors of performance. These were leadership, workforce management and customer focus. These three practices would again fall under Powell's (1995) intangibles category, but similarly the research design did not allow for the identification of potential indirect effects of the intangibles on performance through the core quality practices. In fact, the usage of core practices was found to be strongly correlated with the use of the intangible practices, thus casting doubts over the separation of the effects of each of the sets of practices.

Voss and Blackmon (1995), in their study of 328 UK manufacturing plants, found that the level of usage of QM practices was significantly associated to internal process quality, external product quality (encompassing reliability and durability quality dimensions), and customer satisfaction (which may be regarded as encompassing all dimensions of quality). Customer satisfaction was directly and strongly related to external product quality, and indirectly to internal process quality through external product quality. The study suggests that QM practices related to internal process quality and external product quality are both necessary and important.

Adam (1994) examined the impact of quality and productivity improvement practices on quality, operating and business performance in a sample of 187 US manufacturing firms. Results indicated a strong relationship between QM practices and quality performance (comprising conformance, customer satisfaction and total cost of quality). The relationship between quality practices and operating and financial performance was weaker but significant.

Dean and Snell (1996) investigated the impact of QM, Advanced Manufacturing Technology, and JIT on the operational performance of 160 manufacturing firms in the US. They found that only QM, measured as a single construct in this study, was directly related to perceived operational performance (including product quality, on-time delivery, inventory management, employee productivity, equipment utilisation, production lead time, scrap minimisation, and employee morale).

Hendricks and Singhal (1997) provided statistical evidence that a sample of over 400 US firms having won quality awards (used as a proxy for the effective implementation of a QM program) outperformed a matched control sample on measures of operating income and sales growth.

Choi and Eboch (1998), in a survey study of 339 manufacturing plants in the US, found a significant impact of QM practices on perceptual measures of customer satisfaction and operational performance (conformance quality, delivery and cost). Finally, Adam et al.'s (1997) study of an international sample of 997 manufacturing firms concluded that QM practice had a strong impact on internal process quality and product quality. However, its impact on business performance received weak support.

In summary, research to date suggests that:

- as a whole, QM practices have a significant and strong impact on internal process quality, product quality and operational performance.

-the impact of QM practices on business performance is weaker and not always significant.

2.2.3 Conclusions and further research

The results of the empirical studies of the last two sections are remarkably consistent and, although causality cannot be established, they seem to suggest the following. First, QM practices have a significant and strong impact on quality (internal process and product) and operational performance. Second, the indirect impact of QM practices on business performance via the mediating effect of quality and operational performance, although significant, is weaker, and still leaves a reasonable amount of business performance variance unexplained. This second result is open to two different interpretations.

In the first possible interpretation, QM practice may indeed be beneficial to business performance - i.e., quality may be free - and its weak impact reported in empirical studies attributed to research methodology. Hackman and Wageman (1995) rightly warn of the difficulties in using outcome criteria, such as business performance, to measure QM effectiveness. They put forward five difficulties in detecting statistically the direct effects of QM on global measures of organisational outcomes: (1) there are serious measurement problems associated with even standard indices of firm performance such as market share, profitability or stock price, (2) exogenous disturbances can significantly obscure the link between work processes and organisational outcomes, (3) temporal issues can obscure intervention-outcome relationships, (4) it is difficult to isolate the effect of QM from other events that coincided temporally, and (5) it is difficult to ascertain whether the observed improvements arise solely because the initial situation is so poor that rapid improvements are easily accomplished. Some of the difficulties of using outcome criteria can and have been tackled in recent rigorous studies. This has been accomplished by using large samples, by controlling for some exogenous factors (e.g., industry effects, see for example, Powell, 1995) and by adopting a continuous view of quality practice implementation, rather than a dichotomic yes/no approach regarding the adoption of a formal QM program. This continuous view involves using samples comprising organisations with different degrees of adoption of QM practices and using pre-developed instruments to measure the degree of use of QM practices (see for example, Flynn et al., 1995a). As a complement to research using outcome criteria, Hackman and Wageman (1995) propose the use of process criteria - the degree to which improvements in organisational functioning that are expected are actually observed - to measure QM effectiveness.

A second interpretation may be that the impact of QM practice on business performance is contingent on other factors such as whether the issue is performance or conformance quality, or the nature of the market environment, as suggested by Karmarkar and Pitbladdo (1997). According to this interpretation, quality may not always be free. Although conceptually it is difficult to challenge this view, the relevant issue is to identify under which conditions quality may not be free and whether these conditions are bound to occur frequently in real business settings.

Existing theory points to core and infrastructure practices having to be both present to produce success. Spencer (1994), Sitkin et al. (1994) and Dean and Bowen (1994) all defend the integration of mechanistic/process/technical and non mechanistic/sociobehavioural QM aspects. Hackman and Wageman (1995) also note the utility of quality tools and techniques as auxiliary for learning. According to this view, the organic components of QM may only have a positive effect on performance if mechanistic aspects also have been established, i.e., the organic aspects seem to work through the mechanistic aspects to produce improvements.

This view is consistent with Flynn et al.'s (1995a) empirical results. However, some studies have raised doubts about the contribution of core practices to performance (Powell, 1995; Dow et al., 1999; Samson and Terziovski, 1999), although they have been unable to offer definite statistical evidence to support these doubts. Therefore, further research is needed to clarify this issue.

Future research in the quality-performance model also needs to address some of the deficiencies of past studies. First, there is a need to clearly situate studies within the practice-performance model, by indicating which parts of the model the studies are addressing. Several studies address only a few variables of the model and ignore potentially important effects of other variables (for example, research relating QM practice to business performance without considering quality and operating performance). Second, "quality" needs to be clearly defined in each study. The word "quality" is used to mean different things in different studies such as internal process quality, one or several dimensions of product quality, customer satisfaction (which encompasses all dimensions of product quality as well as other competitive capabilities) and operational performance (e.g., delivery dependability, delivery speed). Universalistic propositions describing the relationship among various variables and quality cannot be made when the meaning of quality continually changes. Some of the conflicting results reported in the literature linking quality to performance outcomes may be largely attributable to definitional deficiencies (Reeves and Bednar, 1994).

Finally, we need to increase our understanding of the means by which QM effects are generated. In this connection, three areas need more investigation. First, more research into the linkages between the several QM practices is needed. Most research to date dealing with specific QM practices tends to ignore their relationship with other practices (e.g., SPC as dissociated from workforce management). Second, we need to know more about the interaction between QM and other best practices. One of the few empirical studies in this area is Flynn et al. (1995b) who looked at the interaction between JIT and QM. Third, one important factor in the practice-performance model needs to be further researched, namely, the time lags between the implementation of QM practice and performance. Reed et al. (1996) provide the first building blocks for this research.

They conceptually identify explicit mechanisms underpinning the time lag for the appearance of benefits after the implementation of QM. Given the integrative and complex nature of research into the means by which QM practice exerts its effects, case-study research and usage of process criteria (Hackman and Wageman, 1995) would be the preferred methods to use in this line of research.

2.3 QUALITY MANAGEMENT IN THE CONTEXT OF MANAGEMENT THEORY

It is important to compare QM with other more established management theories. Areas of agreement will lend support to the QM model; areas of conflict require further research to ascertain whether prescribed QM practice should be modified in light of management theory or whether management theory should incorporate new insights from QM. Although the field of QM has been mainly led by practitioners, recently there have been efforts to bridge the gap between practice and theory, with a particular emphasis on the special issue of the Academy of Management Review in 1994. This section addresses the recent theoretical developments in the field of QM, with an emphasis on the literature attempting to situate QM in the context of Management Theory (MT).

Several authors have contributed to this research stream. However, four pieces of work stand out as the most elaborate and explicit efforts in comparing QM and MT: Dean and Bowen (1994), Anderson et al. (1994), Hackman and Wageman (1995), and Waldman (1994). Dean and Bowen (1994) explicitly compare total quality - defined as an approach to management characterised by three main principles: customer focus, continuous improvement and teamwork - and management theory - defined as a "multidisciplinary academic field, whose links to practice are controversial". Anderson et al. (1994) provide the most elaborate and comprehensive attempt to articulate a theory of QM. They define the basic concepts (constructs) of QM grounded in a Delphi study process involving experts on Deming and his 14 points, and specify relationships between those concepts. Anderson and colleagues find general support in MT for their proposed QM constructs, and establish several links between these and MT. Hackman and

Wageman (1995) comprehensively address conceptual, empirical, and practical issues related to QM as envisaged by the founders of the total quality movement, Deming, Juran and Ishikawa. Finally, Waldman (1994), focusing on human resource management, develops a theoretical framework to explain work performance variation incorporating QM concepts and ideas. Based on the Human Resource Management (HRM) literature and on his developed framework, Waldman (1994) establishes several linkages between QM and HRM theory. Across these four works, several QM topics were systematically compared to MT: Top Management Leadership, Supplier Relationships, Customer Focus and Satisfaction, Strategic Quality Planning, Human Resource Management, Process Management, Information and Analysis, and Organisational Learning. Table 2-2 summarises the conclusions of the above research across these topics with an emphasis on the areas of disagreement between QM and MT. It highlights areas in which QM and MT are essentially similar; and areas of discrepancy between QM and MT: areas in which MT could offer insights into QM (MT>QM), areas where QM raises questions for further development in MT (QM>MT); and clear conflict areas between QM and MT (QM≠MT).

Table 2-2. Comparison at the detailed topic level between Quality Management (QM) and Management Theory (MT).

Quality Management (QM) Topic	Areas of agreement between Quality Management (QM) and Management Theory (MT)	Areas of disagreement between Quality Management (QM) and Management Theory (MT)
Top Management Leadership	- Similarity of QM's top management leadership with the "transformational leadership" concept of MT (Dean and Bowen; Anderson et al., Waldman).	- QM assigns less importance to leadership's role further down the hierarchy. Quality management seems to be portrayed as a substitute for leadership at lower organisational levels. (Dean and Bowen). QM≠MT - QM ignores "transactional" type of leadership (Dean and Bowen). QM≠MT
Supplier Relationships		- MT advocates that supplier relationships should be designed using a contingency approach, rather than assumed to be universally appropriate (Dean and Bowen). MT>QM - Resource dependence theory and transaction cost theory prescribe competitive, as opposed to co-operative, relationships between organisations (Anderson et al). QM≠MT
Customer Focus and Satisfaction		- MT generally ignores the role of customers (Dean and Bowen). QM>MT - The marketing literature treats quality in terms of a single attribute in a static environment; to QM, quality is based upon multiple attributes that evolve over time (Anderson et al.). QM≠MT - The economics literature associates higher quality to higher costs, while QM does not necessarily do so (Anderson et al.). QM≠MT
Strategic Quality Planning		- MT advocates that strategy formulation should include careful assessment of organisational strengths and weaknesses, not just customer expectations (Dean and Bowen). MT>QM - QM portrays quality as the main source of competitive advantage driving improvements on other sources of competitive advantage. To MT, quality is a potentially important source of competitive advantage, but only one among many (Dean and Bowen). MT>QM - QM deals extensively with business unit strategy (how to compete for a set of customers) but is generally silent on corporate strategy (how to decide which customers to compete for) (Dean and Bowen). MT>QM - QM assumes that the processes of strategic formulation and implementation can be continuously improved. MT implicitly assumes that strategic processes are a product of relatively stable organisational conditions (e.g., size, structure), and that firms will not be able to change them (Dean and Bowen). QM≠MT - QM emphasises strategy implementation (deployment); MT emphasises strategic content. MT should devote more attention to strategy implementation (Dean and Bowen). QM>MT
Organisational Learning	- QM's concept of learning is similar to the concept of first-order learning of the organisational learning theory (single-loop, top-down) (Anderson et al., Hackman and Wageman).	- QM's concept of learning departs from the concept of second-order learning of organisational learning theory (Anderson et al.). MT>QM

Table 2-2. Comparison at the detailed topic level between Quality Management (QM) and Management Theory (MT) (cont.).

Quality Management (QM) Topic	Areas of agreement between Quality Management (QM) and Management Theory (MT)	Areas of disagreement between Quality Management (QM) and Management Theory (MT)
Human Resource Management	- QM is similar in approach to MT's literature on employee involvement, use of teams, training needs analysis and evaluation, and career management (Dean and Bowen, Waldman). - The QM assumption that people naturally care about their work is supported by the theory Y perspective on human behaviour (Anderson et al.).	- MT advocates that employee involvement and empowerment initiatives should be designed using a contingency approach, rather than assumed to be universally appropriate (Dean and Bowen). MT>QM - QM and MT posit different relative contributions of person and system factors to performance. QM emphasises system factors while MT traditionally emphasises person factors. This situation is reflected in different HR practices such as: -selection: the HRM literature advocates the selection of employees with the cultural norms and values akin to QM such as flexibility, the desire to learn and solve problems, and a team orientation; selection is generally not addressed by QM. - performance appraisal and compensation: QM proponents have aversion to individual incentive programs and related practices such as individualised goal setting. The HRM literature proposes a contingency approach according to which the emphasis on person vs. system factors should depend on hierarchical level and autonomy (Dean and Bowen; Waldman). MT>QM - QM argues against competitive behaviour and conflict. MT (social interdependency theory) supports internal co-operation, but also admits that internal competition among individuals can be positive (Anderson et al.). QM≠MT - The following QM aspects are inconsistent with motivational theories in the organisational literature, and according to this literature may impact negatively on worker motivation: restricted autonomy of workers in determining the means by which work is accomplished, with QM's emphasis on identifying the "best" work practices (those that bring work processes under the greatest possible control) and subsequent standardisation and diffusion across the organisation; an exaggerated focus on processes out of control, with seldom explicit setting of positive challenging goals; and no performance-related pay (Hackman and Wageman). QM≠MT
Process Management	- QM's concept of continuous improvement is similar to the concept of incremental innovation and is consistent with the process innovation literature (Anderson et al.)	- MT theory should increase coverage of process and technical factors (both addressed by QM) which are currently undervalued when compared to social aspects (Dean and Bowen). QM>MT - While MT proposes incremental innovation as suitable for mature products and industries, QM advocates incremental innovation over a wider span of the product life cycle (Anderson et al.). QM≠MT
Information and Analysis		- QM over relies on formal analysis of information, especially in ambiguous and political settings (Dean and Bowen). MT>QM - QM points to the need to develop prescriptive theories of decision making and information processing in the realm of MT (Dean and Bowen). QM>MT

<u>Sources</u>: Dean and Bowen (1994), Anderson et al. (1994), Waldman (1994) and Hackman and Wageman (1995).

<u>Legend</u>: QM≠MT: indicated by authors as conflict areas between QM and MT.
MT>QM: indicated by authors as limitations of the practice of QM in the light of MT; areas in which MT could offer insights into the practice of QM.
QM>MT: indicated by authors as areas the practice of QM raises questions for further development in MT.

At a more general level than the previous studies, Spencer (1994) examines QM in relation to the mechanistic, organismic and cultural models of organisation. Addressing several QM components (organisation goal, definition of quality, role/nature of environment, role of management, role of employees, structural rationality, and philosophy toward change), she concludes that QM comprises elements from both the mechanistic and organismic models. According to Spencer, "TQM experts have been more successful than academics in generating precise ways of grafting mechanistic and organismic ideas". She argues that QM research can inform management theory, since QM researchers seem to retain some of what is valuable in the mechanistic and organismic models while discarding some of their negative aspects. In fact, Spencer (1994) conceptualises QM "not as a new paradigm, but as a comprehensive management practice that captures signals from established models of organisation and amplifies them by providing a methodology for use". Similarly, Grant et al. (1994) state that QM can bridge the gap between the "rationalist" school (based on the principles of scientific management and the theory of bureaucracy) and the "human relations" school (based on the role of the organisation as a social system, emphasising psychological and social needs).

2.3.1 Conclusions and further research

The main points arising from the theoretical developments described above are:

1) QM in its pure form (as first envisaged by its founders) may not be synonymous of current best practice. As shown above, there seem to be areas where QM could receive insights from MT. Indeed, practitioners, who have traditionally led the QM field, are merging pure QM with other practices prescribed by MT (e.g., performance related compensation, benchmarking) (Hackman and Wageman, 1995). Furthermore, empirical studies using definitions of QM not strictly based on the founders of the movement and incorporating practices in actual use have shown a link between the use of these practices and performance (e.g., Flynn et al., 1995a; Ahire et al., 1996; Black and Porter, 1996). Whether these deviations from pure QM are implementation

deficiencies threatening performance - as defended by some authors (e.g., Kolesar, 1995) - or a worthy modification of the original QM approach needs to be ascertained.

2) QM can offer insights into management theory, especially in what concerns the pragmatic integration of aspects from traditionally opposing schools of management theory (Spencer, 1994; Grant et al., 1994).

3) There are unresolved conflicts between QM and MT in some areas. Further research needs to be undertaken to ascertain whether MT should incorporate insights from QM or QM principles and prescribed practice should be modified in light of MT. Some of the conflicts between QM and MT arise because of the universal orientation of QM, which contrasts with the contingent approach of MT (Dean and Bowen, 1994). Contingency research into QM seems to be a promising avenue to solve some of these conflicts.

2.4 THE IMPLEMENTATION OF QUALITY MANAGEMENT

An important issue in reflecting on the universal validity of QM practices is how these practices are implemented in a real business setting. By implementation I mean the *change process* by which QM practices are embedded in an organisation. A tremendous wealth of advice is available on how a company can go about implementing QM. Works in this area include experience-based recommendations (e.g., Fenwick, 1991; Dawson, 1995; Davis, 1997), lessons based on case studies (e.g., Instone and Dale, 1989; Lascelles and Dale, 1990; De Cieri et al., 1991; McDonnell, 1992), identification of barriers to implementation (e.g., Oakland and Sohal, 1987; Eisen et al.,1992; Whalen and Rahim, 1994), and reasons why QM programs fail (e.g., Harari, 1993; MacDonald, 1993). Of these, it is difficult to extract a series of underlying threads and principles which apply irrespective of the type of company. Indeed, it has been claimed that there is no optimum implementation approach and that each company needs a tailored implementation program (e.g., Van der Akker, 1989; Atkinson, 1990; Mann and Kehoe, 1995).

Implementation studies have been usually exploratory, descriptive and/or prescriptive in nature. Although they were useful in the first stages of research, we now need to raise the theoretical and methodological level of QM implementation research. We need theoretical frameworks that can structure and guide research beyond the exploratory level towards theory building. In this process, the existing literature on the management of organisational change may be a useful starting point (e.g., Tushman and Romanelli, 1985; Mohrman et al., 1989). Armed with these frameworks, we can then conduct more rigorous empirical research on the implementation process. To date there have been very little rigorous academic empirical research on QM implementation, illustrated by the rare presence of a methodology section in published studies. Another blatant inadequacy, this one also typical of the QM literature in general, is the absence in implementation studies of a clear definition of what is meant by QM content wise.

A good example of the type of research needed is the work of Reger et al. (1994). These authors build a conceptual foundation for understanding cognitive impediments to implementing QM. They clarify the implementation process by distinguishing between the overall accumulated change necessary to install QM, and the pace of the implementation process. The implications of their work for QM implementation are that the overall accumulated change that is needed may be most effectively achieved if comprising a *series* of mid-range changes: each sufficiently large to overcome cognitive inertia, but not so great that it overwhelms the organisation. Additionally, implementation should begin with those aspects that are most aligned with members' positive beliefs about the organisation's ideal identity, thus avoiding cognitive opposition[1]. Finally, QM training should establish cognitive links between QM concepts and the organisation's core identity constructs. That is, it should make members understand QM's abstract concepts in the specific context of the organisation, to prevent them from failing to comprehend the new initiative.

Contingency research is also necessary. Given that there is no one best implementation approach to suit all organisations, it is important to ascertain

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[1] Organisational identity is defined as a "set of constructs individuals use to describe what is central, distinctive, and enduring about their organisation". Change efforts introducing concepts that have little meaning to organisational members because the concepts are not part of their existing organisational identity schemas (failure to comprehend), or that oppose the core organisational constructs (cognitive opposition) will face resistance.

which are the relevant factors and their effects on the choice of implementation approach. An example of this type of research is Mann and Kehoe (1995), who identified process factors, type of employees, shared values, management style, organisational structure, size, and industrial relations as factors affecting the implementation of QM.

2.4.1 Implementation deficiencies or invalid management model?

Problems in the implementation of QM practices have been noted by many authors. The practitioner literature abounds with reports of problems in implementing QM. For example, Harari (1993) and MacDonald (1993) listed reasons why QM may not work, Papa (1993) suggested that after 18 months or so, QM practices can revert to the old ways, and Myers and Ashkenas (1993) discussed ways to stop QM from becoming another expensive and unproductive fad. Empirical studies in Europe also uncovered implementation problems (e.g., Van de Wiele et al., 1993). This raises the question of whether these problems are the result of conceptual flaws in the broad QM approach or of implementation deficiencies. Most authors recognise the virtues of the broad QM model and attribute failures to implementation problems (e.g., Hackman and Wageman, 1995; Masterson et al., 1997; Samson and Terziovski, 1999). These views are supported by Barclay (1993) who explicitly addressed the question of whether failures were a result of a faulty model or implementation deficiencies. His study of 31 US manufacturing and service organisations identified deficiencies in top management support and employee involvement. Large proportions of executives failed to actuate the QM model in specific, critical areas. His results suggest that failure of quality programs in the US seemed to result from implementation and non-committal executives rather than use of a faulty operating model.

In parallel, several authors share the view that successful implementation of QM requires a radical change, resulting not only in redistribution of resources and power, but also in a paradigm shift that may bring into question members' most basic assumptions about the nature of the organisation (e.g., Dobyns and Crawford-Mason, 1991; Munroe-Faure and Munroe-Faure, 1992; Blackburn and Rosen, 1993; Grant et al., 1994; Reger et al., 1994). For example, Grant et al.

(1994) claim that QM is difficult to implement in the West because its theoretical assumptions are in conflict with the economic model of the firm on which conventional management practice and strategic initiatives are based. They conclude that QM cannot simply be grafted onto existing management structures and systems, and requires the redesign of work, the redefinition of managerial roles, the redesign of organisational structures, the learning of new skills by employees at all levels, and the reorientation of organisational goals.

In conclusion, the prevalent view seems to be that the broad QM model - taken as an unified package of practices - is valid, although of difficult implementation.

2.5 THE LITERATURE ON QUALITY MANAGEMENT PRACTICE CONTINGENCIES

The field of QM has been led mainly by practitioners. Like other recent management practices it acquired a strong prescriptive stance in its initial phase with QM practice often being advocated as being universally applicable to organisations and organisations activities. Simultaneously, there has been a lack of rigorous academic scrutiny and deep understanding of the QM philosophy. Only recently, efforts have been made to bridge the gap between theory and practice and to position QM in relation to well established theoretical and conceptual constructs (refer to section 2.3). Within this trend, a more critical approach about the universal validity of QM practices is starting to surface. This section reviews existing contingency research on QM practice, broadly defined as research investigating the influence of the organisational context on QM practice. Three studies stand out as the main rigorous and explicit efforts in this area: *Benson et al. (1991)*, *Sitkin et al. (1994)*, and *Reed et al. (1996)*.

Benson et al. (1991) drew on organisation theory to propose a system-structural model of QM that relates organisational quality context, perceived actual QM (how things are currently done), perceived ideal QM (how things should be done), and quality performance. The model was tested using data collected from 152 quality and general managers from 77 business units with more than 1000 employees of 20 US manufacturing and service companies. Benson et al. (1991)

found that managers' perceptions of *actual* and *ideal* QM were influenced by organisational contextual variables. The finding that managers' beliefs concerning *ideal* QM are apparently not context free lends support for a contingency approach to QM. Although this result could be partially explained by factors addressed in the study affecting managers *perceptions* of the objective reality (managerial knowledge, corporate support for quality), other contextual factors included in the study (external quality requirements, product complexity) may indeed have an objective effect on the applicability of QM practices.

Sitkin et al. (1994) divided QM into two conceptually distinct approaches: total quality control (TQC) and total quality learning (TQL). Both approaches are rooted on three common guiding QM precepts which reflect the core philosophy of QM: focusing on customer satisfaction, stressing continuous improvement, and treating the organisation as a total system. The TQC approach is based on the principles of cybernetic control systems and is considered the most suitable to contexts with low uncertainty - task, product/process and organisational uncertainty. The TQL approach is oriented towards the uncovering of new problems or developing solutions independent of current problems, emphasising second-order learning and creativity. This approach is considered the most suitable for fundamentally uncertain contexts, in which tasks are poorly understood. According to the authors, the two approaches give rise to different sets of operating principles and practices that must be used simultaneously in some appropriately balanced way. In their opinion, traditional QM approaches, as they have been conceptualised and applied in the past, are very close to TQC, with an exaggerated emphasis on control. They defend that the current QM approaches can be expanded - while still based on the three common quality precepts - to include TQL so that they can work under conditions characterised by high uncertainty and nonroutineness. Sitkin et al. (1994) propose a contingency model of QM effectiveness, according to which effectiveness depends on the degree to which the balance between the TQC and the TQL approaches matches the level of situational uncertainty of the organisation. The authors propose that organisational effectiveness is the result of the *interaction* between the degree of uncertainty and

QM approach. Thus, they discard a *direct* effect of QM practice alone on effectiveness.

Reed et al. (1996) use contingency theory to consider QM content issues at a strategic level, in the same way that Sitkin et al. (1994) used it to consider process issues at an operational level. According to Reed and colleagues, firms with different strategic orientations (customer vs. operations) achieve financial performance through different routes with which different QM practices are associated (see Table 2-3).

Table 2-3. Firm orientation and the associated route to financial performance and quality management practices.

Firm orientation (strategic choice)	**Route to financial performance**	**Associated QM practices**
Customer Orientation (concern for customer needs, concern for competitors offerings and interfunctional co-ordination of activities in the firm)	- Market advantage (increased revenues) - Product design efficiency (reduced costs)	- Customer focus - Benchmarking - Practices associated with product design
Operations Orientation (the notion of an operations orientation is grounded in classical management theory)	- Product reliability (increased revenues) - Process efficiency (reduced costs)	- Practices associated with product reliability - Practices associated with process management

Source: Reed et al. (1996).

The authors use their framework to develop a contingency model of QM, according to which QM effectiveness depends on the degree of fit between firm orientation (with the associated QM practices) and environmental uncertainty. For an environment with a high degree of uncertainty, a firm should adopt a customer orientation, pursuing financial performance via the market advantage and/or product-design efficiency routes. This would entail adopting a QM program focusing on the right content issues, i.e., customer focus, benchmarking, and/or product design. Similarly, for an environment with a low degree of uncertainty, a firm should adopt an operations orientation, pursuing financial performance via the process efficiency and/or product reliability routes. Again, this would entail adopting a QM program focusing on the right content issues, i.e., product reliability and/or process management.

Besides these three main works which directly addressed the influence of context on QM practice, other studies have tangentially uncovered several contextual factors affecting QM practices, such as industry (Maani, 1989; Powell, 1995), firm size (Price and Chen, 1993; Madu et al., 1995), years since adoption of QM programs (Powell, 1995; Ahire, 1996), country (Madu et al., 1995), and product/process factors (e.g., manufacturing system, Maani, 1989; type of work an organisation does, Lawler, 1994; breadth of product line and frequency of product changes, Kekre et al., 1995).

2.5.1 Conclusions and further research

The existing literature on QM contingencies, although sparse, clearly raises the possibility of individual QM practices being context dependent. With the three exceptions already mentioned (Benson et al., 1991; Sitkin et al., 1994; Reed et al., 1996), to the author's knowledge there are virtually no studies explicitly and rigorously addressing the impact of the organisational context on QM practice. And of the three studies mentioned, only one has an empirical component. It is therefore important to look more carefully behind the proposed universality of individual QM practices by empirically investigating the influence of context on QM practices.

2.6 CHAPTER SUMMARY

This chapter reviews the literature in QM organised along five research themes which are deemed relevant for the progress of knowledge in the field and to the topic of this thesis: the definition of product quality, the impact of QM on firm performance, QM in the context of management theory, the implementation of QM and contextual factors affecting QM. These research themes revolve around the issue of whether QM practices are universally applicable.

Research efforts in defining product quality suggest that quality is a multidimensional construct and that there is no single definition of quality. One must focus upon the fundamental nature of an organisation's output and use a definition of quality encompassing the relevant dimensions for that output.

The impact of QM on business performance may take place via essentially two different routes: the manufacturing route (through improved internal process quality and operational performance) and the market route (through improved product quality). Empirical research to date suggests that QM practices have a significant and strong impact on internal process quality, product quality and operational performance. The indirect impact of QM practices on business performance via the mediating effect of quality performance (internal process quality and product quality) and operational performance, although significant, is weaker.

Theoretical developments in the field have found areas where QM and management theory are similar, areas where QM could receive insights from management theory, areas where QM could offer insights into management theory, and areas of unresolved conflict.

Research in QM implementation suggests that there is no one best way to implement QM, and that the implementation process must be tailored to each company. It also recognises that implementation is difficult, requiring radical change. Despite this, the prevalent view is that, although of difficult implementation, the broad QM model - taken as an unified package of practices - is valid.

Research on QM practice contingencies clearly raises the possibility of individual QM practices being context dependent. However, there is still very little empirical research explicitly and rigorously addressing the impact of the organisational context on QM practice. Future research should look more carefully behind the proposed universality of QM practices by empirically investigating the influence of context on QM practices.

3. QUALITY MANAGEMENT: UNIVERSAL OR CONTEXT DEPENDENT?

This chapter draws on the literature review of Chapter 2 to formulate the study's research question. In addition, it puts forward the contributions that the study aims to make, both at the research and managerial levels.

3.1 QUALITY MANAGEMENT: UNIVERSAL OR CONTEXT DEPENDENT?

Since its inception, the field of QM has been led mainly by practitioners. Like other recent management philosophies, QM has acquired a strong prescriptive stance with practices often being advocated as being universally applicable to organisations and organisations activities. This trend is part of the emergence of a new paradigm in Operations Management based on the assumption that the adoption of best (world class) practice in a wide range of areas leads to superior performance and capability. Voss (1995) calls it the best practice paradigm. This paradigm focuses on the continuous development of best practice on all areas within a company. In fact, the last two decades have been characterised by the introduction of a wealth of new management practices presented as being universally applicable (e.g., MRP, TQM, TPM, JIT). This universal orientation of QM, among other practices, has been pointed out as contrasting with the contingent approach of management theory in general (Dean and Bowen, 1994) (refer to section 2.3). In particular, the field of Operations Management has been strongly rooted from its inception on a manufacturing strategy contingency approach. Voss (1995) calls this the strategic choice paradigm. The assumption of this paradigm is that internal and external consistency between manufacturing strategy choices increases performance (e.g., Woodward, 1965; Hayes and Wheelwright, 1979a; Hill, 1985; Ward et al., 1996). Internal consistency refers to the coherence between the different elements of a manufacturing strategy; external consistency refers to the match between this set and the wider strategic context (e.g., marketing strategy). This is in contrast with the universal approach of the best practice paradigm.

In addition, as QM has matured, more recent rigorous academic studies have raised doubts as to the universal validity of its set of QM practices (e.g., Benson et al., 1991; Sitkin et al., 1994; Reed et al., 1996). The existing literature on QM contingencies, although sparse, clearly raises the possibility of QM practices being context dependent (this literature was reviewed in section 2.5).

Doubts have also been raised as to whether all QM practices need to be in place in order to produce superior quality outcomes. Several large scale empirical studies examining the impact of QM on firm performance have found that some QM practices did not have a significant impact on performance (e.g., Powell, 1995; Dow et al., 1999; Samson and Terziovski, 1999) (these studies were reviewed in section 2.2.2). It has been suggested that this may be due to these practices being context dependent (Powell, 1995; Dow et al., 1999).

Simultaneously, as seen in section 2.4.1, the QM practitioner literature abounds with reports of problems in implementing QM. This raises the question of whether these problems are the result of conceptual flaws in the broad QM approach or of implementation deficiencies. The existing evidence points to the broad QM model - taken as an unified package of practices - being valid, although of difficult implementation (refer to section 2.4.1). Although proponents of the universal view of QM would argue that implementation difficulties are part of moving the organisation towards quality, an alternative explanation is that those difficulties result from too great a mismatch between the proposed form of QM and the particular organisational context. This explanation has been overlooked by research on QM implementation. Taking for granted that espoused QM is universally applicable, the influence of an organisation's context has been ignored. To what extent are implementation difficulties the result of an underlying structural mismatch between the proposed form of QM and the organisation's context? Is it always worth, or even possible, to change an organisation's context to accommodate QM practices as espoused? Or are there innate organisational characteristics resulting for example from the nature of the markets, business strategy, or process hardware that cannot or are very difficult to change in order to accommodate standard QM? Should one instead adapt the content of QM and the organisation's context to each other? There is a fine line between implementation difficulty and inadequacy with respect to context, and more research is needed to shed light on these difficult questions.

Many of the potential contingency factors uncovered in the QM contingency studies reviewed in section 2.5 have strong associations with strategic context which is at the root of the clash between the best practice and strategic choice paradigms. In addition, links have been empirically observed between a firm's strategic context and the pattern of adoption of improvement programmes (Kim and Arnold, 1996). Despite the tensions identified in the literature, apparent across different streams of research in the Quality Management/ Operations Management field, there is still little empirical research conducted at the intersection of the two paradigms and aimed at shedding light on the question: Are QM practices contingent on a plant's strategic context? Could QM practice strategic contingencies be the missing link?

3.1.1 Research question

To address the above question, this study sets out to empirically investigate whether QM practices are contingent on a plant's manufacturing strategy context (testing); and if so, to explain how a plant's strategic context affects these practices (explaining).

3.2 MOTIVATION FOR THE STUDY

This study aims to make a contribution both at the research and managerial levels. At the research level, and besides shedding light on the aforementioned tensions in the QM field between the best practice and strategic choice paradigms, the study aims to provide contributions to the specific QM research streams of implementation, practice-performance relationships, links with management theory, and QM practice contingencies (refer to Chapter 2).

At the implementation level, identifying the boundaries of applicability of QM practices would help distinguish between implementation difficulties and inadequacy of certain practices for the organisational context. This in turn would clarify the implementation process, and lead the way to developing guidelines for the implementation of QM practice in different contexts. This would help to structure the current chaotic wealth of implementation advice (refer to section 2.4).

At the practice-performance level, existing models have examined universal associations between QM practice and performance. The fact that these relationships may be affected by contextual factors, may partially explain the sometimes weak power of QM practice in explaining firm performance (Powell, 1995; Dow et al., 1999). In fact, it has been proposed that performance results from the *match* between QM practice and organisational context (Sitkin et al., 1994; Reed et al., 1996). If contextual factors are taken into account, we can increase the explanatory power of the practice-performance models, and develop different models for different contexts (refer to section 2.2).

At the management theory level, it has been suggested that some of the conflicts between QM and management theory arise due to the universal orientation of QM which contrasts with the contingent approach of management theory (Dean and Bowen, 1994). Contingency research into QM might solve some of these conflicts (refer to section 2.3).

In what concerns QM practice contingencies, by empirically examining the effect of manufacturing strategy on quality management practices, this study aims to increase our understanding of the influence of a major facet of the organisational context on quality management and enlarge the existing sparse body of knowledge in this area (refer to section 2.5).

A philosophy of science perspective provides a final research level motivation for the study. Given the applied nature of the Operations Management subject area, it should provide theories that are useful across a spectrum of contexts. As Van de Ven (1989) put it, "Nothing is so practical as a good theory". This reinforces the need to have a more sophisticated descriptive contingency theory. The present study aims to test the scope of existing theory on quality management. Moreover, it may reveal patterns that could lead to the extension and refinement of existing theories. These more complete theories would not only stipulate relationships, but also closely specify the contexts in which they are expected to occur. This in turn would have several benefits. First, it would facilitate theory testing procedures by directing efforts to disproving theories in the known situations in which they should apply. Second, identifying relevant contextual factors would contribute to increasing the confidence in the results of empirical research. Even if these contextual variables are not the main purpose of empirical studies, controlling for as many relevant factors as possible increases the likelihood that findings will not be affected by factors other than those specifically under consideration. Finally, increasing our knowledge about the influence of context would guide the selection of the unit of analysis for research. For example, if plant level characteristics are relevant for a particular line of enquiry, then the study should be conducted at plant level, rather than at corporate level.

For businesses, failure to acknowledge the limits of applicability of QM practices may lead to their application in contexts to which they are not suitable. This reduces the chances of success, discrediting practices whose validity, although not universal, might certainly hold in appropriate contexts. MacDonald (1993), for example, notes that the early pioneers in QM exhibited the highest ratio of success. At that stage there was no packaged solution nor a set of defined tools available. This led to a more critical application of the concepts to the particular contexts of the organisations. Followers, heeded by the initial success of QM, embarked on a mass adoption of these concepts, resorting to the then available turnkey packages, and there was not the same need for hard thinking. This may have led to the much lower ratio of success in quality programs in recent years. It is therefore crucial to identify in which contexts a certain practice works. This would provide guidelines for the selection of the set of QM practices that is most appropriate for a plant's strategic context, or taking a more proactive approach, guidelines for which aspects of a plant's context may need to be modified before the adoption of certain practices.

3.3 CHAPTER SUMMARY

The bulk of the QM literature is practitioner oriented and universalistic. A reflection on the literature review of Chapter 2 revealed the need for a more critical approach regarding the espoused universal validity of QM practices. In particular, the contrast between the universal approach of QM and the strong manufacturing strategy contingency approach in which the Operations Management field is rooted, the doubts raised by some studies about the universal validity of the whole set of QM practices, and the large number of problems reported in the implementation of QM programs, pointed to the need to investigate the influence of a plant's strategic context on quality management practices.

To address this need, the present study sets out to empirically investigate whether QM practices are contingent on a plant's manufacturing strategy context (testing); and if so, to explain how a plant's strategic context affects these practices (explaining). At the research level, the study aims to make a contribution to the research streams of implementation, practice-performance relationships, links with management theory, and QM practice contingencies, discussed previously in the literature review. At the managerial level, the study aims to provide guidelines for the selection of the set of QM practices that is most appropriate for a plant's strategic context, or taking a more proactive approach, to provide guidelines for which aspects of a plant's context may need to be modified before the adoption of certain practices.

4. RESEARCH DESIGN

Contingency research on Quality Management (QM) practices may be broadly defined as research investigating the influence of the organisational context on QM practices. Chapter 3 defined the objective of the present study as being to empirically investigate whether QM practices are contingent on a plant's manufacturing strategy context; and if so, to explain how a plant's strategic context affects these practices. The present study is thus an instance of a general contingency study on QM practices, examining the influence of a specific contextual factor - a plant's strategic context.

This chapter develops a general design for conducting contingency research into QM practices and then describes how this general design is applied to address the study's specific research question, seen as an instance of general contingency research. This design will underpin subsequent chapters.

4.1 A GENERAL DESIGN FOR CONDUCTING CONTINGENCY RESEARCH ON QUALITY MANAGEMENT PRACTICE

The objective of contingency research on QM practice is to ascertain the adequacy of different practices for different organisational contexts. The definition of what is meant by a given practice being adequate for a given context is crucial, as it determines the research design strongly. For the purposes of this study, a specific practice is considered adequate for a given organisational context if it contributes to improved performance, i.e., if its use is effective from a technical perspective. Thus, a practice is contingent on context if its effectiveness varies significantly according to the context in which it is used. According to this definition, non-efficiency considerations are not considered in assessing a practice's adequacy for a particular context.

The general research design that I propose is based on the adopted definition of "adequacy of a practice to context" and is closely associated with three main aspects relevant to contingency research on QM practices: 1) The drivers of adoption of QM practices; 2) The process of adoption of QM practices; and 3) The role played by context in the adoption and use of QM practices. These are each addressed next. The associated considerations are then used to develop a general research design for conducting contingency research into QM practice.

4.1.1 Drivers of adoption of quality management practices

By drivers of adoption I mean the forces leading an organisation to the decision to adopt QM practices in its particular organisational context. Given that the adopted definition of "adequacy for context" is based on efficiency concerns, it is of interest to classify the factors leading to the decision to adopt a certain practice into two categories:

1) *Efficiency related factors*: These lead to the adoption of practices with the direct objective of enhancing performance: increased competition/ decline in performance.

2) N*on-efficiency (institutional) related factors*: These factors are not directly associated with the objective of improving performance: coercive and mimetic pressures.

The two efficiency related factors, *increased competition and decline in performance*, are very closely linked. Lascelles and Dale (1986) distinguish between defensive and offensive drivers of adoption of QM. Defensive drivers result from competitive forces (or changes in competitive forces) which motivate companies to improve in response to a threat. These can include profits squeezed under competitive pressure, lost market share due to entry by foreign companies, changes in market structure, rationalisation following market contraction due to economic recession, and buyer attitudes in export markets (Lascelles and Dale, 1986). Offensive drivers are linked to some kind of proactive strategy designed to give a company a competitive lead. These can include product innovation strategies, building market share (Lascelles and Dale, 1986), achieving quality leadership in the market and increasing strategic options (Eisen et al., 1992).

Non-efficiency (institutional) factors can also drive the adoption of management practice (DiMaggio and Powell, 1991). Nohria and Green (1996) and Westphal et al. (1997) provide empirical evidence for the influence of institutional factors in the process of adoption of QM. Institutional factors can be classified into coercive and mimetic pressures[1] (DiMaggio and Powell, 1991). *Coercive pressures* refer to organisations adopting certain practices because of pressure from the state, other organisations or the wider society. They include force, legal compulsion, fear of suit, gaining legitimisation, gaining funding, subordination to a parent organisation, need to fit with a technical system (e.g., telecommunication interconnections), conformity to institutionalised rules, and need to be acceptable to powerful, hierarchically structured organisations and rationalising ideologies (DiMaggio and Powell, 1991). In QM, there are numerous publicised cases of customer pressure, legitimisation pressures (e.g., image building and gaining credibility with potential customers, especially for a new untried company), pressures from the parent company already using the practices, and legal requirements (e.g., product liability legislation).

Mimetic pressures are at work when, as a result of bounded rationality and limits on time, energy, as well as substantial uncertainty regarding the efficiency of new practices, organisations copy others by adopting what are perceived to be legitimate practices (DiMaggio and Powell, 1991). These practices have been called "fads" or "fashions" (Abrahamson, 1991). Strictly speaking, mimetic factors cannot be, a priori, objectively differentiated from efficiency factors, since adopting a practice that is perceived as effective in other organisations is open to both an efficiency and a mimetic interpretation (Donaldson, 1995, p. 83).

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[1]Although most institutional studies concentrate on mimetic and coercive effects, institutional theorists consider a third group of institutional effects: normative pressures (DiMaggio and Powell, 1991). These are related to professionalisation. It is argued that, in certain sectors such as hospitals and others with professionalised personnel, status competition playing to professional criteria can significantly influence the form of the adopted organisational structure. Since these factors are only prevalent in specific contexts, and are almost certainly absent in most manufacturing contexts - the focus of this study - they will not be considered here.

Both efficiency and non-efficiency factors have been empirically identified as drivers of adoption of both individual QM practices (SPC, Team Work, Zero Defects, Simultaneous Engineering) (Cagliano and Spina, 1998) and company wide and system wide manufacturing improvement initiatives (Ahlstrom et al., 1998).

4.1.2 The process of adoption of quality management practices

In the current environment of fast diffusion and innovation in managerial concepts and best practices, the adoption of particular practices requires organisations to assume a proactive role. Organisations may, in a relatively short period of time, adopt, modify and/or discard practices as they see fit. The set of best practices circulated by media, consultants, etc., and which are candidates for adoption, are perceived by the wide business community as being universally applicable and as off-the-shelf measures to improve performance (Smith and Tranfield, 1996). The presumption that innovations will universally benefit organisations corresponds to what Abrahamson (1991) calls "pro-innovation biases", and is a phenomenon which has been accounted for in the diffusion of innovation literature (e.g., Kimberly, 1981; Rogers, 1983). Practices are encapsulated by organisations under a theme generally associated with the improvement of certain performance criteria (e.g., the TQM theme associated with the improvement of quality) (Smith and Tranfield, 1996). However, the role of these thematic labels seems to be more of providing organisational legitimacy and focusing the change programme, rather than defining the specific practices to be adopted (Smith and Tranfield, 1996). As elaborated in more detail later, I propose that the long-term pattern of use and effectiveness of QM practices is determined by the interaction of the pressures for adoption and the organisational context, which acts as a filter. The emphasis is on the restrictions imposed by context on the adoption of QM practices. Figure 4-1 uses a physical analogy to depict the proposed model for adoption of QM practice emerging from this discussion.

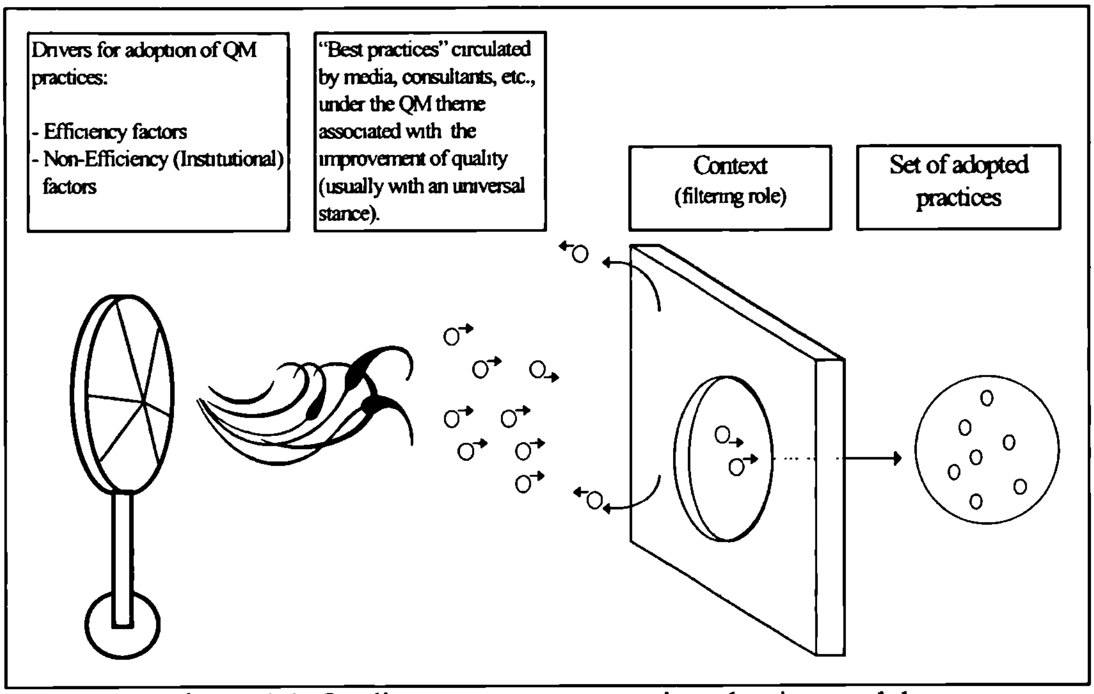

Figure 4-1. Quality management practice adoption model.

4.1.3 The role played by context (the filter)

This section elaborates on the mechanisms by which the proposed filtering action of context is assumed to take place, determining the long-term pattern of use and effectiveness of practices in an organisation. Here, we need to distinguish between two types of organisations: purely efficiency driven organisations and organisations subject to non-efficiency pressures for adoption of QM practices.

For a purely efficiency driven organisation, the filtering action of context is proposed to take place by means of a cost-benefit logic of implementation of individual practices. Underpinning this cost-benefit logic is the fact that budgets, technical knowledge and manpower resources are finite. Within this efficiency logic, the continuous use of a specific practice will result from a favourable weighing of the perceived payoffs against the implementation difficulty (or cost). Practices with a favourable weighing will be perceived as effective and are expected to be highly used. I call these practices *Best-Practice Tool-Kit*. Practices with an unfavourable weighing will be perceived as ineffective and are expected to be lowly used. I call these practices *Misfits*.

Of course, even in purely efficiency driven organisations ineffective practices can be temporarily in place. For example, the initial cost-benefit analysis leading to a favourable balance and a notion of perceived effectiveness and subsequent adoption, may have been ill-founded. However, in these cases, an organisation is expected to discard these practices as soon as it realises that they are indeed not paying off. Oliver (1992) and Van de Ven and Polley (1990), for example, recognise that efficiency forces may indeed lead to the rejection of existing practices. In the long-term, one would then expect to observe a low degree of use of these practices. Therefore, for an efficiency driven organisation, the long term observed pattern of use of individual practices should enable one to infer about their adequacy for context because it is expected that there will be a perfect correlation between the degree of use of the practices and their effectiveness in context[2].

However, for organisations for which non-efficiency factors may also drive the adoption of some practices, then ineffective practices may be in place, long-term, in an organisation. Hence, the long term observed pattern of use of individual practices may not be sufficient for one to infer about their adequacy for context. In fact, for those organisations, coercive and/or mimetic pressures may break the context (or efficiency) barrier leading organisations to take a conscious decision to adopt a practice which is perceived as non effective in their context. In this case, it is expected that the practice stays in place, whether as a facade or for real, for extended periods of time. One would expect to observe a high degree of use of these practices. Organisations should attempt to remove pressures for the use of these practices and then discard them. I call these highly used, but low effectiveness practices, *Panaceas*. Non-efficiency pressures may also lead to the low use of efficient practices. For example, powerful outside organisations with vested interests may exert political pressures discouraging the use of a particular practice (Abrahamson, 1991). Or newly, more fashionable practices, with their

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[2] The proposed role of context in a purely efficiency driven organisation is consistent with the perspective on organisational change found in evolutionary economics (Aldrich, 1979;Nelson and Winter, 1982). The evolutionary perspective suggests that organisations develop a set of organisational routines ("practices") over time. These routines are subject to selection pressures. Only changes that result in positive change for the organisation are retained. Routines can be changed through trial and error experimentation and/or organisational search for superior ways of doing things. In this search for superior routines managers typically look only to familiar technologies and practices.

symbolic power of signalling innovation, may take the place of emotionally worn out practices which have become routine and generated boredom (Abrahamson, 1991). I call these practices *Worn Out.*

Table 4-1 summarises the discussion and provides a basis for an empirical distinction between practices according to their adequacy for a specific type of organisational context.

Table 4-1. A characterisation of practices according to their adequacy for a specific type of organisational context.

Type of Practice	Description	Empirical Characterisation (*)
Best Practice Tool-kit	Adequate for context Practices constitute the basic set for the organisation to implement in its context.	High degree of use High effectiveness
Misfits	Inadequate for context Practices should be discarded from the set of alternatives for the organisation's context.	Low degree of use Low effectiveness
Panaceas	Inadequate for context Practices are used for reasons other than their effectiveness. Organisation should attempt to remove pressures for use, and then discard them.	High degree of use Low effectiveness
Worn Out	Adequate for context Practices are less used due to reasons other than their effectiveness. If they have not been replaced by equivalent practices, the organisation should remove the pressures against their use, and re-instate them.	Low degree of use High effectiveness

(*) Based on observations across a number of organisations which are representative of the type of organisational context in question.

4.1.4 A general design for contingency research on quality management practice

The role of context just examined provides clues to the development of a general design for conducting contingency research on QM practice. In fact, since context influences the pattern of use and effectiveness of practices, these patterns provide an empirical means for assessing the influence of context. Because the effectiveness of individual practices is difficult to ascertain empirically - the impact on performance outcomes of the use of a particular practice is difficult to disentangle from the impact of other practices and factors - it would be desirable to be able to rely on the patterns of use of practices. It is proposed that the adequacy of QM practices for a specific context can be empirically determined by investigating their long-term pattern of use in organisations which are representative of the context in question and which fulfil the following conditions (or research controls):

1) There is a strong efficiency drive for adoption of QM practices (the fan). This ensures a good correlation between the degree of use and effectiveness of practices in place in the organisations (or equivalently, it reduces the likelihood of finding Panacea or Worn Out practices). Examples would include organisations in highly competitive industries.

2) There is a high degree of awareness by the organisations of the whole range of best practices encapsulated under the QM theme, and of the links between these and the improvement of performance. These practices are candidates for adoption by the organisations in order to improve performance. This condition ensures that no practices within the QM set are overlooked thus avoiding the distortion of the observed pattern of use. In this manner, one will able to state that the fact that a particular practice is not used does not result simply from the organisations not being aware of it. Examples would include companies regularly involved in benchmarking exercises, regularly receiving information on best practice (e.g., by being members of quality associations, participating in conferences, seminars, etc.), having tight co-operation with management research institutions or consulting firms, etc.

3) The organisations have undergone a reasonably long process of experimentation in the adoption of QM practices. In other words, the organisations should be "mature" in terms of the adoption of QM practices, for example, having had a formal program of quality improvement in place for an extended period of time. This ensures that the efficiency logic of implementation of practices has had the time to produce effects, and overcome eventual non-efficiency pressures as well as override the influence of an organisation's particular starting point and implementation process (the embedding of practices in the organisation along time) on the observed pattern of use.

In summary, it can be argued that the observed pattern of use of QM practices in organisations fulfilling the above conditions is likely to reflect the filtering action of context, isolated from other confounding factors. On the one hand, this assures that the plant has had the time to adopt the practices it deems suitable to its context. If the plant is aware of the whole range of existing practices it will have made an informed decision regarding the practices it has adopted. On the other hand, with sufficient time elapsed, a plant is able to make a sound assessment of a practice's effectiveness. Time should be allowed for the informed adoption of a practice to bear fruits and consequently for it to be maintained in the plant's tool-kit; or for its ineffectiveness to be acknowledged and the practice discarded, due to the strong efficiency pressures. This need for experimentation in adopting new practices has been highlighted by several authors (e.g., Smith and Tranfield, 1996). Whilst the initial starting position may affect the process of implementation (e.g., the sequence by which the set of practices are implemented), it is assumed that it will not affect the long-term pattern of use of practices. This pattern is assumed to be determined by the interaction of the ideal (or espoused) final form of QM practice and the organisational context by means of the cost-benefit mechanisms described earlier. Because the ideal form is shared widely by organisations - by virtue of their diffusion by the media, consultants, etc. - the assumption that it is context that will determine the actual final form seems reasonable.

If empirical observations are replicated across organisations representing different contexts, Table 4-1 provides a basis for an empirical distinction between practices which are universally applicable and practices which are context dependent. Practices which consistently fall under the Best-Practice Tool-kit category across a whole range of different organisational contexts will approach universal status; while those which do not, will be context dependent.

4.1.5 Scope of application of the general research design

The developed general research design assumes that changes in context occur at a slow rate when compared to changes in QM practice adoption. That is, contextual variables are assumed to exhibit high inertia. Accordingly, the design should only be applied to aspects of context fulfilling this assumption. This limitation does not seem to be very restrictive. In fact, configurations of important contextual aspects such as competitive strategy, organisational structure, manufacturing processes and infrastructure are consistently viewed in the literature as exhibiting high inertia and being stable. For example, in the Operations Management field, the manufacturing strategy context is seen as being subject only to slow changes. Investments in manufacturing processes and infrastructure are inherently large and fixed, and once a company has invested in them it will have to live with them for better or for worse for many years unless it is willing and able to re-invest (Hill, 1985). As another example, in the economic theory field, mobility barriers are viewed as constraining the movement of one organisation from a particular strategic configuration to another (e.g., Caves and Porter, 1977; McGee and Thomas, 1986), and empirical studies have found that indeed these movements are rare (Mascarenhas, 1989; Ketchen et al., 1997). Mobility barriers include the cost of improving production efficiency, market related strategies, industry supply characteristics, firm specific characteristics (McGee and Thomas, 1986), and structural inertia (factors such as sunk cost in plants, equipment and personnel, dynamics of political coalitions and barriers to entry and exit) (Hannan and Freeman, 1984), among several others.

In conclusion, the general research design fits a wide range of contextual aspects, among which are strategic context aspects.

4.2 A RESEARCH DESIGN FOR INVESTIGATING THE INFLUENCE OF STRATEGIC CONTEXT ON QUALITY MANAGEMENT PRACTICE

The objective of the present study is to empirically investigate whether QM practices are contingent on a plant's manufacturing strategy context; and if so, to explain how a plant's strategic context affects these practices. As indicated in Chapter 1, the study has the manufacturing plant as the unit of analysis and concentrates on production related QM practices. Given the scope of the study and rooted on the general research design described in the previous section, I propose to address the study's research question by:

examining the pattern of use of individual production-related QM practices in manufacturing plants representative of different strategic contexts spread across the strategic spectrum and complying with the identified research controls.

Practices found to consistently exhibit a high level of use in plants spread across the strategic spectrum will approach universal status, while those which do not will be contingent on strategic context.
This research design will underpin subsequent chapters.

4.3 CHAPTER SUMMARY

This chapter put forward a general design for conducting contingency research on QM practice. The objective is to ascertain the adequacy of different practices for different contexts. The "adequacy of a particular practice for a particular context" is defined as the extent to which the use of the practice in that context is effective from a technical point of view. It is proposed that by examining organisations exhibiting certain characteristics (i.e., complying with certain research controls) one can ensure that the observed pattern of use of practices enables one to infer about their adequacy for context. These characteristics are: having strong efficiency pressures for the adoption of QM practices, being highly aware of the whole range of QM practices, and having had a quality improvement programme in place for a long period of time.
The objective of the present study is to empirically investigate whether QM practices are contingent on a plant's manufacturing strategy context; and if so, to explain how a plant's strategic context affects these practices. Thus, the study is an instance of a general contingency study on QM practices, examining the influence of a specific contextual factor - a plant's strategic context. It has the

manufacturing plant as the unit of analysis and concentrates on production related QM practices. Given the scope of the study and rooted on the general design for contingency research that was developed, I propose to address the study's research question by examining the pattern of use of individual production-related QM practices in manufacturing plants representative of different strategic contexts spread across the strategic spectrum and complying with the identified research controls. These observations will allow for the identification of universal and context dependent practices. This research design will underpin subsequent chapters.

5. DEFINING STRATEGIC CONTEXT

Chapter 4 delineated a research design to investigate the influence of strategic context on quality management (QM) practices. This design is based on the examination of the use of QM practices in plants representing different strategic contexts spread across the strategic spectrum. In the present chapter, I define how strategic context variables are considered as a group, how the strategic context spectrum is chosen to be represented, and which specific aspects of a plant's strategic context are considered (i.e., the specific variables across which a plant's strategic context will be characterised).

5.1 CONSIDERING CONTEXTUAL VARIABLES AS A GROUP

Here, two approaches can be adopted: the configurational or the multi-dimensional approach. The term *organisational configuration* denotes

> "any multidimensional constellation of conceptually distinct characteristics that commonly occur together (...). Configurations may be represented in typologies developed conceptually or captured in taxonomies derived empirically." (Meyer et al., 1993)

The configurational approach to organisational analysis takes the view that the multiple attributes tend to fall into coherent patterns, which occur because attributes are in fact interdependent and often can change only discretely or intermittently. This implies that only a fraction of the theoretically conceivable configurations are viable and apt to be observed empirically. The configurational approach does not admit that multiple attributes of an organisation vary independently and continuously, in which case the set of possible combinations would be infinite. On the other hand, the multi-dimensional approach considers the additive influence of the individual dimensions independently.

In the field of Operations Management several authors have proposed a discrete number of strategic configurations in which several dimensions appear to cluster together. Woodward (1965) demonstrated that production technology has a systematic relationship with organisational structure and management characteristics. Hayes and Wheelwright's (1979a, 1979b) product-process matrix categorises process structure into Job-Shop, Batch, Assembly Line, and Continuous Flow. These process structures are associated with other aspects of the manufacturing system such as people, technology, equipment and control procedures, and are linked with the marketing and business unit strategies. Later, Hill (1985) develops his manufacturing strategy contingency framework. He categorises manufacturing processes into Project, Jobbing, Batch, Line and Continuous Processing. These process types are matched with corresponding infrastructure types comprising other aspects of the manufacturing system such as organisational structure, work structuring, compensation agreements, clerical procedures, manufacturing systems engineering, quality assurance and control, manufacturing planning and control systems and function support. Hill (1985) also links the five process and infrastructure types to the corporate, business unit and marketing strategies. Stobaugh and Telesio (1983) developed a typology of manufacturing strategies comprising Technology-Driven, Marketing-Driven, and Low-Cost strategies. Miller and Roth's (1994) study of 188 US manufacturing companies provided empirical support for the previously developed typologies by finding three configurations of manufacturing strategy: Innovator, Marketeer, and Caretaker. Recently, Ward et al. (1996) have integrated past work from the fields of manufacturing strategy and competitive strategy, and developed four conceptual configurations of manufacturing strategy, business strategy, environment and structure: Niche Differentiators, Broad Differentiators, Cost Leaders, and Lean Competitors.

The present study adopts a configurational approach due to four reasons. First, there has been substantial theoretical and empirical evidence supporting the existence of strategic configurations. Besides the above mentioned studies in the OM field, research in the Organisation Theory field has found that organisations adopting adequate configuration forms exhibit superior performance (Ketchen et al., 1997). Second, the configurational approach has been recommended for examining strategic fit issues in Operations Management (Bozarth and McDermott, 1998). Third, the consideration of a discrete number of strategic configurations - each embodying a different strategic context - facilitates the conceptualisation of findings, without over simplifying. Finally, the rationale for the existence of strategic configurations is based on efficiency considerations, and is therefore consistent with the research design described in Chapter 4. In fact, the assumption underlying strategic configurations is that following one of these configurations, assuming it is implemented appropriately, increases the odds of long run success (Ward et al., 1996). Organisations driven by efficiency concerns would thus be expected to adopt one of the proposed strategic configurations.

5.2 REPRESENTING THE STRATEGIC CONTEXT SPECTRUM

Three main strategic configurations are consistently identified in the aforementioned Operations Management studies, and there is substantial agreement on the characteristics of those configurations. The three configurations are what Ward et al. (1996), for example, call Niche Differentiators, Broad Differentiators, and Cost Leaders. Given the substantial agreement on the three basic strategic configurations among the mentioned studies, it is not critical which study is chosen as the basis for the research. Given its integrative nature, I consider Ward et al.'s (1996) three basic strategic configurations. These three strategic configurations do not represent the entire realm of strategic possibilities; thus, they are representative, not exhaustive. The three configurations, embodying three strategic contexts, are taken as anchor points representing the strategic context continuum.

5.3 CHARACTERISING THE STRATEGIC CONTEXT

Given that a configurational approach is adopted, choosing which aspects of context to consider equates to choosing the dimensions across which the three chosen configurations - Niche Differentiator, Broad Differentiator, and Cost Leader - will be characterised. It is impossible to consider all dimensions of context, so that a restricted set of variables must be chosen. In this process, the following guidelines should be followed:

- the selection should have a theoretical basis;
- the list of chosen variables should be coherent and not merely eclectic (e.g., Pettigrew, 1987);
- the list of variables should be relevant to the phenomenon under study.

Accordingly, the contextual dimensions selected for this study correspond to the dimensions addressed in the studies that have developed the three strategic configurations. Thus, they have a theoretical basis, are coherent, and, based on the formulation of the research question presented in Chapter 3, are expected to be relevant to QM practices, the phenomenon under study.

All the studies developing the three strategic configurations, although emphasising the association between the marketing strategy and manufacturing strategy (processes and infrastructure) dimensions, also make clear associations between these two strategies and the competitive environment and business strategy of the manufacturing organisations. There is also substantial agreement among the studies on what the characteristics of the three configurations are along these dimensions. Based on those studies, Table 5-1 compares and characterises the three strategic configurations across these dimensions. Each of the dimensions is characterised by several context variables. Given that the focus of the study is on production-related QM practices, the variables in Table 5-1 are organised along Hill's (1985) manufacturing strategy framework. Table 5-2 provides the definitions for all the variables.

Besides the formal strategic context variables in Table 5-2, complementary data is also collected on a number of aspects. These enrich the knowledge about a particular plant, acting as background information, as information to be triangulated with the formal strategic context variables, and/or as exploratory leads. While some of these complementary aspects will be peculiar to individual plants and are not pre-specified, I do consider a priori some aspects to be systematically examined across all plants. These are displayed in Table 5-3.

Table 5-1. Strategic configurations and corresponding characterisation across chosen contextual variables.

Strategic Configuration	Competitive Strategy (Ward et al.; consistent with Hill, Miller and Roth, and Hayes and Wheelwright)	Business Environment (Ward et al.; consistent with Hill, Miller and Roth, and Hayes and Wheelwright)	Marketing Strategy (Ward et al.; Miller and Roth; Hill; Hayes and Wheelwright)		
			Degree of Product Customisation	Total Production Volume	Rate of New Product Introduction
Niche Differentiator (Ward et al.) Innovator (Miller and Roth) Technology-Driven Strategy (Stobaugh and Telesio)	- Offer of a specialised product bundle to a market segment which is not well served by larger firms in the industry. - Pursuit of a narrow segment defined by customer, product, or technology. - Differentiation is achieved by customisation (based on manufacturing capabilities). - High asset parsimony. - Emphasis on increasing market share by developing new products for old and new markets.	- High velocity environment in which firms face change from customers, competitors and society at large which is both rapid and relatively unpredictable. - Complex environment due to the variation in customer needs. - Low munificence; growth opportunities constrained by the size of the niche	+	-	+
Broad Differentiator (Ward et al.) Marketeer (Miller and Roth) Marketing-Intensive Strategy (Stobaugh and Telesio)	- Provision of a wide range of products to a variety of markets, while striving to develop and maintain a large share in each market on the basis of quality or service as opposed to price. - Use of new product development in existing markets as a means of expanding market share and preempting competitors; less emphasis in entering new markets with new products. - Efforts to maintain asset parsimony and strategic flexibility by attempting to keep investments in fixed plant and equipment as small as possible.	- Variety in customer and competitor behaviour between markets. - Unpredictable, dynamic environment. - Complex environment, because the many customer types and markets served define a heterogeneous environment.	0	0	0
Cost Leader (Ward et al.) Caretaker (Miller and Roth) Low Cost Strategy (Stobaugh and Telesio)	- Provision of final product bundle at a lower price than comparable offerings by competitors. - Focus on a range of high-volume, stable, usually mature products. - Emphasis on scale economies and product, rather than service, attributes. - Pursuit of process rather than product innovations - Heavy investments in fixed assets such as plant and equipment	- Stable environment, in which neither customers nor competitors substantively alter their aggregate behaviour. - Low munificence; mature industries provide limited opportunity for growth.	-	+	-

Table 5-1. Strategic configurations and corresponding characterisation across chosen contextual variables (cont).

Strat. Confg.	Dominant Order Winners and Qualifiers (Hill; consistent with Ward et al., Miller and Roth, and Hayes and Wheelwright)	Manufacturing Strategy			
		Process		Infrastructure (Hill; Ward et al.)	
		Dominant Process Typology (Hill, Ward et al., Miller and Roth, Hayes and Wheelwright)	Detailed Process Characteristics: Internal Item Variety, Internal Run Sizes, Repetitiveness, Standardisation, Rate of Process Change	Workforce Skill Level	Organisational Structure
Niche Diff.	Order-Winners: - Delivery speed and/or - Unique design capability. * ability to make changes in design and to introduce products quickly. * design quality (quality dimensions of performance, features, reliability, durability, aesthetics). Qualifiers: - Price, Conformance quality, On-time delivery.	Jobbing/ Low Volume Batch	-Low repetitiveness - Low standardisation - High internal item variety -High rate of process change - Short runs	- Highly skilled	- Decentralised, simple, entrepreneurial - Few bureaucratic controls, liaison devices, and management layers. - Low level of specialist support to manufacturing.
Broad Diff.	Order-Winners: - Decreasing importance of delivery speed and unique design capability. - Increasing importance of price. Qualifiers: - Conformance quality, On-time delivery	High Volume Batch	↕	- Medium skilled	- Organic structure; decentralised control. - Relatively high degree of specialisation and differentiation (product development, manufacturing, marketing, etc.). - Variety of devices such as cross-functional teams and task forces are used to co-ordinate actions in the absence of strong central control. - Medium level of specialist support to manufacturing
Cost Leader	Order-Winners. - Price. Qualifiers: - Design Quality, Conformance Quality, On-time Delivery.	Line	-High repetitiveness - High standardisation - Low internal item variety -Low rate of process change - Long runs	- Lowly skilled	- Centralised, bureaucratic. - High level of specialist support to manufacturing.

Sources: Hayes and Wheelwright (1979a), Stobaugh and Telesio (1983), Hill (1985), Miller and Roth (1994), Ward et al. (1996).

Table 5-2. Definition of the strategic context variables.

Competitive Strategy. The plant's competitive positioning.
Business Environment. The plant's business environment.
Degree of Product Customisation. The extent to which a plant's products are customised, i.e., the extent to which basic product characteristics relevant to manufacturing are not known a priori due to being determined or influenced by the customer.
Total Production Volume. The total annual production volume in units in the plant's processes.
Rate of New Product Introduction. The frequency of introduction of new products and the occurrence of changes in product designs. The emphasis is on the consequences of these events to manufacturing.
Dominant Order-Winners and Qualifiers. Order winners and qualifiers for the major customers of the main product line.
Typology of Dominant Process. The operations management type of the plant's dominant process: jobbing/low volume batch, high volume batch, line.
Degree of Repetitiveness. The extent to which tasks within a production process are similar over time. A low internal item variety, a low degree of product customisation, and a low rate of new product introduction will increase repetitiveness.
Rate of Process Change. The rate of change in a production process, comprising modifications in equipment and manufacturing procedures. These may result from the introduction of new products/changes in designs and product customisation.
Degree of Standardisation. The degree of standardisation present in a production process, comprising the extent of documentation of work procedures, extent to which documented standards can easily be used for process improvement, extent to which standards are actually followed, level of detail of standards, and division of labour.
Internal Run Sizes. The size of the production runs as "experienced" by the production processes (i.e., many short batches of very similar products, requiring very quick or no set-ups, would be considered a single long run).
Internal Item Variety. The diversity of items dealt with by a production process (both in total number of different items and in the relative differences between them, as "experienced" by the process).
Workforce Skill Level. The skill level of the plant's production workers.
Organisational Structure. The organisational structure of the plant.

Table 5-3. Contextual aspects to be examined in complement to the strategic context variables.

Labour intensity. The extent to which processing steps are performed manually as opposed to being automated.
Turnover rate for production workers. Turnover rate among production workers only.
Nature of quality problems. The most frequent quality problems and their causes.
Organisation of the quality function. How the quality function is organised and its relation to the plant's organisational structure.
Quality performance. Trends and current performance in internal process quality and customer satisfaction.
Financial performance. Includes profits and return on investment.
Overall performance of manufacturing. Perceptual comparison of the plant's operational performance to other plants in the industry and evolution of operational performance over recent years.
Plant performance on relevant competitive dimensions. A perceptual measure of the performance of the plant relative to competition on relevant competitive dimensions.

5.4 CHAPTER SUMMARY

The present study adopts a configurational approach to strategic context by considering the three generally accepted configurations of business strategy, manufacturing strategy, environment and structure: Cost Leader, Broad Differentiator, and Niche Differentiator. These configurations do not represent the entire realm of strategic possibilities; thus, they are representative, not exhaustive. The three configurations - embodying three different strategic contexts - are taken as anchor points representing the strategic context continuum.

The three strategic configurations are characterised along the contextual dimensions addressed in the studies that have developed them.

6. METHODOLOGY

The present chapter describes the methodology used to address the study's research question prior to the data reduction and analysis stages. The methodology aspects related to the data reduction and analysis stages are described in chapters 7 and 8 as they arise.

The issues in the present chapter revolve around the three main sets of research variables resulting from the adopted research design: research controls (Chapter 4), strategic context (Chapter 5), and degree of use of QM practices (Chapter 1). First, further choices made about the general research design are described. This is followed by sample selection, comprising the choice of industry and individual plants. Next, the units of measurement for the several research variables are addressed. Then, I describe data collection methods and the validation of the data collection plan by a pilot study. Finally, the chapter closes with additional internal validity considerations.

Four tests are commonly used to establish the quality of any empirical research: construct validity, internal validity, external validity and reliability (Kidder and Judd, 1986, pp. 26-29). This and following chapters address the several tactics used to deal with these tests as they arise.

6.1 RESEARCH DESIGN - FURTHER CONSIDERATIONS

This study adopts a research design based on multiple case studies focusing on the core research variables and involving interviews, direct observation, a locally administered questionnaire, and collection of secondary site data. Hill et al. (1995) provide a useful categorisation of empirical research in Operations Management according to the distance from the phenomenon being studied and the length of calendar time over which the research is conducted. Figure 6-1 shows this categorisation and the positioning on the continuum of the research design used in the present study.

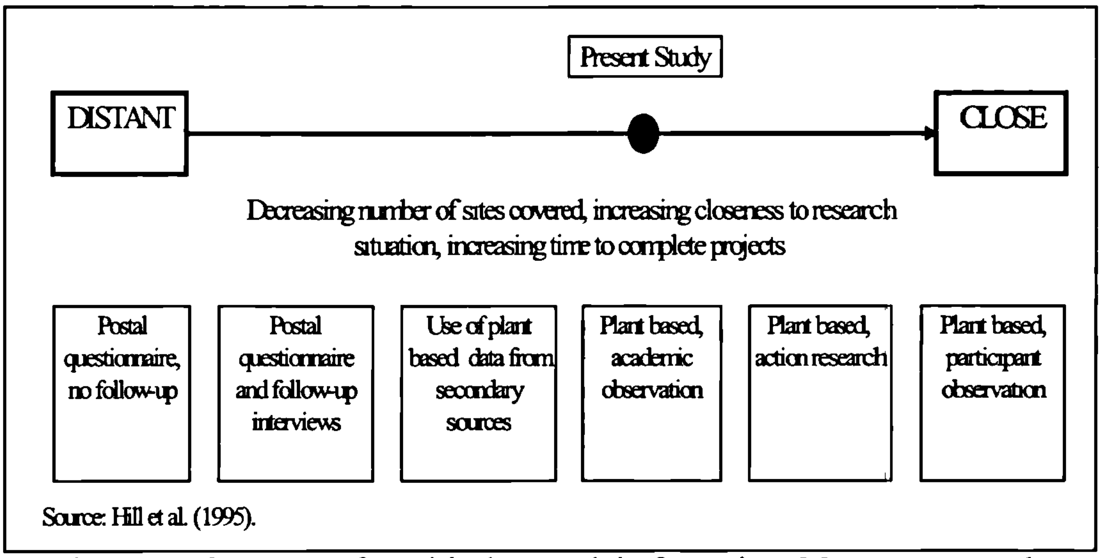

Figure 6-1. Spectrum of empirical research in Operations Management and positioning of the present study.

The choice of the research method is influenced by a number of factors. Paraphrasing Homans (1949),

> "...methodology (...) is a matter of strategy, not of morals. There are neither good nor bad methods but only methods that are more or less effective under particular circumstances." (Homans, 1949, p. 330)

Foremost among these factors is the objective of the study, from which other choices cascade down. The following are the logical steps leading to the choice of the research design for this study.

A. <u>Objective of the study</u>

The study sets out to empirically investigate whether QM practices are contingent on a plant's manufacturing strategy context (testing); and if so, to explain how a plant's strategic context affects these practices (explaining).

B. Cross-Sectional vs. Longitudinal Design

According to the adopted research design described in Chapter 4, the study concentrates on the long-term effects of strategic context on the use QM practices (i.e., its steady state effects), as opposed to delving into the *process* by which context produces its influence over time. Therefore, the study uses a cross-sectional design with a suitably controlled sample.

C. Multiple vs. Single Sites

The nature of the research question requires the inclusion of different types of strategic contexts, leading to the inclusion of multiple sites in the research sample. Multiple cases also protect against several biases, such as misjudging the representativeness of a single event, exaggerating the salience of datum because of its ready availability, or biasing estimates because of unconscious anchoring (Leonard-Barton, 1990) (*internal validity*).

D. Choice of Research Method

Yin (1994) recommends the case study method as the most appropriate when contextual conditions are believed to be highly pertinent to the phenomenon of study. In addition, Dale (1992) advocates the case-study method as the most suitable for QM research. Finally, the research question embodies an explanatory component (how does strategic context affect process QM practices?), for which the case study method is very adequate (Yin, 1994). Therefore, this study uses the case study method.

E. Distant vs. Close Data Collection Methods

The reliability of the measures for the main variables of the study - research controls, strategic context, and degree of use of QM practices - is strongly influenced by the choice of the data collection methods. The research variables are complex to measure, requiring close methods such as interviews, direct observation, and collection of other site data. The existence of several measurement units for different research variables (see section 6.3) and the large number of variables to address in the present study pose obstacles to the use of distant methods, such as postal surveys. Also, the need for a tightly controlled sample in this study makes distant methods hard to use given the difficulty in obtaining measures of the control variables both before sample selection and after sample selection by using such methods (e.g., a questionnaire) to solicit those measures. Finally, the need to have multiple cases restricts the amount of time one can dedicate to each individual case and the closeness of the data collection methods one can use. Therefore, this study uses "medium-distance" data collection methods involving interviews, direct observation, a locally administered questionnaire, and secondary data.

F. Multiple Case Analysis: Case-Oriented Strategy vs. Variable-Oriented Strategy

Ragin (1987) distinguishes between two basically different approaches to multiple cases inquiry: case-oriented and variable-oriented. According to this author, the *case-oriented approach* considers each case as a whole entity, looking at configurations, associations, causes and effects *within* the case - and only then turns to comparative analysis of an usually limited number of cases. The *variable-oriented approach* is conceptual and theory centred from the start, casting a wide net over an usually large number of cases. The "building blocks" are variables and their inter-correlations, rather than cases. So the details of any specific case recede behind the broad patterns found across a wide variety of cases, and little explicit case-to-case comparison is done.

Given the existence of a testing as well as an explanatory component, the present study needs an intermediate approach. On the one hand, the present study needs a structured approach to individual cases to enable cross-case comparisons across the relevant variables of the study to test whether QM practices are contingent on strategic context. This requirement seems to call for a variable-oriented approach. On the other hand, to avoid the risk of "vacuous" findings (Miles and Huberman, 1994, p. 174), the study needs to develop an understanding of individual cases to explain the influence of strategic context on QM practices. This requirement seems to call for a case-oriented approach. Therefore, the study uses a strategy which is a combination of both approaches, what Miles and Huberman (1994, p. 176) call *stacking comparable cases*. Each of a series of cases is written up using a more or less standard set of variables (with leeway for uniqueness as it emerges). Then tabular displays are used to analyse each case in a certain depth. After each case is understood (the cross-cutting variables may evolve and change during this process), case-level displays are condensed and systematically compared (stacked in a "meta-matrix"). An example of this approach appears in Eisenhardt (1989b). This approach is slightly different from Yin's (1994) replication logic in which a theoretical framework is used to study one case in depth, and then successive cases are examined to see whether the pattern found matches that in previous cases. The difference is that Yin's (1984) replication approach is performed sequentially, while the stacking comparable cases approach is done will all cases at once.

In conclusion, the chosen research design is cross-sectional with multiple case studies using "medium-distance" data collection methods, and uses a "stacking comparable cases" approach focusing on the core research variables.

6.2 SAMPLE SELECTION

The building of the research sample comprised a number of steps. First, the choice of industry. Second, the choice of the sample design (target sample). Third, based on publicly available information, the compilation of a short-list of plants likely to match the set target sample. Fourth, the process of building an actual sample matching the set target sample in which I solicited the participation in the study of the previously short-listed plants. These steps are each addressed next.

6.2.1 Choice of industry

As part of the study, we need to determine the effect of different strategic contexts on QM practices. As such, it is important to isolate the effect of the contextual variables from other potentially confounding variables. In particular, the research controls identified in Chapter 4 should be enforced as best as possible. Given that industry effects have been reported as important in strategy research (e.g., Dess et al., 1990), a single industry design is therefore preferred. In addition, by considering plants from a single industry one would expect to find more homogeneity across plants in terms of the identified research controls: efficiency drive for the adoption of QM practice, awareness of the whole range of QM practices, and, to a lesser extent, the degree of maturity of plants in terms of QM practices. Within a single industry one can find plants exhibiting different strategic configurations (e.g., Hayes and Wheelwright, 1979a), so that this does not restrict the range of observable contextual variables. The issue of the generalisability (external validity) of the present study's results, given its adopted single industry design, is discussed in Chapter 9.

The specific industry chosen was electronics, defined for the purpose of this study as the manufacture of products the functional core of which is one or several Printed Circuit Boards[1] (PCBs). This industry was chosen because, being a highly competitive industry for which quality is a very important competitive priority (e.g., Prasad, 1997), it increases the likelihood of finding plants complying with the research controls. In addition, as will be seen in section 6.3, the use of the electronics industry allows one to control for process technology, thus increasing the power of cross-case comparisons and better isolating the effects of strategic context variables.

6.2.2 Sample design (target sample)

The choice of sample design must observe two conditions:

(1) It must allow for the identification of strategic context effects.

(2) The target sample must comprise plants which comply with the research controls identified in Chapter 4.

I opted for what Harrigan (1983) calls an *intricate sample design.* This is a design where the sample is selected to coincide with sites that possess observable traits that are key factors in the propositions to be examined. As such, the target sample comprised two plants representing the Niche Differentiator (ND) configuration,

[1] Printed Circuit Boards (PCBs) are flat pieces of copper covered in laminate which have conductive tracks connecting various electronic components that are mounted on the board. The functioning of most electronics products (e.g., computers, television sets, mobile phones) is determined in great part by their constituent PCBs.

two plants representing the Cost Leader (CL) configuration and one plant representing the Broad Differentiator (BD) configuration, all complying with the established research controls. This sample design allows for *literal replication* and *theoretical replication* (Yin, 1994, p. 46). Having two instances of each of the polar strategic configurations allows for literal replication, i.e., to verify whether similar results occur for plants representative of the same configuration. It was considered that it was sufficient to have only one plant representing the Broad Differentiator configuration which would essentially act as a bridge between the two polar configurations. Having instances representing all three configurations allows for theoretical replication, i.e., to verify whether contrasting results across configurations occur as predicted. The replication logic permits analytical generalisation, i.e., the generalisation of a particular set of results to some broader theory (Yin, 1994, p. 36) (*external validity*).

The number of literal replications to have is a matter of discretionary, judgmental choice, and depends upon the certainty one wants to have about the multiple case-study results (Yin, 1994, p. 50). It was considered that two replications for each polar configuration would be sufficient. Although more literal replications would undoubtedly increase the degree of certainty of the results, time and cost constraints as well as the need for a very tightly controlled sample (thus reducing the total pool of eligible plants) also posed difficulties to the inclusion of more plants in the sample. The number of cases chosen is in line with Eisenhardt's (1989a) guideline that a number between 4 and 10 usually works well.

6.2.3 Compilation of a short-list of plants likely to match the set target sample

This was done in two steps, and was based on publicly available information. First, I generated a list of candidate plants categorised by likely strategic configuration. Then, I selected plants from this list which were likely to comply with the research controls. These two steps are described next.

6.2.3.1 Compilation of a list of plants categorised by likely strategic configuration

A list of plants categorised according to the likely strategic configuration was created by identifying segments of the electronics industry where one would most likely find plants representing each strategic configuration. An investigation into the electronics industry segments (e.g., Todd, 1990) revealed the candidate segments for each configuration displayed in Table 6-1. Several plants were identified in each segment from the FAME database (FAME, 1997; a database of 270,000 major public and private British companies), internet directories, trade magazines, and personal contacts, and as much secondary data as possible was collected on the plants (e.g., type of products and customers). This information led to the elaboration of a list of plants categorised by likely strategic configuration.

Table 6-1. Association between strategic configurations and electronics industry segments.

Strategic Configuration	Candidate Electronics Industry Segments
Cost Leader	* Commodity type electronic products (simple and/or high volume) * Consumer electronics * Automotive electronics
Broad Differentiator	* Printing/copying electronics * Telecommunications electronics
Niche Differentiator	* Industrial products electronics * Medical/ Scientific devices * Aerospace electronics * Defence electronics

6.2.3.2 Compilation of a list of plants likely to comply with the research controls

The starting point in this step was the list of plants categorised by likely strategic configuration that was compiled in the previous step. The second step reduced this list to a short-list of plants likely to comply with the research controls identified in Chapter 4. These controls are:

- The plant should have a strong efficiency drive for the adoption of QM practices.

- The plant should have a high degree of awareness of the whole range of QM practices.
- The plant should be "mature" in terms of the adoption of QM practices.

Regarding the first control, given the characteristics of the electronics industry one would expect the list generated in the previous step to already comprise plants subjected to strong efficiency pressures for the adoption of QM practices. This was re-enforced by only considering plants from that list which were certified by ISO9000. ISO9000 organisations are expected to be more likely to have quality as an important competitive factor (either as an order-winner or as an important qualifier).

Certification by ISO9000 also increases the likelihood that the second control is met. In fact, ISO9000 plants are also more likely to be aware of the whole range of QM practices. Going through the ISO9000 certification process increases quality awareness and may lead to better quality procedures and focus employee attention on quality (Corrigan, 1994; Voss and Blackmon, 1995).

Plants certified by ISO9000 are also expected to have quality programs in place for longer periods, thus increasing the likelihood that the third control is met. The quality standard requires the plant to have a quality system in place, and a plant mature in quality will usually have a quality system that is similar to the ISO9000 system (Corrigan, 1994). In fact, the view that ISO9000 may be a good entry point for total quality management has been echoed by many authors (e.g., Oakland and Mortiboys, 1991; Nicholls, 1993; Corrigan, 1994; Ho, 1994; Reimann and Hertz, 1994; Voss and Blackmon, 1995). It has also been found that ISO9000 registered companies exhibit higher levels of use of a wide range of quality practices (Rao et al., 1997).

Other publicly available information was also used to assess the a priori likelihood that the research controls were fulfilled by the several plants. These included whether the plant had received a quality award, whether it was mentioned as a best practice company in trade magazines or best practice company lists, and whether the plant was a supplier to a major electronics manufacturer. An additional consideration was that the plants should use Surface Mount Technology in their

PCB assembly operations, so that the study could control for process technology (see section 6.3). This was ascertained by consulting publicly available information about the plant (e.g., web sites describing the plant's facilities and equipment) and contacting the plant's manufacturing or engineering departments by telephone to enquire about the use of such technology.

A list of 25 plants which were considered to be likely to comply with the research controls and match the required strategic configurations was thus put together.

6.2.4 Sample building process

In this step, I built an actual sample of plants matching the set target sample by soliciting the participation in the study of the previously short-listed plants. The process for selecting individual plants was to sequentially contact plants from the short-list towards the achievement of the target sample and then to test the initial judgements - strategic configuration classification and compliance with the research controls, both based on publicly available information - by collecting data in the field. The next section explains why I opted for a sequential construction of the sample. The sequential construction was conducted as follows.

I solicited participation of two plants from each polar strategic configuration and one plant from the Broad Differentiator configuration, all at one time (the way this was done is described in the next section). If any of those plants declined participation, another plant in the short-list belonging to the same strategic type was contacted. The plants agreeing to participate were the object of field visits. If the initial field visit(s) revealed that the plant actually did not comply with the research controls (the way this assessment was performed is described in section 7.2.2), the plant was dropped from the sample, and an equivalent plant from the short-list was contacted to replace it. Each plant that was visited was also classified into the strategic configuration it resembled the most based on the data collected on site (the way this assessment was performed is described in section 7.3.3). This process was repeated until the target sample was achieved. Overall, 13 plants were contacted (4 in the ND category, 4 in the BD, and 5 in the CL), 6 of which agreed to participate in the study (3 NDs - plants 4, 5 and 6; 1 BD - plant 3; and 2 CLs - plants 1 and 2). As will be seen in section 7.2.3, of these plants, Plant

6 was dropped for being found not to comply with the research controls after two field visits. The initial thorough collection of publicly available information about the plants proved fruitful, as all of the plants that were visited corresponded to the predicted strategic configuration type and only one did not comply with the research controls. Six of the seven plants that declined participation indicated lack of time as the reason, and one indicated the fact that its management structure was undergoing substantial change at the time. Appendix 2 provides an overview of plants 1 to 6. Table 6-2 summarises the characteristics of plants 1 to 5, which constitute the final research sample.

Table 6-2. Final research sample.

	Plant				
	1	2	3	4	5
Revenue (£m)	25	11	60	15	16
Employees	450	123	226	170	224
Main products	Electricity and gas meters (commodity products).	Access control systems (for buildings).	PCBs for assembly into final products (document processing machines) at the customer plants.	PCBs, standalone for assembly into final product units by the customer or already incorporated into final product units, in the context of the provision of a manufacturing service (subcontracting).	
Customers	Electricity and gas utilities.	Dealers, selling products to hospitals, police forces, etc.	Plants part of the corporation the plant belongs to. PCBs supplied on a free market basis.	Companies in the industrial, instrumentation and communication segments.	
Nature of customisation	Own set of standard products (OEM).	Own set of standard products (OEM).	Production of PCBs to customer supplied conceptual designs. Physical design developed by the plant alone or in tight co-operation with customer (supplier/ OEM).	Production of PCBs to customer supplied physical designs. Customers also influence testing strategies (supplier).	

6.2.5 Soliciting the participation of individual plants

Soliciting participation of a plant consisted of sending a letter to the Production Director, Quality Director, or a person in an equivalent position, with a general description of the study and areas to be addressed and with a promise of customised feedback to the plant resulting from its participation in the study (refer to Appendix 3 (Annex 1) for an example of a typical letter). The study was framed as a collaborative venture, without any formal contractual arrangements. A few days after having sent the letter, the relevant persons were contacted by phone at which point it was determined whether they would join the study. When I contacted plants, I promised unconditional participation in the study regardless of their suitability, because it would have been awkward to ask for a few visits to assess their suitability for the study - demanding a substantial investment in time and effort on behalf of the plant - without guaranteeing the plant's participation in the study and the receipt of the respective feedback. This would inevitably have reduced the acceptance rate on what was already a limited pool of eligible plants. The sequential construction of the sample described in the previous section was therefore necessary to keep the research effort to a manageable level. Each plant that would agree to participate would represent a high effort as it would be the object of, at best, a scaled down version of the study (I needed to visit each candidate plant at least once to determine their suitability for the research; in case the plant was not suitable, I needed at least one more visit to be able to provide meaningful feedback). In fact, the plant that was dropped from the research sample (Plant 6), was the object of a scaled down version of the investigation to provide it with feedback, as had been promised when it was first contacted. Contacting many companies simultaneously would have carried the risk of ending up with a large number of companies agreeing to participate and an unmanageable research effort. The drawback of the adopted method was that it took about one month since the first plant acceptance to the last.

6.3 UNIT OF MEASUREMENT

The way the research variables were measured/characterised is addressed in Chapter 7, where I present the data reduction methodology. This section addresses the issue of the unit of measurement for the several research variables, as this has a direct bearing on the methodology prior to the data reduction and analysis stages (e.g., data collection).

The conceptual unit of analysis of the present study is the plant, as opposed to the business unit or the corporate levels (refer to Chapter 1). The several research variables in the study have different "natural" measurement units, i.e., different units within which the variables exhibit homogeneity. While some of these natural units coincide with the plant, others do not, either because the natural measurement unit is broader than the plant or because it is narrower than the plant. Given the study's unit of analysis, we are faced with the problem of reconciling the several research variables in terms of the unit chosen for measurement. This is a methodology issue, not a conceptual issue. For the variables with natural measurement units that are broader than the plant, the issue is whether the plant level is sufficiently broad to capture its essence. For the variables with natural measurement units that are narrower than the plant, the issue is whether the variables are representative of the plant. Strategic configurations embody variables that cut across several natural measurement units, ranging from Competitive Strategy at the business unit level to variables at the production process level. Despite this, their proponents argue that there are consistent patterns of association between these variables. This same rationale is followed in the present study. Next, I elaborate in more detail on how different natural units of measurement are reconciled in this research.

a) Variables with natural measurement units broader than the plant

These comprise Business Environment and Competitive Strategy, which more naturally refer to the business unit level than the plant level. The present study examines Competitive Strategy as it is deployed in a single plant. Similarly, it considers the effects of Business Environment at the plant level only.

b) Variables with natural measurement units narrower than the plant

These include several context and QM practice variables. For example, order-winners and process level variables may not exhibit homogeneity within a plant. Order-winners/qualifiers may vary across products (Hill, 1985), and different process typologies may coexist within a plant. However, despite this within-plant variability, one would still expect to observe significant cross-plant differences for different strategic configurations. For example, if a Cost Leader exhibits different levels of product variety in different processes, one would still expect these levels to be lower than the ones found in equivalent processes in a Niche Differentiator plant. One would also expect these inter-plant differences to be reflected in the plants' main product line and corresponding production processes. Therefore, for measurement purposes, this study takes a pipeline view of a plant by focusing on the *Main Product Line Supply Chain*. This supply chain comprises the order-winners for the main product line (called Dominant Order-Winners); the production process where the main product line is produced (called the Dominant Production Process); and the supplies for the production of the main product line in the dominant production process (an example of the use of these supplies as a measurement unit can be found in Handfield, 1993). The underlying assumption is that the main product line supply chain is representative of the broader strategic configuration for the purpose of cross-plant comparisons. Figure 6-2 shows the different levels at which the several research variables are measured according to this perspective.

The Main Product Line is defined as follows:

i) when there are clearly defined and stable product lines, the main product line is defined as the product line exhibiting the highest production volume. This is the typical situation for Cost Leaders; or

ii) when the concept of individual stable products does not apply, the main product line is defined as the set of products representative of the most commonly supplied technology. This would be the typical situation for a Niche Differentiator manufacturing to customer design. Typically, the plant would offer capabilities across a number of set technologies (for example, PCBs for applications in the sectors of telecommunications, industrial products, instrumentation, etc.). The main product line would consist of the set of products in the most common technology category (i.e., the one corresponding to a "typical" customer order).

The Dominant Production Process is defined as comprising the Printed Circuit Board (PCB) assembly lines used to produce the Main Product Line. This particular process was chosen because it is common to all electronics plants. Additionally, all plants in the research sample use the same technology (Surface Mount) in their PCB assembly lines. Assembly lines using this technology comprise the same fundamental processing steps. This enables one to control for process technology thus maximising the power of cross-case comparisons. A brief description of PCB Surface Mount assembly operations is included in Appendix 4.

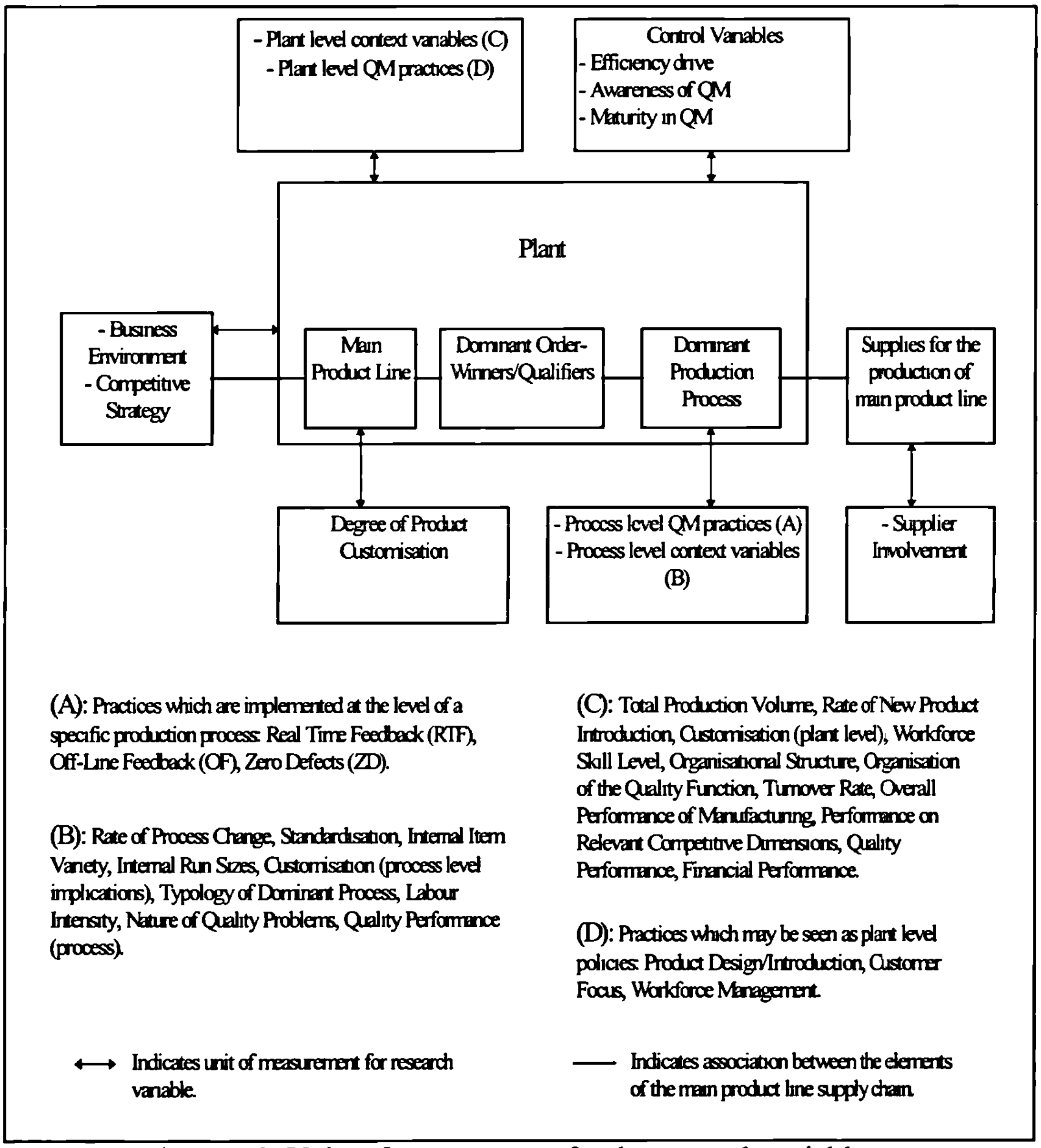

Figure 6-2. Units of measurement for the research variables.

6.4 DATA COLLECTION

Each participating plant was the object of a case-study involving four visits to the manufacturing site on separate days. For each plant, a "project champion" was selected to act as the main co-ordinating link between the researcher and the plant. The project champion of each plant assisted the researcher in identifying at the outset the main product line supply chain, enabling subsequent data collection to focus on this measurement unit. The role of the researcher on site was one of a non-participant observer. In each case-study, several data collection methods were used, including semi-structured interviews, direct observation, a short questionnaire, and secondary site data. During the course of the field work, the researcher was able to solicit any information he requested in the form of documents, access to specific plant personnel and direct observation of a plant's activities. Typically, the researcher was escorted by a member of staff who organised the data collection activities on site during the course of the visit.

The *reliability* of the research design was enhanced by developing a case-study protocol comprising a list of all the areas to address, and the respective indicative questions, potential sources of information, and field procedures. The areas to address include the three formal sets of research variables (research controls, strategic context and use of QM practices), as well as any other rich case data enabling the understanding of the use of QM practices observed in the plant. The protocol is included in Appendix 3. The guidelines provided in the appendix for collecting the data on the formal research variables are based on the measures/ characterisation of these variables that will be described in Chapter 7. The protocol also provides guidelines for the collection of the other rich case data, such as the difficulties experienced by plants in the use of the several practices, the strategies that were in place to address these difficulties, the perceived effectiveness of the practices, etc. However, a substantial part of these data was collected on an exploratory, case-specific basis.

The protocol assured a consistent approach across all cases and also allows future researchers to repeat the data collection procedures. Reliability was further improved by maintaining a database for each case-study containing all the raw data evidence conveniently organised and accessible for future retrieval. This consisted of notes, documents and narratives[2]. The case study database was kept separately from the case study data analysis.

The several data collection methods that were used are next addressed in more detail.

6.4.1 Semi-structured interviews

The project champion helped the researcher to identify several persons knowledgeable about the areas addressed in the study with whom semi-structured interviews were conducted. Each person interviewed was also asked about his/her duties and responsibilities in the business to assess his/her knowledge of the areas addressed in the interview. These procedures helped to ensure that the information collected was representative (*internal validity*). Across cases, interviewees included the Managing Director, the Plant Manager, shop-floor supervisors and workers, and representatives from Marketing/Sales, Customer Service, Engineering, Manufacturing, Quality, Testing, and Product Design/Introduction. Interviews were typically one hour long, having ranged across cases from 30 minutes to 4 hours. Tape recordings and/or written notes were taken during interviews. Each case involved around 20 interviews. The semi-structured format is suitable for the "stacking comparable cases" research design (see section 6.1). It enabled the researcher to address the pre-specified research variables, while at the same time it allowed leeway for the idiosyncrasies of each case.

6.4.2 Direct observation

To gain a better understanding of the manufacturing process and the QM practices used, one or more plant tours were undertaken for each case, with a focus on the dominant production process. This presented a good opportunity to observe the operation in practice and to ask questions complementing the interviews. Thus, direct observation permitted both the collection of new data and the triangulation with interview data.

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[2] Narratives are reflections by the researcher about case-study questions. They represent an attempt to integrate the available evidence and to converge upon the facts of the matter or their tentative interpretation (Yin, 1994).

6.4.3 Questionnaire

A short questionnaire was used to request mostly descriptive contextual information about each plant complementing both interview and direct observation data. The main purpose of this questionnaire was to save interview time so that interviews could address mainly complex issues, and not be burdened with the collection of simple descriptive information about the plant. Additionally, much of the information requested by the questionnaire was of a quantitative descriptive nature (eventually requiring consultation of other sources by the respondent) and/or highly structured. This type of data is more adequately collected via a formal instrument in a written form such as a questionnaire, rather than by interviews. In the construction of the questionnaire the usual guidelines for questionnaire design were followed (e.g., Dillman, 1978). The questionnaire is part of the case-study protocol included in Appendix 3 (see Annex 2 of the appendix). The protocol also shows the research variables which were addressed by the questionnaire.

During the course of the plant visits, the project champion assisted the researcher in identifying the most adequate persons to fill in the questionnaire (different sections of the questionnaire were filled in by different persons). The questionnaire was then handed to the right persons, who were responsible for mailing it back to the researcher. Respondents across cases included the Managing Director, the Plant Manager, and representatives from Quality, Marketing/Sales, Engineering, and Manufacturing.

6.4.4 Secondary data

Several plant documents were collected during the visits, including the mission statement, quality mission, quality procedures, customer care policy statement, internal newsletters, product brochures, strategic goals, financial statements, organisational chart, quality control forms, and documents/reports addressing manufacturing and quality performance measures. The most important use of documents was to corroborate and augment evidence from other sources (Yin, 1994, p. 81). They were carefully used and not taken at face value. In cases where documentary evidence was contradictory rather than corroboratory, further enquiries were made into the topic so as to try to solve the conflicts.

Archival sources were also investigated before the visits to provide background information on the company or site. These included annual reports, press clippings, company history, databases (e.g., ABI, Financial Times Index, Bloomberg), web sites, and general information about the industry (e.g., trade magazines).

6.5 THE PILOT CASE STUDY

The pilot study was conducted in Plant 1 which, as seen earlier, was subsequently taken to be part of the research sample (a brief description of this plant is given in Appendix 2). This particular plant was chosen because it seemed to comply with the research controls (as was confirmed after data collection) and because I had privileged access to the site. This enabled me to address both substantive and methodological issues. The main objective of the pilot study was to refine the data collection plans, as detailed in the case study protocol, with respect to both the content of the data and the field procedures to be followed. In particular, it enabled the test of the questionnaire with the plant's Quality Manager who discussed any unclear questions with the researcher. The questionnaire was additionally tested with several Operations Management academics (one of them with extensive experience in the electronics industry in general and in PCB assembly operations in particular) and doctoral students from other management subject areas. Feedback thus received helped improve the design of the questionnaire.

6.6 ADDITIONAL INTERNAL VALIDITY CONSIDERATIONS

Throughout the chapter, I have described several activities that were undertaken to enhance the internal validity of the study. I now complement this with a description of several precautions that were taken to limit the threats to internal validity caused by researcher effects in the process of interaction with informants in the context of case study research. Researcher effects can lead to two possible bias: (A) the effects of the researcher on the case, by which the researcher affects the behaviour of informants; and (B) the effects of the case on the researcher, by which the researcher "goes native", subscribing to the agreed-upon or taken for granted version of local events (Miles and Huberman, 1994).

The following precautions were taken to limit bias (A):

- I made sure that my intentions as a researcher were clear to informants. When meeting each person, I stated why I was at the site, what I was studying, how I would collect the data, what I would do with it, and assured him/her of confidentiality.
- I told the informants about my own background and asked them to do the same at the start of the interview. This served as an ice-breaker and facilitated the development of a rapport with informants. In this process, my technical background in electrical and electronic engineering was an advantage because informants, usually having a strong technical background in this area themselves, saw me as "one of them". This also enhanced my credibility and my own understanding of the issues being addressed.
- I used informal social contacts during the course of the field visits (e.g., lunch and coffee breaks) to pursue issues which I had sensed as sensitive during the course of the formal interviews. I then compared the information collected in this manner with the information collected under formal settings and pursued any arising conflicts in later data collection rounds. In particular, I re-visited key issues at later stages in the field work, as personal relationships with informants became more established.

The following precautions were taken to limit bias (B):

- the site visits were spread along time to provide time for reflection and distancing from the cases. Typically, consecutive visits to a plant were separated by one month.
- I covered a spread of informants from different functions and hierarchical ranks in each plant (refer to section 6.4).

- I triangulated with several data collection methods, so that I would not overly depend on talk or on observation to make sense of the cases (refer to section 6.4).
- I kept the research questions firmly in my mind during the visits, by preparing a short script for the interviews with each informant, based on the case study protocol, and which I took with me to the site (refer to Appendix 3).
- I avoided showing how much I knew about each case so that informants would not simply confirm what I would say.
- I made an active effort to keep thinking conceptually, translating sentimental or interpersonal thoughts into more theoretical ones.

6.7 CHAPTER SUMMARY

The study is based on "medium-distance" cross-sectional case studies conducted in five plants of the UK electronics industry complying with the research controls identified in Chapter 4. The research sample comprises two instances of each of the polar strategic configurations - Cost Leader and Niche Differentiator - and one instance of a Broad Differentiator acting as a bridge between the polar configurations. Each case revolves around the core groups of research variables: research controls, strategic context and degree of use of QM practices. After each case is understood, cases are systematically compared using the "stacking comparable cases" approach. Data collection methods include semi-structured interviews, direct observation, a locally administered questionnaire, and secondary data sources. The data collection plans were validated and refined by undertaking a pilot case study. Duly care was taken throughout the study to enhance construct validity, internal validity, external validity and reliability.

7. DATA REDUCTION

This chapter describes the process of reduction of case data, a preliminary stage of analysis consisting of selecting, focusing, simplifying, abstracting and transforming the data that appear in written-up field notes so that conclusions can be drawn and verified in later and deeper stages of analysis (Miles and Huberman, 1994, p.10). Data reduction in this study consisted mainly of the characterisation of individual plants across the three sets of formal research variables: research controls, context variables, and degree of use of Quality Management (QM) practices. Thus, this preliminary analysis is guided by the developed theoretical framework, an analysis strategy advocated by Yin (1994; p. 103). In addition, I also present the reduction of data related to the difficulties experienced by plants in using the several QM practices and the coping/mitigating strategies used by the plants to deal with those difficulties. As will be seen in Chapter 8, these data, collected on an exploratory basis as part of the case study protocol, are used in later stages of analyses in triangulation with data on the formal research variables to draw and verify conclusions.

The structure of the chapter is as follows. Firstly, I describe the general methodology used for reducing data. This underpins most of the analysis done. Additions and variations to this general methodology are described as the specific analyses are addressed along the chapter. Secondly, I describe the reduction of research control data, resulting in the characterisation of plants across the research control variables. This characterisation is used to decide which plants comply with the study's research controls and which should therefore be included in the final research sample. Thirdly, I describe the reduction of contextual data for the final research sample, resulting in the characterisation of the plants across the several contextual variables. This characterisation is used to rank the plants across the strategic context spectrum and to classify each of them into one of three configurations: Niche Differentiator, Broad Differentiator or Cost Leader. Fourthly, I describe the reduction of data on the use of QM practices for the final research sample, resulting in the assignment of a High, Medium or Low rating to the degree of use of each practice in each plant. Finally, I summarise the difficulties experienced by each plant in the use of the several QM practices and the coping/mitigating strategies identified to be in place to deal with those difficulties.

7.1 GENERAL METHODOLOGY FOR DATA REDUCTION

This section describes the general methods used in reducing data. Data reduction comprised two main stages:

i) The organisation and coding of the data. This stage applies to all the data collected, comprising the data on the formal research variables as well as other rich case data.

ii) Building on the outcome of stage i), the characterisation of plants across the several research variables.

These stages are discussed next.

7.1.1 Organisation and coding of the data

Data reduction started as soon as the first data were collected and continued throughout and after the data collection phases. Each field visit was followed by a data reduction round as shortly after as possible. The working material for data reduction consisted of all the raw data collected using the case study protocol, organised in a case study database (refer to section 6.4). The first step was to convert these data into text files. This involved transcribing interviews, field notes and questionnaire answers, and summarising secondary data (e.g., documents). During this process, each piece of data was kept closely associated with its original source by appropriate references to the nature of the source (a document, a respondent, direct observation, etc.), the conditions under which the data was collected, and the indication of the date of collection (*reliability*). Pieces of data were also kept associated with any researcher comments and reflections about them, such as:

- second thoughts on the meaning of what an informant was "really" saying during an exchange.
- doubts about the quality of some of the data.
- cross-references to material in another parts of the data set.
- elaboration or clarification of previous information that seemed to become of possible importance.
- new hypotheses that might explain some puzzling observations.

These researcher notes were clearly differentiated from the field data by writing them under a different format in the text file. These procedures enabled the researcher to maintain a chain of evidence from later judgements to raw data (*reliability*).

The resulting text data was then coded using codes corresponding to the adopted definition of each research variable, as well as codes emerging from the data (Yin, 1994). This enabled the capturing of any idiosyncrasies of the case escaping the existing research variables and to consider other rich case data for use in later analyses. Appendix 5 lists all codes that were used, the respective definitions and, where appropriate, their respective association with the formal research variables. The development of detailed code definitions enhances *reliability* by increasing the likelihood that both a single researcher at different times, or multiple researchers at one time, arrive at the same coding patterns. Because of the structured approach resulting from the testing component of the study and the existence of an a priori, well-defined conceptual framework and research question, the nature of the codes and the definitions were considered to be straightforward, thus not justifying the conduction of inter-coder reliability tests.

The coding unit was typically a paragraph. Each unit was associated with one or several codes. The coding of the data was performed as soon as possible after each field visit. In parallel with the coding process, I regularly wrote short *memos* (Miles and Huberman, 1994, p. 72) theorising ideas about codes and explanations for the observed patterns of use of practices. These emerging interpretations partly steered the subsequent data collection efforts towards their investigation. After each visit and the subsequent analysis just described, an *interim case summary*

(Miles and Huberman, 1994, p. 79) was produced listing what was already known about the case and the information that still needed to be collected both to fulfil the established case study protocol and to follow up on leads from previous data collection rounds. This was used to develop the data collection plan for the following field visits.

The outcome of these early stages of analysis was a set of text files containing all the data coded and a set of conveniently organised memos.

7.1.2 Characterisation of plants across the research variables

This data reduction stage builds on the outcome of the previous stage. The characterisation of each plant was performed by constructing tabular displays to manage and present qualitative data across the relevant research variables, an analysis strategy recommended by Miles and Huberman (1994). Table 7-1 shows the general template that was used for the displays.

Table 7-1. General template used for the characterisation of a plant across a set of research variables.

Research Variable	Unit of Measurement	Measurement items/ Characterisation of the variable	Summary	Judgement
A	Plant	-Item 1 -Item 2 - ...	...	...
B	Process	...	...	...
...	...	...	...	...

The first column in the table shows the research variables the plant is being characterised on by the particular display. The second column indicates the unit of measurement of the variables (refer to section 6.3). The third column displays the condensed evidence from the raw data on the variables' measurement or characterisation items. This condensed evidence is obtained by searching the raw data for the codes associated with the variable in question (the codes are shown in Appendix 5). A fixed set of measurement/characterisation items is used to ensure consistent and objective comparisons across the several cases. These items are described later for each research variable. Each research variable was characterised using information collected from several sources (data triangulation,

Yin, 1994, p. 92). For example, while each interview focused on the respondent's area of expertise, there was overlap between the themes addressed with several respondents. Similarly, several research variables received input not only from interview data but also from questionnaire items, direct observation and, to a lesser extent, secondary site data (method triangulation, Miles and Huberman, 1994, p. 267). The characterisation of the research variables was arrived at by triangulating all sources of information pertaining to the variable in question. The use of multiple sources of evidence allows the development of converging lines of enquiry (Yin, 1994, p. 92). This consists of following a corroboratory mode based on several different sources of information and strengthens the accuracy and confidence in the findings and conclusions of the study. Additionally, it addresses potential problems of *construct validity* because the multiple sources of evidence essentially provide multiple measures of the same phenomenon (Yin, 1994, p. 92).
The "Summary" column contains a summary or interpretation of the information displayed in the previous columns. Finally, the "Judgement" column displays a judgement made by the researcher regarding the variable. This could be the degree of use of a QM practice, the intensity of a particular context variable, or whether a plant complies with a particular research control, depending on the variable in question. In using the displays, the summaries and judgements for each variable were kept closely associated with the raw data and associated context from which they were drawn. This maintains a chain of evidence from judgements to raw data and increases *reliability* by allowing other researchers to review the evidence directly and not be limited to written reports.
In the process of building the displays, several items of information related to a plant were given High, Medium or Low ratings. These ratings were attributed in relation to the same observed items of information in other plants. Thus, the ratings within a case are *relative* to the realm of experience encompassing all cases. The rules that were used in arriving at these ratings are the following:

Rule 1. Rule for arriving at High, Medium, Low ratings for individual information items. This rule takes different formats depending on the nature of the items:

R1.1 Quantitative items (numerical values): For each item, the decision was taken as to whether there were "significant and clearly identifiable differences" across plants. In case the conclusion was that no significant and clearly identifiable differences existed across plants, all the plants were rated as Medium on that item by default Otherwise, the interval [minimum observed numerical value; maximum observed numerical value] was divided into three equally sized intervals, each corresponding to the Low, Medium, and High ratings.

R1.2 Qualitative items (textual descriptions): For each item, the decision was taken as to whether there were "significant and clearly identifiable differences" across plants. In case the conclusion was that no significant and clearly identifiable differences existed across plants, all the plants were rated as Medium on that item by default. Otherwise, the plants were ranked according to the item in question with the level High being attributed to the plant ranked the highest and the level Low to the plant ranked the lowest. A notional item was considered in between these two extremes as an exemplar of the Medium rating. These three items (two real and one notional) then acted as the anchor points for the rating of the remaining plants. The remaining plants' were attributed the rating High, Medium and Low according to the anchor item they most resembled. This procedure is exactly equivalent to the one followed for the quantitative items.

Rule 2 (R2). Rule for arriving at a High, Medium, Low rating for an aggregate variable made up of several individual items (dimensions), each rated as High, Medium or Low. The ratings of High, Medium and Low corresponding to the individual items making up the aggregate variable for a plant were assigned the values 3, 2, and 1 respectively. These values were added to arrive at a numerical score for the variable. This score was compared with the other plants' scores to arrive at a High, Medium, Low rating using rule R1.1.

These rules reflect a conservative policy of only differentiating plants if there are "significant and clearly identifiable differences" between them. That is, there must be sufficiently strong evidence of differences, thus reducing the chance of spurious results. In addition, the following factors further reduce the complexity of the judgments and increase their objectivity, thus increasing the likelihood of different researchers arriving at the same ratings when confronted with the same data (*reliability*):

- the consideration of only three levels for rating information items: High, Medium and Low.
- the use of a fixed set of information items across which to compare the several cases.
- the fact that the ratings are relative to other plants, thus independent of the researcher's realm of experience.
- the method and data triangulation described earlier.
- the fact that the study controls for industry and process technology, allowing for simple comparisons of like with like.

The specific displays used for the several research variables and the individual items which were used to measure/characterise those variables are discussed in the following sections. These displays either follow the general template in Table 7-1 exactly or are variations of it. Variations include the omitting of one or several types of columns or the addition of extra columns. But the general pattern of systematically showing how the researcher moved from raw data evidence to a summary or a judgement, remains. Details of the field procedures that were used to collect data on the measurement/characterisation items of the several research variables are given in the case study protocol (Appendix 3).

7.2 ASSESSING THE SUITABILITY OF PLANTS FOR THE RESEARCH

This section describes how research control data was processed to arrive at a judgement of whether a plant complied with the study's research controls. This was done for the six plants that were the object of field work (plants 1 to 6; refer to section 6.2.4).

7.2.1 Detailed methodology

In Chapter 4, I identified three research controls with all of which each plant had to comply for it to be considered suitable for the study:

a) The plant should have a strong efficiency drive for the adoption of QM practices.
b) The plant should have a high degree of awareness of the whole range of QM practices.
c) The plant should be "mature" in terms of the adoption of QM practices.

Following the general methodology described in section 7.1, a tabular display comprising all the control variables was constructed for each plant to judge whether each plant complied with the research controls. Appendix 6 shows the template that was used.

7.2.2 Measurement

The characterisation of each of the research control variables by means of several items is now addressed in more detail. The reader should consult Appendix 6 when going through this section.

a) Efficiency drive for the adoption of quality management practices
As seen in section 6.2, the choice of ISO9000 certified plants from the electronics industry was considered to increase the likelihood that they would be subjected to strong efficiency pressures towards the adoption of QM practices. This information was complemented with data collected in the field on two items: the importance of quality as a competitive priority and the history of adoption of QM practices. Plants which have quality as an important competitive priority are expected to be subjected to stronger efficiency pressures towards the adoption of

QM practices. Learning about the history of adoption of practices enables one to find out about the nature of the drivers for adoption of the practices and the time since the formal adoption of a quality improvement program in the plant and during which efficiency pressures may have been at play shaping the pattern of use of practices. In this connection, the extent to which the plant had engaged in experimentation of practices during this period was also examined. A three year period is generally considered to be sufficient for the implementation of all the elements of a quality program (Ahire, 1996; Dawson and Patrickson, 1991; Doran, 1985).

b) Awareness of quality management practices

The awareness of QM practices was assessed by enquiring about the sources of information on quality available to the plant, the background of its managers, whether the plant was affiliated with quality associations, participated in quality seminars, workshops, and other training. These items are self-explanatory.

c) Maturity in quality management

This was assessed by examining three items: the time since the start of a formal process of quality improvement at the plant, external indicators of QM maturity, and the existence of a quality culture in the plant. A plant mature on quality will have had a quality improvement program in place for a long period of time (a three year period is generally considered to be the cut-off point between young and mature organisations in QM (Ahire, 1996; Dale and Lascelles, 1997; Dawson and Patrickson, 1991; Doran, 1985), will have been recognised as such by the business community, and will exhibit evidence of a quality culture. The first item is self-explanatory. In what concerns external indicators of maturity, the following indicators were used: certification by ISO9000 (or another major quality standard), receivership of quality awards, being a supplier to a major electronics manufacturer, and being mentioned as a best practice plant in the business community. The implications of the ISO9000 certification have already been discussed (section 6.2.3.2). The receivership of quality awards has been used elsewhere as a proxy for a firm exhibiting an effective (and by implication, mature) quality program (Hendricks and Singhal, 1997). The other sub-items are self-explanatory. Finally, the existence of a quality culture was assessed by the profile that quality enjoyed in the plant, the extent to which top management were involved in quality, the extent to which there were clear quality goals, and the existence of mechanisms for closed loop corrective action. These items are self-explanatory.

The suitability of plants for the research was further verified by detailed case data related to the use of the practices in the plants fulfilling the formal controls and which were the object of full scale field work, in particular, evidence related to the extent to which efficiency concerns were the major drivers of the pattern of use of practices. This complementary assessment is described in Chapter 8.

7.2.3 Results

Appendices B-1 to B-6 show the data for the six plants that were the object of field data collection. As is shown in the appendices, all the plants were considered to comply with the three research controls, with the exception of Plant 6. The reason why the initial sample selection strategy failed in relation to Plant 6 is as follows. Plant 6 had been originally selected due to being ISO9000 certified and to having been identified via secondary sources as belonging to a national group of UK exemplars of best practice factories. Once in the field, it was found that the company which owned Plant 6 also owned another plant in the same site under the same name which was dedicated to the *fabrication* of PCBs (not the *assembly* of PCBs, which is the focus of this study, and to which Plant 6 was dedicated). This other plant had an independent management structure, and it was found that it was this plant - and not Plant 6 - which belonged to the national list of best practice exemplars referred to. Plant 6, however, played the important role of providing a comparison point for assessing the compliance of the other plants with the research controls, thus increasing the validity of the judgements that were made (that is, there was a clear similarity across plants 1 to 5 in this respect, and all clearly differed from Plant 6). It also demonstrated the *discriminant validity* of the measures used to assess the compliance of the plants with the research controls.

As mentioned earlier, the suitability of plants for the research was additionally verified by detailed case data related to the extent to which efficiency concerns were the major drivers of the observed pattern of use of practices. This assessment was only performed for the plants which were found to comply with the formal research controls and which were the object of full scale field work (plants 1 to 5). As will be seen in Chapter 8, no evidence was found of non-efficiency pressures influencing the use of practices in these plants, that is, there was no evidence of the existence of Worn Out or Panacea practices.

Resulting from the above analysis, plants 1 to 5 were kept as part of the final research sample and Plant 6 was discarded from this sample. From here onwards, I will refer to the research sample as comprising plants 1 to 5 only.

7.3 RANKING AND CLASSIFYING THE STRATEGIC CONTEXT OF PLANTS - REDUCTION OF CONTEXTUAL DATA

This section describes how contextual data was reduced to rank plants across the strategic context spectrum and to classify them under one of three strategic configurations: Niche Differentiator, Broad Differentiator, or Cost Leader.

7.3.1 Detailed methodology

Following the general methodology described in section 7.1, a tabular display comprising all the contextual variables was constructed for each plant. Appendix 7 shows the template that was used.

7.3.2 Measurement

Given that the literature is sparse in measures for contextual variables, the measurement items for each variable were developed directly from the respective definition. The information in Appendix 7 is self-explanatory. Some of the variables that are measured at the process level use items that relate to the PCB assembly process. These were developed based on an in-depth study of the PCB assembly process and discussions with persons knowledgeable about this manufacturing process.

7.3.3 Results

The data on all contextual variables for the five plants in the final research sample are shown in Appendices B-7 to B-11. Most of the ratings were derived by applying rule R1.1, which requires virtually no researcher interpretation. There were only a few instances in which rule R1.2 was applied, and these required only minor researcher interpretation. The information provided in the appendices is self-explanatory of the judgements made.

As explained in Chapter 5, the three strategic configurations that are considered in this study are representative, but not exhaustive of the entire realm of strategic possibilities. As such, the plants in the study were classified according to their degree of similarity to one of the representative configurations, even though not all the contextual variables might match that ideal configuration. *For the purpose of the objective classification of the plants*, I concentrated on the following contextual dimensions of Table 5-1: Marketing Strategy, Order Winners and Qualifiers, and Manufacturing Strategy Process variables. These dimensions are critical for production related QM, the focus of this study, and are the ones mostly emphasised in the manufacturing strategy literature (e.g., Hill, 1985). In addition, they are amenable to objective measurement and comparison between plants. The other strategic context dimensions shown in Table 5-1 (Competitive Strategy, Business Environment, and Manufacturing Strategy Infrastructure) are more difficult to compare objectively across plants. They will, however, be taken into account as rich case data in later analyses.

Table 7-2 shows the ratings of the central contextual variables across plants. The H (High), M (Medium) and L (Low) ratings were converted into corresponding numerical 1-3 ratings, where "1", "2" and "3" denote closest similarity to the Cost Leader (CL), Broad Differentiator (BD) and Niche Differentiator (ND) configurations, respectively, according to Table 5-1. These ratings were added to arrive at a total plant score. This plant score was in turn classified into Low (CL), Medium (BD), and High (ND) ratings using rule R1.1.

Table 7-2. Classification of the strategic contexts of the plants in the research sample.

Plant	1	2	3	4	5
Marketing Strategy					
Degree of Customisation	L (1)	L (1)	M (2)	H (3)	H (3)
Total Production Volume	H (1)	L (3)	H (1)	L (3)	L (3)
Rate of New Product Introduction	L (1)	L (1)	M (2)	M (2)	H (3)
Order - Winners and Qualifiers					
Dominant OWs/Qs	Resembles a CL the most. (1)	Resembles a BD the most. (2)	Resembles a BD the most. (2)	Resembles a ND the most. (3)	Resembles a ND the most. (3)
Manufacturing Strategy Process Variables					
Internal Item Variety	L (1)	L (1)	M (2)	H (3)	H (3)
Internal Run Sizes	H (1)	H (1)	M (2)	L (3)	L (3)
Typology of Dominant Process	Line (1)	Line (1)	Batch (2)	Jobbing (3)	Jobbing (3)
Summary					
Total Plant Score	7	10	13	20	21
Plant Classification	CL	CL	BD	ND	ND

With the exception of Plant 2, all the individual variable ratings are internally coherent, and match the assigned ideal configuration. As the table shows, Plant 2 exhibits discrepancies from its attributed configuration in what concerns the variables Total Production Volume (which is Low instead of High) and Order Winners and Qualifiers (here, the main discrepancy relates to the reduced importance of price). These are market related variables. A closer look at the contextual information in Appendix B-8 enables us to better understand the observed discrepancies. Plant 2 sells systems made up of a software and a hardware component (see "Business Environment" context variable). In terms of features, there isn't much scope for differentiation in the hardware component which is made up of simple electronic devices (the door controllers, readers and proximity devices). In fact, the plant was already experiencing strong price competition on the standalone hardware units that it sold. The plant achieves differentiation via the architecture of the system provided, delivery speed, delivery reliability and service (see "Order-Winners and Qualifiers" context variable). Delivery and service are important because the system has to be quickly installed in the field with the assistance of the company, which also has to provide after-sales product training and technical support. This, coupled with a low total production volume explains why price is less important as an overall order-winner. Despite the market side not matching exactly an ideal Cost Leader, the required manufacturing task in Plant 2 nevertheless matches the one of a Cost Leader very closely: the production of a narrow range of simple and standard products with stable designs, albeit with the need to provide short manufacturing lead times. Consistent with this, Plant 2's manufacturing processes exhibit all the characteristics of a Cost Leader, as is shown in Table 7-2. This is also consistent with the reported ongoing cost and cycle time reductions initiatives in the plant. In summary, the plant conforms to the picture of a Cost Leader producing a basic hardware product, which managed to differentiate its offer by virtue of providing an architectural application and good service. This is similar in the main to the other Cost Leader plant, Plant 1 (see Appendix B-7), except that Plant 1's market is such that customers are less receptive to differentiation attempts at the expense of price (e.g., the modularisation concept as a means of offering new product features and reduce market risks was not successful - see "Competitive Strategy" context variable). That is, Plant 1 was not able to change the industry's customers perception of its products as being commodities. In conclusion, despite the observed discrepancies, the classification of Plant 2 as a Cost Leader is meaningful from a manufacturing strategy perspective.

7.4 RATING THE DEGREE OF USE OF QUALITY MANAGEMENT PRACTICES - REDUCTION OF DATA ON THE USE OF PRACTICES

This section describes how data on the use of the several QM practices was reduced to arrive at a judgement on the degree of use of each practice across plants.

7.4.1 Detailed methodology

Following the general methodology described in section 7.1, each plant had the use of each of the several QM practices characterised using appropriate tabular displays. In this process, I organised practices under several sets:

- process quality management[1]: practices related to the management of quality in the production processes: Formalised New Product Introduction Process (NPI), Zero Defects (ZD), Real Time Feedback (RTF) and Off-Line Feedback (OF).
- cross-functional design efforts
- workforce management
- supplier involvement
- customer focus

The templates for the displays are shown in Appendix 8[2]. The characterisation of each of the QM practices that is shown in the appendix is now addressed in more detail.

[1] Note that this denomination is not related to the unit of measurement of the practices. The practice Formalised New Product Introduction Process (NPI) is measured at the plant level, while the other practices are measured at process level, as seen in Chapter 6.
[2] The appendix shows three additional practices, not originally considered: In-Process Off-Line Feedback (IOF), Overall-Process Off-Line Feedback (OOF), and Changeover Inspection (CI). As will be described shortly, these practices emerged from the detailed field work data.

7.4.2 Process quality management practices

7.4.2.1 Construct refinement

Sometimes, and even in research geared towards theory-testing, findings suggest the need for a new perspective (Eisenhardt, 1989a). In the present study, the evidence from the multiple cases led to the emergence of a categorisation of process practices slightly different from the one originally adopted (Appendix 1). It became clear during the data collection and analyses stages that different Off-Line Feedback practices were consistently managed differently across plants. In particular, feedback from in-process stages is more detailed and has a higher diagnostic potential than feedback from end-of-process stages. From conversations with managers, it was clear that these differences were taken into account in the way they managed process quality. This is described in more detail later in Chapter 8. These differences led to the partition of Off-Line Feedback practices into two more detailed categories, a tactic recommended by Miles and Huberman (1994, p. 254):

In-Process Off-Line Feedback (IOF). The extent to which data pertaining to specific process steps is analysed off-line.
Overall-Process Off-Line Feedback (OOF). The extent to which data not pertaining to specific process steps (but which is still influenced by the overall process) is analysed off-line (e.g., process related data collected at testing stages after the process, from customers, etc.).

OOF refers mainly to end-of-process data, while IOF refers mainly to in-process data.
The other change concerning the categorisation of practices was the emergence of a new category of practices:

Changeover Inspection (CI). The thoroughness of the verification that a set-up associated with a product changeover has been correctly performed. Comprises the checks performed with the specific purpose of this verification, excluding the checks on the process performed during normal production (which may also contribute to this verification; these are included in the Real Time Feedback practice).

Although the effects of this practice are very similar to the Zero Defects practices - namely, the a priori prevention of defects - there is no explicit mention in the literature of these practices in the context of the management of quality. Yet, plants in the research sample had clear, well defined policies regarding Changeover Inspection, which were established separately from the initiatives under the Zero Defects banner (this is described in more detail later in Chapter 8).

7.4.2.2 Measurement

Appendix 8 shows the way that the several practices were characterised. Their characterisation follows the respective definitions (refer to Appendix 1) and is self-explanatory.

7.4.2.3 Results

The data on the use of process QM practices in the five plants are shown in Appendices B-12 to B-16. This section explains the rationale behind the judgements made using rule R1.2. This rule was applied to the practices Formalised New Product Introduction Process (NPI) and Overall-Process Off-Line Feedback (OOF). The judgements made using rule R1.1 do not require explanation as its application does not involve researcher interpretation.

<u>Formalised New Product Introduction Process</u> (NPI)

In the main, plants 1, 2 and 3 displayed similar new product introduction processes in terms of their thoroughness and formalisation (High rating), whilst plants 4 and 5 clearly had more informal and less thorough processes (Low rating; Plant 4 exhibits a slightly more thorough process than Plant 5, but still similar in the main). Given the strong similarities between plants within these two groups, the application of rule R1.2 resulted in only two levels: High and Low.

Overall-Process Off-Line Feedback (OOF)

The application of rule R1.2 suggested the division of the plants into two groups: plants 1, 2, and 3, with a High use of OOF; and plants 4 and 5, with a Low use of OOF. The processing of customer complaints is similar across all plants, so that this is not a differentiating factor. The processing of customer returns provides little or no feedback in plants 4 and 5, but provides good feedback in plants 1, 2 and 3. Plants 1, 2 and 3 get stronger feedback from testing because all the boards are tested, which does not happen in plants 4 and 5. In essence, Plant 5 was considered similar to Plant 4. Although Plant 5 gets better feedback from testing (in Plant 4 data is only analysed for the plant's major customer), it does not use quality cost information, which Plant 4 does.

7.4.3 Cross-functional design efforts

7.4.3.1 Measurement

Appendix 8 shows the way that this practice was characterised. The characterisation follows the respective definition (refer to Appendix 1) and is self-explanatory.

7.4.3.2 Results

The data for the five plants are shown in Appendices B-17 to B-21. The practice "cross-functional design efforts" refers to the input that the relevant departments of a plant have in the part of the design/introduction process in which, in the context of its service offer, the plant has an input into. The use of cross-functional design efforts achieved good levels across all plants, regardless of the scope of influence that the plants had in the process (which decreased from Plant 1 to Plant 5). According to rule R1.2, it was considered that there were not "significant, clearly identifiable differences" between the use of the practice across plants. Therefore, all the plants were rated as having a Medium degree of use, by default.

7.4.4 Workforce management practices

7.4.4.1 Measurement

Appendix 8 shows the way that the several workforce management practices were characterised: Empowerment (EMP), Suggestion Schemes (SS), Problem Solving Teams (PST) and Recognition for Quality (RQ). The characterisation of the practices follows the respective definitions (refer to Appendix 1) and is self-explanatory.

7.4.4.2 Results

The data for the five plants are shown in Appendices B-22 to B-26. This section explains the rationale behind the judgements made using rule R1.2. This rule was applied to the practices Suggestion Schemes and Problem Solving Teams. The judgements made using rule R1.1 do not require explanation as its application does not involve researcher interpretation.

<u>Suggestion Schemes</u> (SS)

Plants differed in the strength of suggestion structures and the extent to which workers actually participated in them. Plants 2 and 3 had similar and strong suggestion structures in place and similar and the strongest levels of worker participation (High rating). At the other extreme, Plant 4 had weaker suggestion structures in place, exhibited virtually no participation from workers and the suggestion schemes were considered a failure (Low rating). Finally, plants 1 and 5 had suggestion structures in place similar to the ones in plants 2 and 3 but had substantially weaker worker participation (Medium rating).

<u>Problem Solving Teams</u> (PST)

Plants differed in the number of team problem solving structures intended for worker participation and the extent to which workers actually participated in them. Plant 4 did not have any structure in place for team problem solving (Low rating). Plant 5, although having one structure in place in which production workers could participate, in actual fact they were very little involved in these teams (Low rating). At the other extreme, plants 2 and 3 had four and three instances, respectively, of problem solving team structures with participation of workers (High rating). Plant 1 exhibited one problem solving team structure, but with substantially stronger participation of workers than Plant 5 (Medium rating).

7.4.5 Supplier involvement practices

7.4.5.1 Measurement

Appendix 8 shows the way that the several supplier involvement practices were characterised: supplier selection process, assessment of supplier performance (post-selection), nature of relationships (close vs. arms length), co-operation in logistics activities and co-operation in product design/introduction. The characterisation of the practices follows the respective definitions (refer to Appendix 1) and is self-explanatory.

7.4.5.2 Results

The data for the five plants are shown in Appendices B-27 to B-31. The use of supplier practices achieved good levels in all its dimensions across all plants. There were slight differences in emphasis in certain practices across plants and other practices contributed to different competitive priorities in different plants. In addition, plants 2 and 3 seemed to exhibit slightly stronger logistics integration and Plant 3 slightly stronger supplier relationships when compared to the rest of the plants. However, according to Rule 1.2, it was considered that these were not "significant, clearly identifiable differences". Therefore, all the plants were rated as having a Medium degree of use, by default.

7.4.6 Customer focus practices

7.4.6.1 Measurement

Appendix 8 shows the way that the several customer focus practices were characterised: customer relationships (CRELATS), customer involvement in product design (CDESIGN), collection of information on latent customer needs (LATENT), collection of information on existing customer needs (EXIST), and dissemination and responsiveness to customer information (DISSEM). The characterisation of the practices follows the respective definitions (refer to Appendix 1) and is self-explanatory.

7.4.6.2 Results

The data for the five plants are shown in Appendices B-32 to B-36. This section explains the rationale behind the judgements made using rule R1.2.

Customer Relationships (CRELATS)

Plants 3, 4 and 5 exhibit the strongest relationships with customers (High rating), while Plant 1 exhibits the weakest (Low rating). Plant 2 is in between, exhibiting clear concern for customers, but displaying more distant relationships than plants 3, 4 and 5 (Medium rating).

Customer Involvement in New Product Design/ Introduction (CDESIGN)

Customers of plants 3, 4 and 5 have the strongest involvement in the design process (High rating), while Plant 1 exhibits the weakest (no formal processes in place to involve customers; Low rating). Plant 2 is in between, exhibiting formal processes, but having more distant and less frequent interactions, less intense information exchange, and less influence of customers on the design process than plants 3, 4 and 5.

Collection of Information on Latent Customer Needs (LATENT)

Plants 3, 4 and 5 have the strongest processes for collecting information on latent customer needs (High rating), while Plant 1 exhibits the weakest (no formal processes in place; Low rating). Plant 2 is in between, exhibiting formal processes, but using more distant methods and collecting information less frequently.

Collection of Information on Existing Customer Needs (EXIST)

All plants have strong processes for collecting information on customer complaints, so that this is not a differentiating factor. Considering other customer information, plants 3, 4 and 5 have the strongest and similar processes for collecting information on competitive requirements (price, delivery, etc.) (High rating). Plants 1 and 2 exhibit a similar emphasis on collecting this type of information, but they use more distant methods and collect information less frequently than the other plants (Low rating).

<u>Dissemination of Customer Information within the Organisation and Responsiveness to that Information</u> (DISSEM)

All plants have strong processes for disseminating and acting on customer complaints, so that this is not a differentiating factor. Considering other customer information, plants 2, 3, and 5 have formal mechanisms in place to disseminate and respond to customer information, although the type of information disseminated and its recipients differ across plants (High rating). While in plants 5 and 3 there are good links with shop-floor personnel, the main recipients of customer information in Plant 2 are staff in the new product development team. Plant 4 has substantial mechanisms in place to disseminate customer information, but these are more informal (Medium rating). Finally, Plant 1 has weak and informal mechanisms to disseminate customer information (Low rating).

7.5 DIFFICULTIES EXPERIENCED IN THE MANAGEMENT OF QUALITY

Following the general methodology described in section 7.1, each plant had the difficulties associated with the use of the several QM practices and the coping/mitigating strategies used to deal with those difficulties characterised using appropriate tabular displays. The template for the displays is shown in Appendix 9. The data for the five plants are shown in Appendices B-37 to B-41. As can be seen in these appendices, besides the difficulties associated with the use of the several practices and the respective coping/mitigating strategies, the displays also show the degree of use of the practices in question, as rated in section 7.4. Such a layout was purposefully devised to support the analyses to be conducted in Chapter 8.

7.6 CHAPTER SUMMARY

In this chapter I have reduced the case study data, in preparation for later and deeper stages of analysis. This consisted of selecting, simplifying, abstracting and transforming the data that appear in written-up field notes. The analysis comprised two main stages: i) the organisation and coding of data; and ii) building on the outcome of i), the characterisation of plants across the several research variables:

- research controls: this characterisation was used to judge whether plants complied with the established research controls and whether therefore they should be included in the final research sample. Five out of the six plants that were the object of field work were considered to comply with the research controls (plants 1 to 5).
- contextual variables: this characterisation was used to rank plants across the strategic context spectrum and to classify each of them into one of three strategic configurations: Niche Differentiator, Broad Differentiator, and Cost Leader. Plants 1 to 5 were ranked across the strategic context spectrum in this order, with plants 1 and 2 being classified as Cost Leaders, Plant 3 as a Broad Differentiator, and plants 4 and 5 as Niche Differentiators.
- use of QM practices: this characterisation resulted in the assignment of a High, Medium or Low rating to the degree of use of each practice. In this process, practice Off-Line Feedback was desegregated into two sub-practices (In-Process Off-Line Feedback and Overall-Process Off-Line Feedback), and a new practice, Changeover Inspection, was considered.

In addition to the above characterisation of plants, I also summarised the difficulties experienced by plants in using the several QM practices as well as the strategies that were in place to mitigate/cope with those difficulties. This analysis is used in the next chapter in triangulation with data on the formal research variables to draw and verify conclusions.

The first stage of analysis - the organisation and coding of the data - followed the usual guidelines for qualitative research. The second stage of analysis - the characterisation of plants across the several research variables - consisted of constructing tabular displays to manage and present qualitative data across the relevant research variables. These displays present a chain of evidence from raw data to the judgements made in characterising the research variables. In this process, several strategies were used to ensure the reliability of the results, i.e., that different researchers would arrive at similar judgements when confronted with the same data. These included, but were not limited to:

- the development of a fixed set of items to measure/ characterise the research variables to ensure consistency in cross-case comparisons.
- the development of a set of detailed rules for arriving at the judgements based on the raw data and the measurement/ characterisation items. These rules were based on the comparison of cases against each other.

8. DATA ANALYSIS

In this chapter I analyse the data to address the two components of the research question: i) Are quality management (QM) practices contingent on a plant's strategic context? (testing); and ii) If so, what are the mechanisms by which strategic context affects those practices? (explaining). In this process, I make use of the first order concepts, or "facts" which do not speak for themselves (Van Maanen, 1979), resulting from the data reduction stages described in Chapter 7, as well as other rich case data.

The chapter begins by describing the strategy that was used for analysing the data and the general methodology that was employed. The chapter then describes the application of these analysis procedures to the data associated with the several QM practices. This is presented in separate sections, each addressing a different set of practices: process quality management, cross-functional design efforts, workforce management, supplier involvement, and customer focus.

8.1 STRATEGY FOR DATA ANALYSIS AND ASSOCIATED METHODOLOGY

Three pieces of analysis were conducted for each set of practices. The first piece of analysis employs the patterns of use of the practices in question across plants (resulting from the ratings of their degree of use arrived at in the data reduction stages) to attempt to answer the first part of the research question: are the practices contingent on a plant's strategic context? The analysis consists of testing for association between a plant's overall strategic context and the pattern of use of the practices.

The second piece of analysis makes use of the richness of case data to investigate in greater depth the observed patterns of use of practices. In this process, it adopts a theory building mode to identify the detailed mechanisms leading to the observed pattern of use of practices, thereby producing explanations for the empirical observations. These mechanisms may or may not be related to a plant's overall strategic context. This analysis attempts to answer the second part of the research question: for practices that are contingent on strategic context, what are the mechanisms by which strategic context affects those practices?

Finally, the third piece of analysis further verifies the validity of the conclusion - arrived at in Chapter 7 when reducing the data on research controls - that the pattern of use of practices is determined by efficiency (cost-benefit) concerns. That is, it further verifies that there are no Panacea practices (high use, low effectiveness) or Worn Out practices (low use, high effectiveness). This verification is in addition to the assessment of the compliance of the individual plants to the formal research controls described in section 7.2. Whilst the assessment performed in section 7.2 used mostly aggregate plant data, this further assessment makes use of detailed data related to the use of the individual practices. This third piece of analysis attempts to further validate the mechanisms identified in the second piece of analysis, by investigating whether they determine the observed pattern of use of practices via the application of a cost-benefit (efficiency) logic. As a by-product, it also contributes to a better understanding of how the mechanisms linking strategic context to the use of practices are played out in the plants.

After the three pieces of analysis are conducted, I discuss them jointly at the end. The methodologies used in the three pieces of analysis are described next.

8.1.1 Testing for association between overall strategic context and the pattern of use of practices

The testing is based on the statistical analysis of the observed patterns of use of the different practices across the strategic context spectrum. Here, I am interested in ascertaining whether a *relative* movement across the strategic context spectrum is significantly associated with a *relative* change in the degree of use of practices. The analysis consisted in computing a correlation coefficient between a context variable (CTX) categorising the relative position of each plant across the strategic spectrum and the degree of use of each practice across the plants. This is consistent with the fact that the rules that were adopted for rating a plant across the strategic context variables and degree of use of practices are relative to the other plants in the sample. As a consequence, a statistical correlation method based on the *ranks* of variables, rather than their absolute values, is needed. The use of ranks has the additional advantage of making the results robust to individual variable ratings because these can be subjected to reasonable changes without affecting the ranks of the variables. This increases the reliability of the results. Because the sample is small (n=5), we are limited to using a nonparametric correlation method.

One simple correlation method that fully satisfies the above requirements is the *Spearman's rank correlation coefficient* (e.g., Conover, 1999). This coefficient is calculated as the sample correlation between the ranks of the two variables in question. In accordance with the context scores in Table 7.2, I define the CTX variable as taking the values 1 to 5 for plants 1 to 5, respectively. Thus, a low value for CTX denotes a location towards the Niche Differentiator end of the strategic spectrum and a high value denotes a location towards the Cost Leader region. The degree of use of each practice is defined as 3 (High), 2 (Medium), or 1 (Low) according to the degree of use ratings arrived at in the data reduction stage. The statistical computations were performed using the SPSS statistical software.

8.1.2 Explaining the pattern of use of practices

The analysis consisted of building causal networks, an analysis strategy recommended for explanation (Miles and Huberman, 1994). A causal network is a "display of the most important independent and dependent variables in a field study and of the relationships among them" (Miles and Huberman, 1994, p. 153). Causal networks are associated with analytic texts describing the meaning of the connections among factors.

Five networks - one for each case, explaining the observed pattern of use of practices - were built following Miles and Huberman's (1994) guidelines. The working blocks were the codes, researcher comments, interim case summaries and the displays constructed in the data reduction stages. In the whole process, several tactics for generating meaning were used such as noting patterns, seeing plausibility, clustering, counting, making contrasts/comparisons, subsuming particulars into the general, noting relations between variables, finding intervening variables, building a logical chain of evidence and making conceptual coherence (Miles and Huberman, 1994, pp. 245-262). As more knowledge became available during the course of the field work and associated conceptualisation, recurrent patterns of interaction between variables within the orienting research framework started to emerge, both within and across cases. Some variables looked connected, while others looked random or unconnected. These patterns guided guesses about directions of influence among sets of variables. Initial versions of the causal networks were amended and refined as they were successively tested against the data collected in the field. During this process, I actively looked for negative evidence opposing the emerging relationships as well as rival explanations (*internal validity*). In addition, I received feedback from informants on the networks' emerging relationships (*internal validity*). In order to reduce the effect of the researcher on the behaviour of informants, this was done towards the later stages of the data collection when a certain rapport had already been established with the informants. At these later stages, the relationships to be tested were also clearer. This process led to five individual networks whose relationships received support from the data.

In parallel, the five individual case networks were compared with each other in order to identify similarities and differences. These comparisons resulted in the extraction of relationships that were found to replicate across cases, abstracting from the peculiarities of individual cases and generalising them to a broader theory. This resulted in the building of general (cross-case) causal networks embodying generalisable explanations that were empirically grounded in the five individual case networks.

8.1.3 Further assessment of whether the pattern of use of practices is the result of efficiency concerns

As seen in Chapter 4, the use of a practice can be said to result from an efficiency logic if its degree of use is correlated with its effectiveness. Because the impact on performance outcomes of the use of a particular practice is difficult to disentangle from the impact of other practices and factors, it is difficult to use objective measures of the effectiveness of individual practices to compare with their degree of use. As a consequence, the assessment of whether the use of a practice results from an efficiency logic was made by triangulating several types of rich case data collected on an exploratory basis as part of the case study protocol, instead of resorting to a direct measure of effectiveness. Because these analyses follow different formats for different practices, they are described along the present chapter as each set of practices is addressed. Among the rich case data that were used, are data on the difficulties experienced by plants in using practices and the coping/mitigating strategies identified to be in place to address them. Chapter 7 described how these data were reduced in preparation for the analyses to be presented in the current chapter. Appendices B-37 to B-41 show the reduced data for all the plants. As will be shown in the analyses presented later, the triangulation of these data with the degree of use of practices and other rich case data such as management's perceptions of the effectiveness of individual practices, provides insights into whether the observed pattern of use of practices results from the application of an efficiency logic. As a by-product, it also contributes to a better understanding of how the mechanisms linking strategic context to the use of practices are played out in the plants.

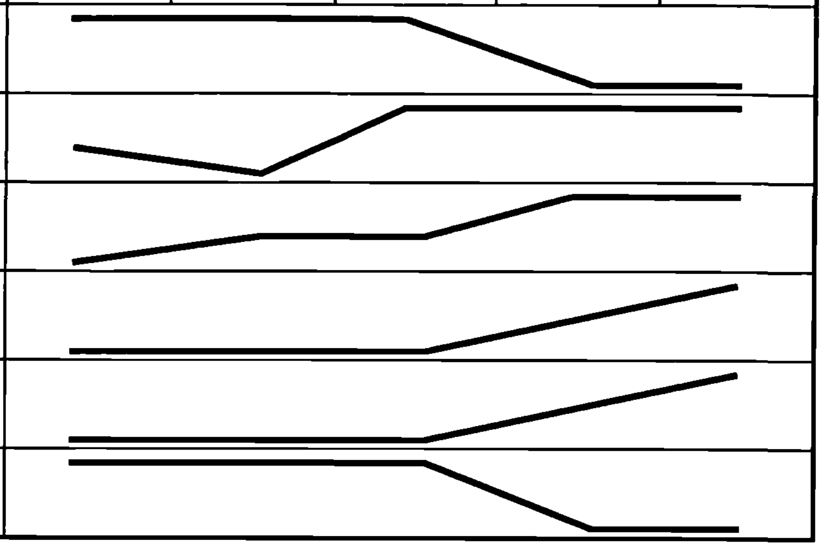
8.2 PROCESS QUALITY MANAGEMENT PRACTICES

8.2.1 Testing for association between overall strategic context and the pattern of use of practices

Following the methodology outlined in section 8.1.1, the analysis makes use of the observed patterns of use of practices across plants. Table 8-1 summarises the degree of use of the several process QM practices across plants resulting from the data reduction stage: Formalised New Product Introduction Process (NPI), Zero Defects (ZD), Changeover Inspection (CI), Real Time Feedback (RTF), In-Process Off-Line Feedback (IOF), and Overall-Process Off-Line Feedback (OOF). The plants are ordered according to their relative positions along the strategic context spectrum, as given by the context scores in Table 7.2.

Table 8-1. Degree of use of process quality management practices across plants.

Practice		Plants				
		1 CL	2 CL	3 BD	4 ND	5 ND
NPI	H M L					
ZD	H M L					
CI	H M L					
RTF	H M L					
IOF	H M L					
OOF	H M L					



The visual pattern in Table 8-1 strongly suggests that process QM practices are dependent on strategic context. To further investigate this, and in accordance with the general methodology described in section 8.1.1, I computed the Spearman rank correlation coefficients between the context variable (CTX) categorising the relative position of plants across the strategic spectrum and the degree of use of each practice across the plants. Table 8-2 shows the results of the correlation analysis.

Table 8-2. Spearman's rank correlation coefficients between ranks of strategic context (CTX) and degree of use of individual process quality management practices.

	NPI	ZD	CI	RTF	IOF	OOF
CTX	-0.87 (0.06)	0.78 (0.12)	**0.95*** (0.01)	**0.89*** (0.04)	**0.89*** (0.04)	-0.87 (0.06)

- Numbers in brackets indicate the significance level of the correlation (2-tailed tests).
- * Indicates that the correlation is significant at the 0.05 level (2-tailed tests).

As can be seen in Table 8-2, if we take a significance level of 0.06, context (CTX) is significantly and strongly correlated with the degree of use of all practices, except for Zero Defects (ZD) (with which it is nevertheless correlated at the 0.12 significance level). In addition, the strength (size effects) of the correlation coefficients is high (all above 0.78). This suggests that changes in overall strategic context significantly explain a large part of the variability in the degree of use of individual practices.

Therefore, the results of the analysis provide strong support for the pattern of use of process QM practices being contingent on overall strategic context.

8.2.2 Explaining the pattern of use of practices

Following the methodology described in section 8.1.2, causal networks and associated analytic texts were developed for the five plants. These are shown in Appendix B-42. The cases are ordered in the appendix so as to expose cross-case patterns in the degree of use of process QM practices: first, the two Niche Differentiator plants, 5 and 4; then the polar extreme Cost Leader plants, 2 and 1; and finally the Broad Differentiator bridge plant, 3. As individual case networks were constructed, it became clear that the pattern of use of process QM practices could be explained across all plants by a stable set of relationships among strategic context variables and individual practices. In addition, it was found that the directions of these stable relationships in the two Niche Differentiator plants were similar between them and were the reverse of the directions of the same relationships in the two Cost Leader plants, which were also similar between them. The Broad Differentiator plant was found to exhibit a transition pattern between these two groups. This resulted in the building of two general cross-case causal networks for the two polar strategic configurations, embodying generalisable explanations that were empirically grounded in the five individual case networks. The two general networks are shown in Figure 8-1 and Figure 8-2. The research variables are shown in boxes or circles and the relationships among them are shown by arrows. I next describe the meaning of the connections among variables in the two networks.

8.2.2.1 Management of process quality in a Niche Differentiator (Figure 8-1)

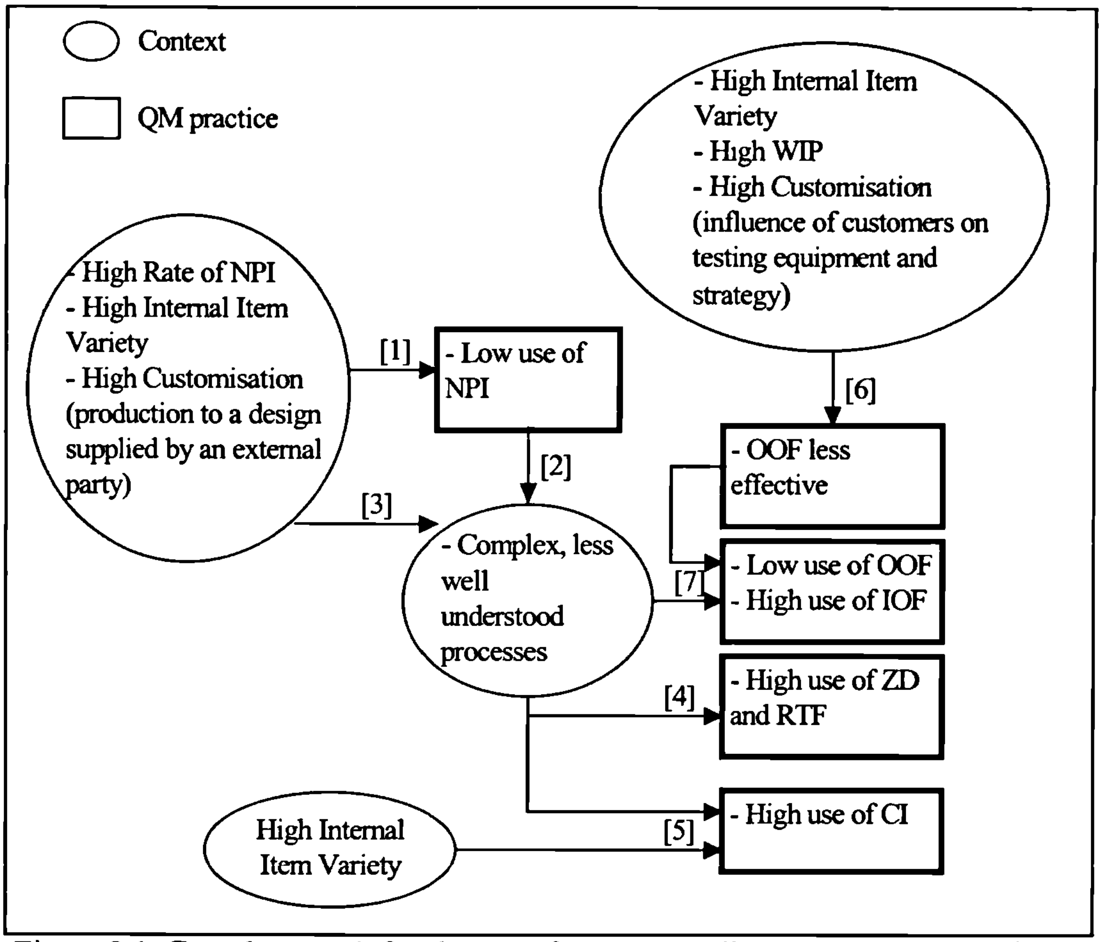


Figure 8-1. Causal network for the use of process quality management practices in a Niche Differentiator plant.

The Niche Differentiator plant faces contextual obstacles in using a Formalised New Product Introduction Process (NPI) (Relationship 1). The high degree of customisation, with product designs being developed by an outside party, poses problems in influencing their manufacturibility:

- it is difficult for the plant to make design for manufacturibility issues explicit and communicate them to the design party before units are physically produced. In particular, it is difficult to translate these issues into design for manufacturibility standards to be used by the design party before units are physically produced.

- the design party has little knowledge of the plant's processes and has little manufacturing expertise.

- there is a lack of incentive on the design party to incorporate manufacturibility concerns in its designs once it has arrived at a physical design which has been proved to work from a functional point of view.

Simultaneously, the frequent new product introductions with very short lead times and the high internal item variety prevent the use of a thorough NPI process attempting to solve most problems before production begins:

- engineering resources are absorbed by the frequent new product introductions with short lead times and by the complexity of the information exchange with the design party.
- fool-proofing processes and conducting manufacturibility exercises is difficult due to the obstacles faced in influencing the designs (typically, manufacturibility initiatives require the designs to exhibit predictable characteristics), the high product variety and the frequent new product introductions.
- the decision of when to start "volume" production is highly influenced by the customer, rather than being determined internally. While a manufacturing department can offer resistance towards a rushed introduction of a new product pushed by an internal development/marketing department, this is more difficult to accomplish when development is conducted by the customer who sees rapid new product introduction as part of the Niche Differentiator's service offer and is less aware of the associated manufacturing issues. This makes it difficult for a Niche Differentiator to conduct trial runs. Instead, the manufacturibility of the design is gradually improved as customers place orders (to the extent that customers agree to modify their designs to incorporate manufacturibility concerns). With the absence of trial runs, the units produced, even during initial stages of the introduction of a new product, are shipped to customers.
- the difficulty in conducting manufacturibility exercises on existing products, the fact that designs are less stable, and the high rate of new product introduction prevent the Niche Differentiator plant from accumulating knowledge about the manufacturibility of designs to be incorporated in future products. Also, the variability over and above the inherent process variability caused by the interaction between product design and the manufacturing processes is hard to eliminate due to the difficulties in influencing the

manufacturibility of designs. These improvements would only be possible to accomplish in a context in which there is total control over the design process, there is tight co-operation between the relevant functions, a narrow product range, a low rate of new product introductions, and stable product designs.

As a consequence, the emphasis of the new product introduction process is to get a product fit to be manufactured quickly, rather than solving all problems before production begins (Relationship 2). In addition, the Niche Differentiator's manufacturing task is inherently complex due to a large number of externally induced opportunities for errors (such as customer supplied information, design and materials), high internal item variety, and high rate of new product introduction (Relationship 3). All these factors lead to a less well understood process in which not all the problems have been solved. In such a process it is beneficial to use many Zero Defects (ZD) mechanisms to reduce as much as possible any potential sources of error on what is already a complex process (Relationship 4). In a process in which many things can go wrong, it also pays off to use a high degree of Real Time Feedback (RTF) to maintain the process in control and avoid the production of defects (Relationship 4). The same rationale, coupled with the existence of more frequent and complex set-ups, leads to more effort being placed in Changeover Inspection (CI) practices (Relationship 5).

Overall-Process Off-Line Feedback (OOF) data refers mainly to end of process product data, and thus is more aggregate, less timely and has reduced diagnostic potential. The diagnostic capability of OOF is particularly reduced in a Niche Differentiator context due to higher levels of WIP inventory (reducing the timeliness of OOF), high internal item variety (increasing the difficulty in linking product defect data to process variables), and the customers' influence on the testing strategies and equipment (posing obstacles to using testing strategies to maximise the feedback on the processes) (Relationship 6). As a consequence, OOF is not sufficient to guide the improvement of the Niche Differentiator plant's complex processes for which the plant relies mostly on detailed in-process data (In-Process Off-Line Feedback, IOF) (Relationship 7).

8.2.2.2 Management of process quality in a Cost Leader (Figure 8-2)

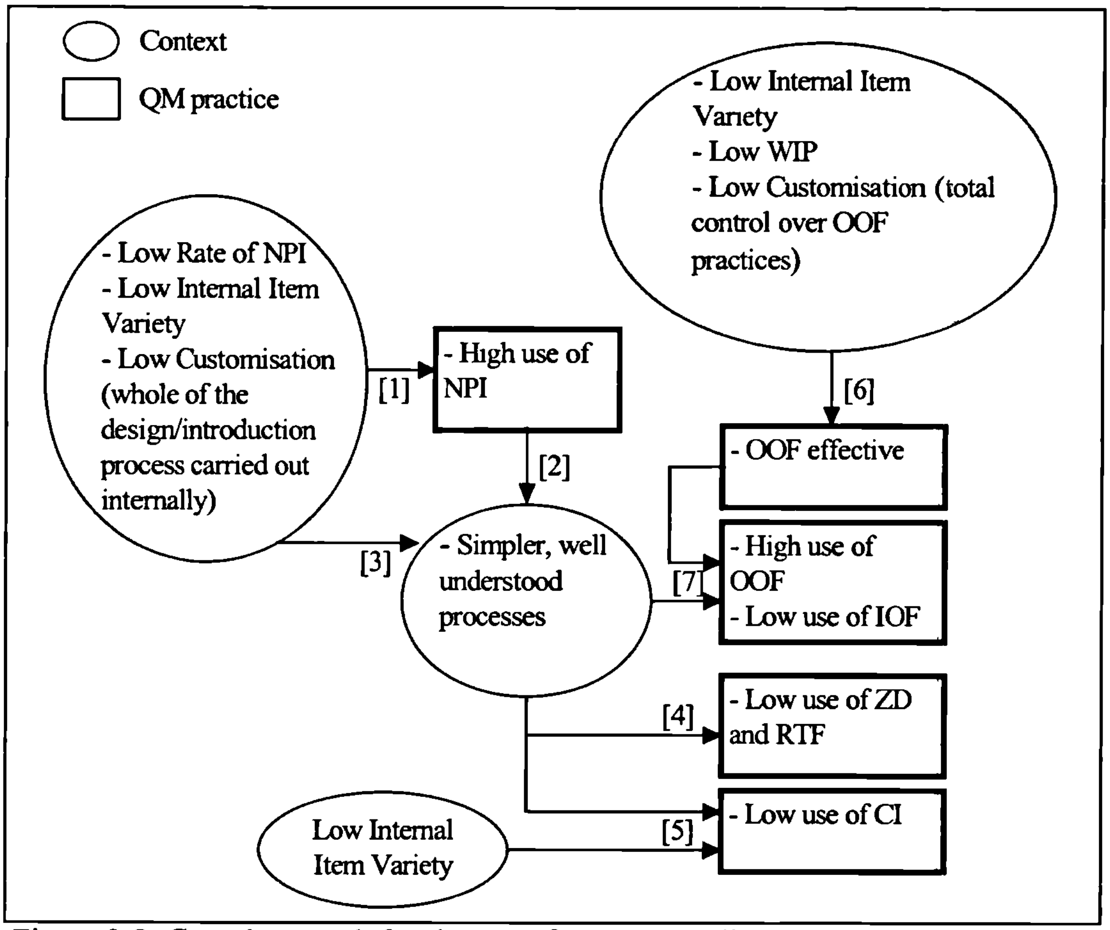


Figure 8-2. Causal network for the use of process quality management practices in a Cost Leader plant.

The non customised nature of the Cost Leader's service offer allows it to conduct new product design and introduction internally. This facilitates tight co-operation between the party responsible for the design and the manufacturing function. This tight co-operation enables the consideration of the detailed characteristics of the plant's processes in the development of easy to manufacture designs. This, coupled with less frequent new product introductions with longer lead times, more stable designs and lower product variety, allow for the use of a Formal New Product Introduction Process (NPI) (Relationship 1). The emphasis is on solving all the problems before full scale production begins (Relationship 2). It also allows for the conduction of regular manufacturibility exercises which gradually improve the manufacturibility of existing products. In addition, the nature of the manufacturing task is less complex because of low customisation, low internal item variety and a low rate of new product introduction (Relationship 3). All these conditions lead to a process which is less complex and better understood.

In such a process, there are less opportunities for errors, and therefore the benefits from the high use of Zero Defects (ZD) mechanisms do not outweigh the costs (Relationship 4). A better understood process also requires less Real Time Feedback (RTF) to remain in control, that is, the benefits from a high use of RTF do not outweigh the costs (Relationship 4). Similarly, the existence of less and simpler set-ups does not justify the high use of Changeover Inspection (CI) (Relationship 5).

The diagnostic capability of Overall-Process Off-Line Feedback (OOF) is higher in a Cost Leader plant because (Relationship 6):

- the reduced internal item variety allows for a better traceability of end of process product defects to process causes.
- the reduced levels of WIP inventory and the simplicity of data analyses improve the timeliness of the feedback.
- resulting from the low degree of customisation, the plant has total control over OOF practices which can thus be geared towards maximising feedback on the process.

Because the diagnostic capability of OOF is high and because the processes are well understood - thus requiring less detailed feedback for guiding improvement - the Cost Leader plant relies heavily on OOF and less on In-Process Off-Line Feedback (IOF) for improvement (Relationship 7). The strong feedback capability of OOF reduces the need for formal IOF and RTF.

8.2.3 Further assessment of whether the pattern of use of practices is the result of efficiency concerns

In accordance with the methodology outlined in section 8.1.3, I used rich case data to further assess whether the patterns of use of process QM practices were the result of efficiency concerns. To this end, I summarised the data from Appendices B-37 to B-41 on the difficulties experienced by plants in managing process quality and the respective coping/mitigating strategies in place, raising the abstraction level of the data. During this process, strong similarities were found between the difficulties experienced by the two Niche Differentiator and the two Cost Leader plants between them, so that I aggregated the results from the pairs of plants in question. It was also found that the coping/mitigating strategies used exhibited substantial regularities across plants. To facilitate the presentation of the results, the strategies were classified into several categories:

- INFO: use of intensive information processing to deal with complexity and variety.
- GEN: reduction of a high variety of problems to generic categories of process related problems which, once solved, are expected to yield improvements across all products.
- PRIOR: identification of the most important problems to focus improvement efforts.
- DYN: dynamic adaptation of quality control procedures to match different levels of product complexity and defect rates.
- CUST: developing long term, co-operative relationships with customers.
- ORG: adoption of specific organisational structures directed at dealing with the difficulties.
- TECH: use of technology to reduce the effort associated with QM practices.

The results are shown in Table 8-3. Based on Table 8-3 and the individual causal networks (Appendix B-42) I then compiled Table 8-4. Table 8-4 shows that, for practices that were less used, either there were efficiency related obstacles posed by context preventing its use despite the strategies employed to counter these obstacles (here the obstacles seem to be such that they would require a very high investment in strategies to counter them); or, when no obstacles were reported, there were identifiable efficiency justifications for the reduced need of those practices (here the benefits from the practices do not seem to be sufficient to outweigh the costs). Thus, there is no evidence of Worn Out practices. For practices which were highly used, either there were no obstacles reported, in which case no non-efficiency pressures for use were identified and management perceived the use made of the practices as effective (here the benefits from the practices seem to outweigh the costs); or there were obstacles posed by context which were overcome by coping strategies (here, the benefits of the practices were such that it seemed to pay to invest in coping strategies to counter the obstacles). Thus, there is no evidence of Panacea practices.

In conclusion, there is strong evidence that the use of the practices was dictated by a cost-benefit (efficiency) logic.

Table 8-3. Summary of difficulties experienced in the use of process quality management practices across plants and respective coping/mitigating strategies.

Reported difficulties and causes	Associated practices (*)	Coping/mitigating strategies used
ND plants		
-Difficulties in the interaction with customers both in terms of the complexity of the information exchange and influencing the manufacturibility of customer supplied designs. This absorbs high engineering resources. - Difficulties in fool-proofing processes and conducting manufacturibility exercises due to the above difficulties in the interaction with customers as well as the high product variety, frequent new product introductions and high labour intensity.	NPI - Low use	INFO CUST GEN ORG
- Difficulties in defining control parameters for a large diversity of products produced in small batches.	RTF - High/Med. use	INFO DYN
- Difficulties in conducting off-line analyses of information and extracting benefits from them due to the high variety of products and the customers' influence over the testing strategies.	IOF - High/Med. use OOF - Low use	INFO GEN CUST PRIOR
BD plant		
- Minor difficulties in influencing the manufacturibility of designs supplied by one of the customers due to its adherence to a different design for manufacturibility standard.	NPI- High use	CUST
- Difficulties in conducting off-line analyses of information and extracting benefits from them due to the high variety of products.	IOF - Low use OOF - High use	GEN INFO PRIOR
- Final testing/data collection considered expensive.	OOF - High use	DYN TECH
CL plants		
- Final testing/data collection considered expensive.	OOF - High use	DYN TECH

(*) Degree of use of practices is as reported in Table 8-1.

Table 8-4. Evidence of efficiency logic in the use of process quality management practices across plants.

	Practices and plants	Evidence of efficiency logic from individual case analyses	Conclusion (*)
Practices with Low use and with reported difficulties	- NPI for ND plants - OOF for ND plants	Plants had mitigating strategies in place but these were not sufficient to break the context barrier and enable a high level of use of the practice. No evidence of lack of desire to adopt practices.	Plants wished to have practices in place, but context did not allow it. Most probably, the very high cost of strategies to break the context barrier would not justify the benefit. This suggests that NPI and OOF approach Misfit status for an ND context.
Practices with Low use and no reported difficulties	- ZD for CL Plant 2	- Management explicitly indicated the use of ZD mechanisms in placement operations as not being worth the cost.	Practices are less needed in context. Most probably the reduced benefits would not outweigh costs. This suggests that ZD, CI, RTF and IOF approach Misfit status as one moves towards the CL configuration. (Medium use of ZD and CI for plants 1 and 2, respectively, is consistent with this conclusion)
	- CI for CL Plant 1	- CI not needed because of very simple and infrequent set-ups.	
	- RTF, IOF for CL and BD plants	- Strong feedback provided by OOF practices made RTF and IOF less necessary. In addition, RTF was less needed due to the processes being well understood.	
Practices with High use and with reported difficulties	- RTF for ND Plant 5 - IOF for ND plant 5. - OOF for BD and CL plants	- Management explicitly recognised the high cost of the practices, but considered them necessary. Coping strategies were used to deal with the difficulties posed by context. No evidence of non-efficiency pressures for adoption, i.e., no evidence of Panacea practices.	Benefits from the use of practices outweigh costs and practices are effective in use. This suggests that RTF and IOF approach Best-Practice status as one moves towards an ND context, and that OOF approaches Best-Practice status as one moves towards a CL context. (Medium use of RTF and IOF for Plant 4 is consistent with this conclusion)

Table 8-4 (cont.). Evidence of efficiency logic in the use of process quality management practices across plants.

	Practices and plants	Evidence of efficiency logic from individual case analyses	Conclusion (*)
Practices with High use and with no reported difficulties	- NPI for BD and CL plants	- Evidence of strong benefits from the use of the practice. High use was a conscious decision of the plants for fool-proofing their processes. No evidence of non-efficiency pressures for adoption, i.e., no evidence of Panacea practices.	Benefits from the use of practices outweigh their (reduced) costs and practices are effective in use. This suggests that NPI approaches Best-Practice status as one moves towards a CL context, and that ZD and CI approach Best-Practice status as one moves towards a ND context. (Medium use of CI for Plant 3 is consistent with this conclusion)
	- ZD for BD and ND plants	- BD Plant: use of ZD justified by management to fool proof processes and avoid the use of in-process checks (low use of RTF and IOF; high use of OOF). - ND plants: Limitation of as many potential sources of error as possible was seen as necessary in the context of the plants' complex processes with many opportunities for errors which were statistically very visible due to the small size of customer orders.	
	- CI for ND plants	- Evidence that practices were needed due to more complex and frequent set-ups with many opportunities for error.	

(*) For simplification purposes, information related to practices exhibiting a Medium degree of use was omitted from this table. By consulting the analytic texts for the individual cases in Appendix B-42, the reader may verify that this information is consistent with the conclusions, as indicated in the "Conclusion" column.

8.2.4 Discussion

The statistical analysis suggested that the pattern of use of process QM practices was strongly influenced by a plant's overall strategic context. The causal network analyses reinforced this conclusion. For every plant, they uncovered mechanisms by which the detailed characteristics of the respective strategic context determined the observed pattern of use of practices. These mechanisms found replication both across similar strategic contexts (i.e., their application to similar contexts explained the similarity observed in the patterns of use of practices - literal replication) and across the strategic spectrum (i.e., their application to different contexts explained the differences observed in the patterns of use of practices - theoretical replication).

The causal network analyses also identified two interaction effects between process QM practices. One is the substitution effect between the two off-line feedback practices, IOF and OOF (Relationship 7 in Figure 8-1 and Figure 8-2). For example, a higher use of OOF partially determined IOF to be less needed. The other is the partial effect of the use of new product introduction (NPI) practices on the use of most of the downstream practices via the impact it has on how well processes are understood (Relationship 2 in Figure 8-1 and Figure 8-2). For example, an increase in the use of NPI partially led to the reduction in the use of CI, RTF and IOF practices due to increased process knowledge. These findings suggest the existence of an internally coherent process QM practice configuration matching a plant's strategic configuration.

Finally, the third piece of analysis found strong evidence that the mechanisms linking strategic context to the use of practices operated via an efficiency (cost-benefit) logic. It also revealed that there are specific difficulties in the use of process QM practices associated with particular strategic contexts. The highest number of difficulties is associated with the Niche Differentiator context, resulting mainly from the complexity of its processes and the high degree of customisation. While some of the difficulties may be overcome by adequate strategies enabling a high level of use of the associated practices (e.g., the difficulties posed by a Niche Differentiator context to the use of practice RTF), others cannot be overcome, preventing the use of the associated practices (e.g., in a Niche Differentiator context the reduced integration with the design party prevented the high use of NPI practices, regardless of the attempts to mitigate the associated difficulties).

The empirical results are remarkably consistent with Bohn's theory on process knowledge (Bohn, 1994). Bohn proposes several stages of knowledge of processes (Table 8-5). He argues that different stages of knowledge should be managed differently. In particular, he argues that the quality control approach should be one based on sorting for the very lowest stages of process knowledge (stages 1 and 2), move towards statistical process control for stages 3, 4 and 5, and shift towards feed-forward control for stages 6, 7 and 8.

Bohn (1994) also suggests that the knowledge of a process at start-up is less than at later stages. In addition, changes in the processes cause a regression of its effective knowledge to earlier stages. He also argues that increasing knowledge is accompanied by the conversion of exogenous (environmental) variables into endogenously controlled variables. Niche Differentiator plants exhibit a high rate of start-ups and change in their processes and are subject to more environmental variables (e.g., resulting from the high degree of customisation). The context analysis of the plants in the research sample suggests that the Niche Differentiator plants are positioned about stages 3, 4 and 5, and that as one moves towards the Cost Leader plants, the stage of process knowledge moves towards levels 6, 7 and 8. Consistent with Bohn's theory, the Niche Differentiators' QM approach was based on a high use of RTF and IOF practices (falling within Bohn's "statistical process control" category), while the Cost Leaders' approach was rooted on a high degree of use of NPI for fool-proofing processes (falling within Bohn's "feed forward control" category). In addition, process knowledge was found to be a central variable in the causal networks explaining the pattern of use of process practices.

Table 8-5. Bohn's (1994) stages of process knowledge.

Stage	Description of knowledge about process variables
1. Complete Ignorance	You do not know that a phenomenon exists, or if you are aware of its existence, you have no inkling that it may be relevant for your process.
2. Awareness	"Pure art". You know that the phenomenon exists and that it might be relevant to your process. There is still no way to use the variable in your process, but you can begin to investigate it in order to get to the next stage.
3. Measure	"Pre-technological". You can measure the variable accurately, perhaps with some effort. Variable can still not be controlled.
4. Control of the mean	"Scientific method feasible". You know how to control the variables accurately across a range of levels, although the control is not necessarily precise.
5. Process capability	"Local recipe". You can control the variables with precision across a range of values.
6. Process characterisation (know how)	"Trade-offs to reduce costs". You know how the variable affects the result, when small changes are made in the variable. Now you can begin to fine tune the process to reduce costs and to change product characteristics.
7. Know why	"Science". You have a scientific model of the process and how it operates over a broad region, including non linear and interactive effects of this variable with other variables. You can optimise the process in respect to the variables.
8. Complete knowledge	"Nirvana". You know the complete form and parameter values that determine the result as a function of all the inputs.

Adapted from Bohn (1994).

8.3 CROSS-FUNCTIONAL DESIGN EFFORTS

As seen in Chapter 7, all the plants exhibited the same (good) level of use of cross-functional design efforts. This suggests that this practice is independent of strategic context. Rich case data reinforced this conclusion. Management of all plants explicitly reported benefits of cross-functional co-operation between the relevant functions internal to the plant. In particular, in plants 2 and 3, the comparison between the situation, some years before, where this co-operation was less strong, and the present situation, clearly highlighted the benefits of co-operation (see causal networks for the use of process QM practices in plants 2 and

3, in Appendix B-42[1]). Also, plants 4 and 5 reported major difficulties resulting from the obstacles that its strategic context posed to co-operating with the design party responsible for the conceptual and physical design of the products, who is an outside party for these plants (see difficulties associated with the use of process QM practices in plants 4 and 5, in Appendices B-40 and B-41, respectively; note that the practice cross-functional design efforts refers to the co-operation between internal plant departments only). No difficulties were experienced by any of the plants in their internal co-operation activities (see Appendices B-37 to B-41) and no evidence was found in the individual case analyses of non-efficiency pressures for the use of the practice (see Appendix B-42). This indicates that the use of the practice is dictated by a cost-benefit efficiency logic (i.e., the practice is not a Panacea practice).

In conclusion, the several analyses suggest that cross-functional design efforts are independent of strategic context.

8.4 WORKFORCE MANAGEMENT PRACTICES

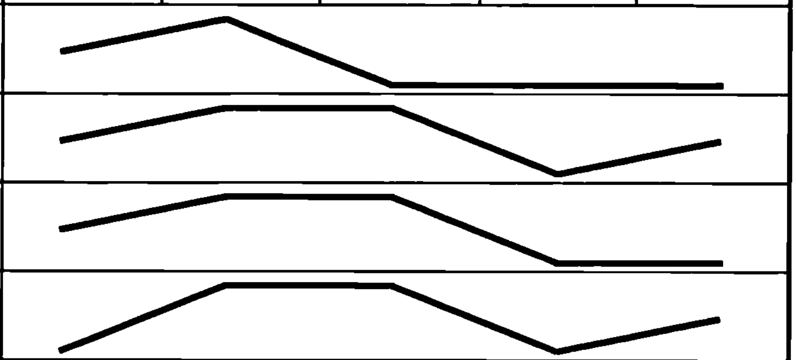
8.4.1 Testing for association between overall strategic context and the pattern of use of practices

Following the methodology outlined in section 8.1.1, the analysis makes use of the observed patterns of use of practices across plants. Table 8-6 summarises the degree of use of the several workforce management practices across plants resulting from the data reduction stage: employee empowerment (EMP) and employee involvement practices (suggestion schemes (SS), problem-solving teams (PST), and recognition for quality (RQ)). The plants are ordered according to their relative positions along the strategic context spectrum, as given by the context scores in Table 7.2.

[1] Although this appendix does not refer explicitly to the practice "cross-functional design efforts", it contains the relevant information on the use of this practice. This information is intertwined with the information on the use of the practice "formalised new product introduction process" (NPI).

Table 8-6. Degree of use of workforce management practices across plants.

Practice		Plants				
		1 CL	2 CL	3 BD	4 ND	5 ND
Empowerment (EMP)	H M L					
Suggestion Schemes (SS)	H M L					
Problem Solving Teams (PST)	H M L					
Recognition for Quality (RQ)	H M L					



The visual pattern in Table 8-6 suggests the following:

i) with perhaps the exception of empowerment - whose use seems to decrease from the Cost Leader to the Niche Differentiator context - there is a weak association between strategic context and the degree of use of practices.

ii) there seems to be a link between the use of the several individual involvement practices (suggestion schemes, problem-solving teams and recognition for quality).

To further investigate i), and in accordance with the general methodology described in section 8.1.1, I computed the Spearman rank correlation coefficients between the context variable (CTX) categorising the relative position of plants across the strategic spectrum and the degree of use of each practice across the plants. Table 8-7 shows the results of the correlation analysis.

Table 8-7. Spearman's rank correlation coefficients between ranks of strategic context (CTX) and degree of use of individual workforce management practices.

	EMP	SS	PST	RQ
CTX	-0.78 (0 12)	-0.37 (0 54)	-0.63 (0 25)	0.00 (1 00)

Numbers in brackets indicate the significance level of the correlation (2-tailed tests).

Although the use of empowerment practices seems to associated with strategic context (high correlation coefficient, significant at the 0.12 level), the use of the other practices seems to be independent of strategic context (low correlation coefficients and statistically non-significant). This is consistent with the initial visual conjecture.

To further investigate ii), I computed the Spearman rank correlation coefficients between the degree of use of the several practices. Table 8-8 shows the results of the correlation analysis.

Table 8-8. Spearman's rank correlation matrix between the degree of use of individual workforce management practices.

	EMP	SS	PST	RQ
EMP	1	0.41 (0 49)	0.53 (0 36)	0.18 (0.78)
SS		1	**0.92*** (0 03)	**0.92*** (0 03)
PST			1	0.75 (0.14)
RQ				1

Numbers in brackets indicate the significance level of the correlation (2-tailed tests).
* Correlation is significant at the 0.05 level (2-tailed tests).

The high and significant correlation coefficients SS-RQ and SS-PST, the moderately high correlation coefficient PST-RQ significant at the 0.14 level, and the non-significance of the correlation coefficients associated with EMP, support the initial visual conjecture.

Result i) suggests that strategic context has little influence in the use of workforce management practices (or its influence is overshadowed by other factors), its influence being limited at best to empowerment practices. This, in conjunction with result ii), suggests that there are other factors not associated with strategic context affecting each plant as a whole and driving the conjoint use of involvement practices.

8.4.2 Explaining the pattern of use of practices

Following the methodology described in section 8.1.2, causal networks and associated analytic texts were developed for the five plants. These are shown in Appendix B-43. As the individual causal networks were constructed, it became clear that the pattern of use of workforce management practices was best explained by the existence of "facilitating factors" which, when absent, caused difficulties to the use of practices. These factors and their association with strategic context are:

a) a flat organisational structure. Although originally considered as part of the characterisation of strategic context, no association was found between this variable and strategic context (see context data in Appendices B-7 to B-11).

b) a local pool of labour with favourable intrinsic characteristics, namely, workers who are self-disciplined and willing to take on responsibilities. This is a factor exogenous to the plant and unrelated to strategic context.

c) a workforce with high levels of skill and a quality mindset. This is partly under the control of the plant via its training activities, although several other factors were found to also affect this variable (this is why this variable is treated separately from the intrinsic characteristics of the pool of labour, which is a purely exogenous factor). These include the intrinsic characteristics of the pool of labour, the rate of growth in the company, workforce turnover rate, use of temporary workers, worker selection processes, and resources available for training on quality. All of these factors are unrelated to strategic context.

d) simple work tasks. The simplicity of tasks was measured by the context variable "degree of standardisation", which is strongly associated with strategic context (the degree of standardisation increases as one moves from the Niche Differentiator to the Cost Leader context - see Table 7.2).

All these facilitating factors were present in Plant 2, which exhibits a high use of all practices, and there is evidence in the other individual case analyses that the absence of one or more of them caused difficulties in the use of some practices. The data on the difficulties experienced by the plants due to the absence of facilitating factors are included in Appendices B-37 to B-41. Table 8-9, based on the individual case analyses, shows that indeed this absence led to the reduced use of some practices.

Table 8-9. The effect of facilitating factors on the use of workforce management practices across plants.

Plant	Pattern of use of practices	Facilitating factors absent	Practices for which there is evidence that their reduced use was influenced by the absence of the facilitating factors
Plant 1 (CL)	- Medium use of EMP, SS, PST. - Low use of RQ.	- Workforce with a high skill level and quality mindset.	- All.
		- Favourable pool of labour.	- EMP.
Plant 2 (CL)	- High use of all practices.		
Plant 3 (BD)	- High use of SS, PST and RQ. - Low use of EMP.	- Flat organisational structure. - Favourable pool of labour.	- EMP.
Plant 4 (ND)	- Low use of all practices.	- Simple tasks.	- SS, PST, RQ.
		- Favourable pool of labour.	- EMP.
		- Workforce with a quality mindset.	- All.
Plant 5 (ND)	- Low use of EMP and PST. - Medium use of SS and RQ.	- Simple tasks.	- SS, PST, RQ.
		- Workforce with a high skill level and quality mindset.	- All.
		- Flat organisational structure. - Favourable pool of labour.	- EMP.

Figure 8-3 depicts the cross-case causal network showing how the facilitating factors work in determining the use of involvement (SS, PST, RQ) and empowerment (EMP) practices. The research variables are shown in boxes or circles and the relationships among them are shown by arrows. I next describe the meaning of the connections among variables in the network.

8.4.2.1 The effect of facilitating factors on the use of workforce management practices (Figure 8-3)

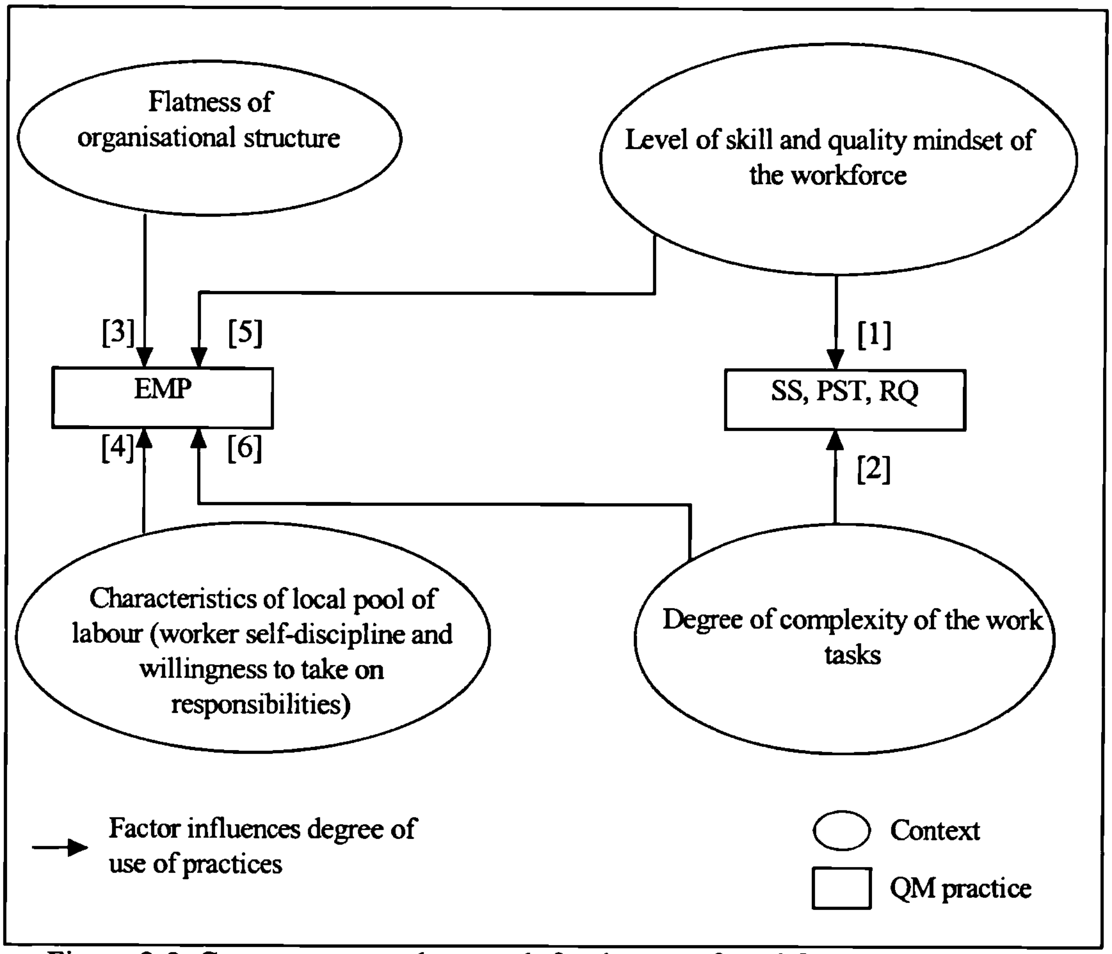


Figure 8-3. Cross-case causal network for the use of workforce management practices.

The use of involvement practices (SS, PST, RQ) requires a workforce with high skill levels and quality mindset (Relationship 1) and simple work tasks (Relationship 2). Simple work tasks allow workers to contribute meaningfully considering their skills. The associated high degree of standardisation also provides workers with a structure to think about problems to contribute with improvements. In turn, a high level of skill facilitates meaningful contributions from workers. Coupled with this, a quality mindset provides workers with the tools and motivation to participate. Involvement practices can be used even if the intrinsic characteristics of the local pool of labour - worker self-discipline and willingness to take on responsibilities - are unfavourable (the case of Plant 3). This is because the main objective of these practices is to extract ideas and controlled feedback from the workforce and to increase communication. Because this implies a well defined and structured role for workers, self-discipline and willingness to take on responsibilities are less critical. Where the facilitating factors are absent, involvement structures are used to involve indirect staff, rather than the direct workforce (the case of the use of problem solving teams for indirect staff in Plant 5).

Worker empowerment (EMP) requires a flat organisational structure (Relationship 3), allowing for the pushing down of responsibilities to the lower levels of the organisation. It also requires a workforce with favourable intrinsic characteristics, namely, worker self-discipline and willingness to take on responsibilities (this is in part why Plant 2 had a high empowerment level compared to Plant 3) (Relationship 4). While the absence of these characteristics is not critical for involvement practices, it is so for empowerment practices, given its emphasis on employee autonomy. In addition, these intrinsic characteristics of the workforce are very difficult to overcome via internal training activities (the case of Plant 3). Finally, even with a flat organisational structure and a favourable pool of labour a plant needs to instil high levels of skill and a quality mindset in the workforce to motivate workers to participate and provide them with the tools to do so (Relationship 5). This is further facilitated by a low degree of complexity of tasks (the case of Plant 1) (Relationship 6).

8.4.3 Further assessment of whether the pattern of use of practices is the result of efficiency concerns

In accordance with the methodology outlined in section 8.1.3, I used rich case data to further assess whether the pattern of use of workforce management practices was the result of efficiency concerns. To this end, I summarised the data from Appendices B-37 to B-41 on the difficulties experienced by plants in using those practices and the respective coping/mitigating strategies in place, raising the abstraction level of the data. During this process, strong similarities were found between the difficulties experienced by the two Niche Differentiator plants, so that I aggregated the results from these two plants. The results are shown in Table 8-10.

As can be seen in Table 8-10, practices which have a low or medium degree of use are associated with reported difficulties (which in turn result from the absence of the facilitating factors identified previously), suggesting that there are no Worn Out practices. Also, there aren't any difficulties associated with highly used practices. In addition, as can be seen in the individual case causal networks (Appendix B-43), these practices were perceived as effective by management, suggesting that there are no Panacea practices.

In conclusion, the facilitating factors seem to work via a cost-benefit logic in determining the observed pattern of use of practices.

Table 8-10. Summary of difficulties experienced in the use of workforce management practices across plants and respective coping/mitigating strategies.

Plants	Reported difficulties and causes	Associated practices (*)	Coping/mitigating strategies used
	ND	**plants**	
4, 5	- Heterogeneous workforce in terms of skills and/or quality mindset (caused by a substantial labour turnover, strong growth in the workforce, and internal training deficiencies). - Inherent characteristics of pool of labour (lack of discipline, lack of high technical skill and willingness to take on responsibilities). - (Plant 4 only) The high internal item variety, leading to a high variation in the complexity of tasks in the shop floor, created difficulties in the institution of a fair system to reward workers for defect free output.	EMP - Low use SS - Low/ Medium use PST - Low use RQ - Low/ Medium use	- Simplification of tasks. But this was made difficult or even virtually impossible by the plant's strategic context (high internal item variety, high rate of new product introduction, high degree of customisation, low degree of standardisation).
	BD	**plant**	
3	- Inherent characteristics of pool of labour (lack of discipline and willingness to take on responsibilities) prevented the empowerment of workers.	EMP - Low use	- Simplification of tasks (via high standardisation and training). However, management considered that this was not enough to overcome the inherent limitations of the workforce resulting from the characteristics of the local pool of labour.
	CL	**plants**	
2	None.		
1	- Low level of skill and quality mindset of the workforce (caused by the characteristics of local pool of labour, use of poorly trained temporary workers due to volatility in demand, and deficiencies in internal training). - Inherent characteristics of pool of labour (lack of discipline, lack of high technical skill and will to take on responsibilities).	EMP - Medium use SS - Medium use PST - Medium use	Simplification of tasks. There was an initiative planned for the near future for the classification of problems arising in the shop floor according to their degree of complexity, so that workers would only be involved in solving simple problems, with more complex problems being escalated to indirect staff.

(*) Degree of use of practices is as reported in Table 8-6.

8.4.4 Discussion

The statistical analyses suggested that strategic context has little influence on the use of workforce management practices (or its influence is overshadowed by other factors), its influence being limited at best to empowerment practices. It also suggested that there might be other factors not associated with strategic context affecting each plant as a whole and driving the conjoint use of involvement practices. The causal network analyses reinforced these preliminary conclusions. They suggested that certain facilitating factors need to be present to enable the high use of workforce management practices: a flat organisational structure, a local pool of labour with favourable characteristics, workforce with high levels of skill and a quality mindset, and simple work tasks. Of these factors, only the complexity of work tasks is related to strategic context. In addition, several of the other facilitating factors were affected by variables unrelated to strategic context. This is consistent with the weak influence of strategic context detected in the statistical analyses. The possible link that was detected in the statistical analyses between strategic context and empowerment seems to result from the association between the degree of complexity of tasks and strategic context and the facilitating effect that a low task complexity was found to have in the use of empowerment practices (refer to individual causal networks for plants 1 and 2, as instances of Relationship 6 in Figure 8-3). The absence of the same link for involvement practices may result from the confounding effect of the other facilitating factors being played out in the study's specific sample (i.e., the characteristics of the plants in the research sample in terms of the facilitating factors may be such that they do not allow for the detection of a significant effect of the variable "complexity of work tasks" on involvement practices). The conjoint use of involvement practices (SS, PST, RQ) uncovered in the statistical analyses seems to result from the fact that all of the practices are influenced by the same set of variables ("degree of complexity of tasks" and "level of skill and quality mindset of the workforce"; Relationships 1 and 2 in Figure 8-3). The absence of a significant statistical association between the use of empowerment and involvement practices is explained by the fact that while empowerment is strongly affected by adverse exogenous factors (which are very difficult to overcome by internal plant activities), involvement practices are not. That is, while a plant may increase the joint use of involvement practices by creating adequate internal conditions (e.g., via training activities to increase the level of skill of the workforce), this is more difficult to accomplish with empowerment practices because their use depends not only on internal conditions, but also on externally determined conditions (namely, the characteristics of the pool of labour - Relationship 4 in Figure 8-3).

These results received theoretical replication, as changes in the pattern of the facilitating factors explain the respective changes in the pattern of use of practices. This can be verified by comparing the individual case causal networks included in Appendix B-43. The extent of literal replication is only moderate because the number of possible permutations between the individual facilitating factors at play is large in comparison to the sample size. Although the influence of those factors as a whole receives replication across cases, the mechanisms that have been put forward linking the individual factors to the pattern of use of practices can only be considered to have received moderate replication. For example, full replication for the mechanism "degree of complexity of tasks - use of practices" would require observing the degree of use of practices in a plant with complex work tasks and a workforce with a strong quality mindset and skill level, in addition to the existing sample. Full replication could not be investigated in this study because the research sample was not originally selected to address the effect of the facilitating factors (which were identified a posteriori).

The third piece of analysis confirmed that the identified facilitating factors worked via the application of a cost-benefit logic. It also revealed that there are specific difficulties in the use of workforce management practices associated with the Niche Differentiator context (caused by the high complexity of work tasks) which cannot be overcome by adequate coping strategies (see Table 8-10).

In conclusion, strategic context seems to play only a minor role in determining the use of workforce management practices. There is moderate evidence that the use of workforce management practices faces increasing obstacles as one moves from the Cost Leader to the Niche Differentiator context by virtue of more complex work tasks, everything else being equal.

8.5 SUPPLIER INVOLVEMENT PRACTICES

As seen in Chapter 7, all the plants exhibited the same (good) level of use of supplier involvement practices. This suggests that these practices are independent of strategic context. Following the general methodology outlined in section 8.1.3, I further investigated whether the good level of use of supplier involvement practices across plants resulted from efficiency concerns. To this end, I summarised the data from Appendices B-37 to B-41 on the difficulties experienced by plants in the use of these practices and respective coping/mitigating strategies in place, raising the abstraction level of the data. During this process, strong similarities were found between the difficulties experienced by the two Niche Differentiator plants between them, so that I aggregated the results from these two plants. The results are shown in Table 8-11.
As seen in Table 8-11, only the Niche Differentiator plants 4 and 5 reported difficulties in the use of supplier involvement practices. These difficulties result from the production to customer supplied designs and the subsequent influence that customers have in the selection of suppliers, either because there are links between the design of a product and the components it comprises; or because customers have already worked with particular suppliers in the past when placing orders with other plants (for example, as part of the prototyping stages of the development of their designs) or when producing the product in-house. Because customers tend to have little manufacturing expertise they may not be sufficiently qualified to select good suppliers for volume production. This sometimes leads to the use of inadequate suppliers or suppliers with whom the plants have less well developed relationships. This makes it more difficult to reduce the supplier base and also carries the risk of the supplier seeing the plant's customer as its main customer and thus have less incentive to develop relationships with the plant.
In addition to these obstacles faced by the Niche Differentiator plants 4 and 5, the analysis of rich case data revealed benefits in plants 1, 2 and 3 resulting from the fact that the whole design process is conducted internally, and which do not accrue to the Niche Differentiator plants. The good co-operation between the development, the engineering and the purchasing departments in plants 2 and 3 facilitated the reduction of the supplier base via product design initiatives (e.g., the

use of the same components/suppliers across products). For example, one of the early stages of Plant 3's new product introduction process is a procurement review held between the development, engineering and purchasing parties in which the plant tries to use materials which match the profile of its suppliers. There is also a list of preferred parts for use by the development party. In plants 4 and 5, the fact that the design process is not all conducted internally reduces the co-operation between the development side (an external party) and the engineering and purchasing sides (internal plant departments). Also, there was evidence of benefits in plants 1, 2 and 3 resulting from the existence of stable designs and stable design for manufacturibility guidelines which enabled the suppliers to gradually become familiar with them and improve their contribution to the manufacturibility of the products. In plants 4 and 5, the reduced influence over the manufacturibility of designs resulted in products not consistently adhering to stable design for manufacturibility guidelines.

Despite the disadvantages experienced by the Niche Differentiator plants in using supplier involvement practices, Table 8-11 suggests that the strategies used to cope with the obstacles are sufficient to make the balance benefits-costs attractive enough for a high level of use of the practices. In addition, all the plants reported the practices as being beneficial, including the Niche Differentiator plants 4 and 5 which experienced some obstacles to their use. For example, Plant 5 claimed that supplier involvement practices brought the following benefits specific to its strategic context:

- improved on-time delivery, crucial because materials have to fit the tight production slots inherent to small batch production.

- the reduction in the supplier base was seen as a way to increase the volumes offered to suppliers and thus receive better service.

- the single sourcing of bare boards reduced tooling costs in the context of small volume production and a high rate of new product introduction. For each new bare board that is introduced the respective suppliers must acquire new tooling. By using a single supplier, duplication of tooling costs is avoided and these costs can be spread over a larger number of units.

As another example, Plant 3 justified the use of a single sourcing policy by the need to reduce the process variability caused by ordering the same part from several suppliers. As a final example, Plant 2 claimed good supplier relationships as having led to a large reduction in inventory levels, material shortages, supply lead times, and material costs. All this suggests that supplier practices were not Panacea practices.

In conclusion, supplier involvement practices seem to be independent of strategic context.

Table 8-11. Summary of difficulties experienced in the use of supplier involvement practices across plants and respective coping/mitigating strategies.

Plants	Reported difficulties and causes	Coping mitigating strategies used
	ND plants	
4, 5	Less control over the supplier selection process due to customers wanting to specify the suppliers to be used for their orders.	- Explicitly offering a standard range of components to customers provided by the plant's own suppliers, at lower prices due to increased purchasing power and improved product manufacturibility. This is done in the context of the development of stronger customer partnerships and keeping the customers well informed about the choices made in component selection. (Plant 5) - Two strategies to increase the plant's purchasing power: 1) Consolidation of purchasing activities across the several plants in the plant's group; 2) Identification of common parts across all customer orders to increase volumes by placing a single purchasing order for the same parts. (Plant 5) - Getting involved with customers right at the new product development stage and influencing the choice of suppliers. As relationships with customers develop and the plant gets involved earlier, customers are more willing to use the plant's suppliers and come to see supplier selection as part of the service offered by the plant. (Plant 4) - When absolutely having to work with a supplier recommended by a customer, conducting an audit to the supplier to address as many problem areas as possible before the order is placed to avoid discovering problems too late in the process. The objective is to reduce customer involvement and take more control of the relationship with the supplier. (Plant 4)
	BD plant	
3	None.	
	CL plants	
1, 2	None.	

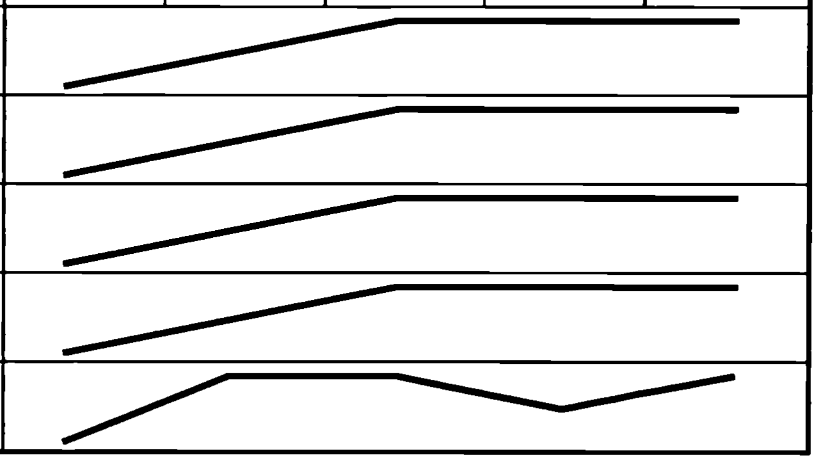
8.6 CUSTOMER FOCUS PRACTICES

8.6.1 Testing for association between overall strategic context and the pattern of use of practices

Following the methodology outlined in section 8.1.1, the analysis makes use of the observed patterns of use of practices across plants. Table 8-12 summarises the degree of use of the several customer focus practices across plants resulting from the data reduction stage: customer relationships (CRELATS), customer involvement in new product design/introduction (CDESIGN), collection of information on latent customer needs (LATENT), collection of information on existing customer needs (EXIST), and dissemination of customer information within the organisation and responsiveness to that information (DISSEM). The plants are ordered according to their relative positions along the strategic context spectrum, as given by the context scores in Table 7.2.

Table 8-12. Degree of use of customer focus practices across plants.

Practice		Plants				
		1 CL	2 CL	3 BD	4 ND	5 ND
CRELATS	H M L					
CDESIGN	H M L					
LATENT	H M L					
EXIST	H M L					
DISSEM	H M L					



The visual pattern in Table 8-12 strongly suggests that customer focus practices are dependent on strategic context. To further investigate this, and in accordance with the general methodology described in section 8.1.1, I computed the Spearman rank correlation coefficients between the context variable (CTX) categorising the relative position of plants across the strategic spectrum and the degree of use of each practice across the plants. Table 8-13 shows the results of the correlation analysis.

Table 8-13. Spearman's rank correlation coefficients between ranks of strategic context (CTX) and degree of use of individual customer focus practices.

	CRELATS	CDESIGN	LATENT	EXIST	DISSEM
CTX	**0.89*** (0 04)	**0.89*** (0 04)	**0.89*** (0 04)	**0.89*** (0 04)	0.45 (0 45)

- Numbers in brackets indicate the significance level of the correlation (2-tailed tests).
- * Indicates that the correlation is significant at the 0.05 level (2-tailed tests).

As can be seen in Table 8-13, context (CTX) is significantly and strongly correlated with the degree of use of all practices, except for DISSEM. In addition, the strength (size effects) of the significant correlation coefficients is high (0.89). This suggests that changes in overall strategic context significantly explain a large part of the variability in the degree of use of individual practices. Therefore, the results of the analysis provide strong support for the pattern of use of customer focus practices being contingent on overall strategic context.

8.6.2 Explaining the pattern of use of practices

Following the methodology described in section 8.1.2, causal networks and associated analytic texts were developed for the five plants. These are shown in Appendix B-44. The cases are ordered so as to expose cross-case patterns in the use of practices. As the individual causal networks were constructed, it became clear that the pattern of use of customer focus practices was best explained by the influence of two main contextual factors. These factors and their association with strategic context are:

- degree of product customisation: this variable is part of the adopted definition of strategic context (refer to Chapter 5) and focuses on the implications for manufacturing of product characteristics being determined or influenced by the customers. This variable was found to be perfectly correlated with overall strategic context configuration, exhibiting a High rating for the Niche Differentiator plants, a Medium rating for the Broad Differentiator plant, and a Low rating for the Cost Leader plants (see Table 7.2).

- scope for service differentiation: service differentiation may be accomplished by customisation supported by the manufacturing function, but also by other features supported by non-manufacturing related aspects (e.g., architecture of the system provided, after sales support, etc.). This context characteristic results from a plant's adopted competitive strategy. Although the variable "competitive strategy" is part of the adopted definition of strategic context, "scope for service differentiation" was not originally included as a separate variable in that definition. Based on the plants' context data (refer to Appendices B-7 to B-11), and applying the data reduction rule R1.2 (refer to section 7.1.2), I attributed a High rating for this variable for both the Niche Differentiator and the Broad Differentiator plants (provision of a manufacturing service to a customer supplied design), a Medium rating for Cost Leader plant 2 (provision of a physical product and associated architecture and service) and a Low rating for Cost Leader plant 1 (provision of a physical commodity product). The separation of plants 1 and 2 results from differences in contextual market variables between the two plants. These differences had already been identified in Chapter 7 when the plants were categorised into the strategic configuration they resembled the most. The reader is referred to section 7.3.3 for a discussion of these differences.

The "scope for service differentiation" variable is thus strongly, although not perfectly, correlated with overall strategic context configuration.

In addition, it was found that the directions of the effects of these two factors were similar in the two Niche Differentiator and the Broad Differentiator plants among them, and in clear opposition to the directions in the Cost Leader plant 1. The Cost Leader Plant 2 differed significantly from Plant 1 in this respect and exhibited a transition pattern between the two polar groups. This resulted in the grouping of plants in the following three configurations of "service offer":

1. Configuration 1 (manufacturing service): the two Niche Differentiator plants 4 and 5, and the Broad Differentiator plant 3, exhibiting a high scope for service differentiation and a medium/high degree of product customisation;

2. Configuration 2 (physical product and associated architecture/service): the Cost Leader plant 2, exhibiting a medium scope for service differentiation and a low degree of product customisation; and
3. Configuration 3 (commodity product): the Cost Leader plant 1, exhibiting a low scope for service differentiation and a low degree of product customisation.

Based on the five individual causal networks, I then built two general cross-case networks for the two polar groups of plants. The two networks are shown in Figure 8-4 and Figure 8-5. The research variables are shown in boxes or circles and the relationships among them are shown by arrows. I next describe the meaning of the connections among variables in the two networks.

8.6.2.1 Customer focus for Configuration 1 (manufacturing service)
(medium/high degree of product customisation and high scope for service differentiation) (Figure 8-4)

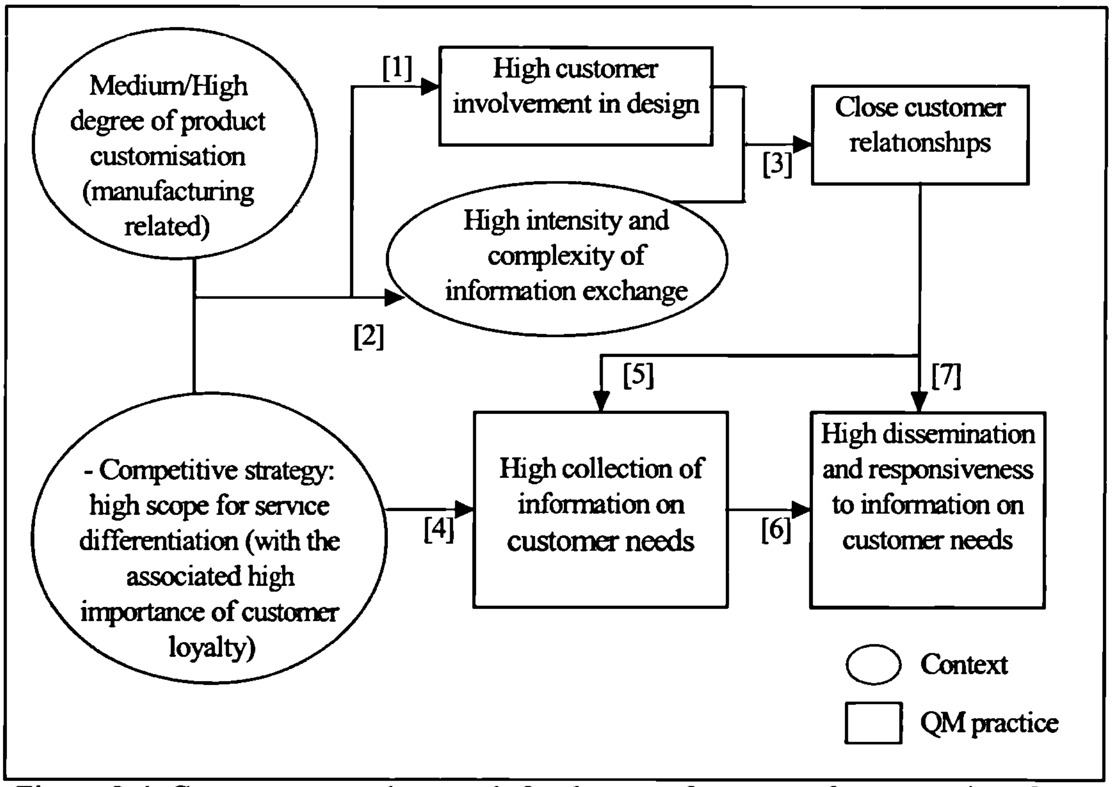


Figure 8-4. Cross-case causal network for the use of customer focus practices for the configuration "medium/high degree of product customisation and high scope for service differentiation".

A medium/high degree of product customisation (namely the production to a customer supplied design) and a high scope for service differentiation (namely the provision of a manufacturing service) dictate a strong customer involvement in product design in order to clarify designs and discuss manufacturibility and other manufacturing related issues (e.g., testing strategies) (Relationship 1). This also requires intensive and complex exchange of information with customers to determine all the parameters of the product and service offer (Relationship 2). The high involvement in design and the need for intensive and complex information exchange demand close customer relationships (Relationship 3). For example, several of the plant's activities may be organised around customers, and there may be frequent and systematic contacts with customers via a rich medium (e.g., personal contacts, video conference links).

The high scope for service differentiation, inherent to the plant's adopted competitive strategy, means that the benefits from collecting information on customer needs are high (Relationship 4). These are compounded by the importance of customer loyalty and repeat business for profitability under the chosen competitive strategy, given that good knowledge of existing and latent customer needs is a pre-requisite for retaining customers. Collecting information on customer needs is in turn facilitated by the plant's close relationships with customers (Relationship 5). The good availability of information on customer needs (Relationship 6) and the fact that several of the plant's activities are organised around customers and their needs (Relationship 7) require strong mechanisms for disseminating and responding to this information. These include strong links to the manufacturing function which is heavily influenced by customers.

8.6.2.2 Customer focus for Configuration 3 (commodity product)

(low degree of product customisation and low scope for service differentiation) (Figure 8-5)

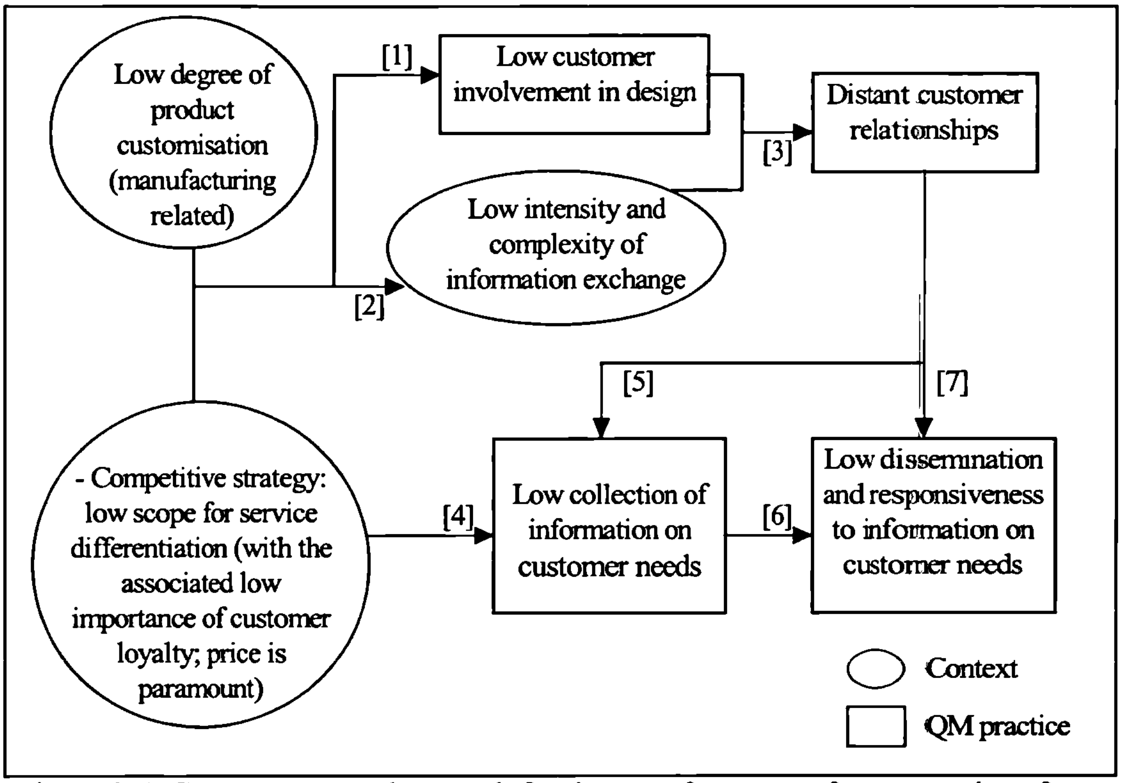


Figure 8-5. Cross-case causal network for the use of customer focus practices for the configuration "low degree of product customisation and low scope for service differentiation".

The low degree of customisation and the low scope for service differentiation do not demand a strong customer involvement in product design (Relationship 1). The low scope for service differentiation and the associated paramount importance of price mean that price is the main parameter defining the service offer. This and the low degree of product customisation lead to a low intensity and low complexity exchange of information with customers (Relationship 2). This exchange may be limited to demonstrating product conformance quality. The low involvement of customers in design and the low level of information exchange do not demand close customer relationships (Relationship 3).

The low scope for service differentiation reduces the benefits of efforts in collecting information on customer needs, which are stable (Relationship 4). This collection of information is also made difficult by the plant's distant relationships with customers (Relationship 5). Finally, with less information on customer needs available (Relationship 6), and the plant's activities being mostly isolated from the direct influence of customers (Relationship 7) there is less need for mechanisms to disseminate and respond to this information.

8.6.3 Further assessment of whether the pattern of use of practices is the result of efficiency concerns

In accordance with the methodology outlined in section 8.1.3, I use rich case data to further assess whether the pattern of use of customer focus practices is the result of efficiency concerns. In this process, I triangulate data on the difficulties experienced by plants in using practices with data on the degree of use of practices and management's perceptions of the effectiveness of individual practices.

As can be seen in Appendices B-37 to B-41, no difficulties were reported across plants in the use of customer focus practices. The low level of use of practices - all customer focus practices in Plant 1 - resulted from identifiable efficiency justifications for the reduced need of those practices (see causal network for Plant 1 included in Appendix B-44). Here, the benefits from the practices do not seem to be sufficient to outweigh the costs. Thus, there is no evidence of Worn Out practices. For practices which had a medium or high level of use, no non-efficiency pressures for use were identified and management perceived the use made of the practices as effective (see causal networks for plants 2 to 5, included in Appendix B-44). Here, the benefits from the practices seem to outweigh the costs. Thus, there is no evidence of Panacea practices.

In conclusion, the use of customer focus practices across plants seems to result from efficiency concerns.

8.6.4 Discussion

The statistical analysis suggested that customer focus practices are contingent on overall strategic context. The causal network analyses reinforced this conclusion. For every plant, they uncovered mechanisms by which the detailed characteristics of the respective strategic context determined the observed

pattern of use of practices. More than the strategic context characteristics overall, two key characteristics were found to have a determinant influence: the degree of product customisation and the scope for service differentiation. These characteristics are strongly but not perfectly correlated with the overall strategic context configurations, leading to the grouping of plants into three service offer configurations which do not exactly match the three strategic configurations: Configuration 1 (manufacturing service), comprising the Niche Differentiator and Broad Differentiator plants, 3, 4 and 5; Configuration 2 (physical product and associated architecture/service), comprising the Cost Leader Plant 2; and Configuration 3 (commodity product), comprising the Cost Leader Plant 1. The mechanisms by which these two characteristics exerted their influence found replication across similar contexts (i.e., their application to contexts which were similar in respect to these two characteristics explained the similarity observed in the patterns of use of practices - literal replication). This replication was only moderate because it only occurred for Configuration 1, comprising plants 3, 4 and 5. Configurations 2 and 3 comprised only one plant each. The mechanisms found strong theoretical replication given that their application to different contexts explained the differences observed in the patterns of use of practices.
Alternative explanations for the observed pattern of use of practices were tried but later discarded, for not being supported by the data. For example, an alternative set of explanatory factors could be the nature of the transaction between the plants and customers (business to business - plants 1, 3, 4, and 5; or business to consumers - plant 2), and the number of customers (Plant 1: 14 customers; Plant 2: over 200; Plant 3: 12; Plant 4: 12; Plant 5: 147). In fact, one might expect that business to business transactions and a smaller number of customers would facilitate the use of customer focus practices. However, while the business to business nature of the transactions could explain the high use of practices in plants 3, 4 and 5, it would not explain the pattern of use in Plant 1. Although Plant 1 is engaged in business to business transactions with a small number of customers, it nevertheless displays a low use of practices. This is, however, consistent with its low degree of customisation and low scope for service differentiation. Also, the

large number of customers of Plant 5, the second highest behind Plant 2, did not prevent it from having a high degree of use of practices.

The causal network analyses also identified several interaction effects between customer focus practices. These included:

- the varying need for strong relationships with customers (CRELATS) depending on the degree to which they are involved in design/new product introduction (CDESIGN) (Relationship 3 in Figure 8-4 and Figure 8-5).
- the facilitating effect of strong customer relationships (CRELATS) on the collection of information on customer needs (LATENT, EXIST) and on the dissemination and responsiveness to that information (DISSEM) (Relationships 5 and 7 in Figure 8-4 and Figure 8-5).
- the association between the level of collection of information on customer needs (LATENT, EXIST) and the level to which it is disseminated and reacted to in the plant (DISSEM) (Relationship 6 in Figure 8-4 and Figure 8-5).

The third interaction effect may explain why the use of practice DISSEM was found not to be statistically associated with overall strategic context (Table 8-13): the use of DISSEM seems to be heavily determined by the extent of collection of information on customer needs, rather than directly by strategic context. In fact, we can see in Table 8-12 that whenever there is substantial information collected on customer needs (High or Medium use of LATENT and EXIST in plants 2, 3, 4, 5), there are adequate mechanisms to disseminate and react to that information (High or Medium use of DISSEM in plants 2, 3, 4, 5), but not so when there is a low level of collection of customer information (Low use of LATENT, EXIST and DISSEM in Plant 1).

The uncovered interaction effects between practices suggest the existence of an internally coherent customer focus practice configuration matching a plant's strategic configuration.

Finally, the third piece of analysis suggested that the mechanisms linking strategic context to the use of practices operated via an efficiency (cost-benefit) logic. It also revealed that a plant's strategic context does not seem to pose difficulties to the use of customer focus practices. Instead, the reduced use of these practices in some contexts seems to result from the reduced need for them, from a cost-benefit perspective.

8.7 SUMMARY OF THE RESULTS

Table 8-14 summarises the results of the data analysis.

Table 8-14. Summary of the results of the data analysis.

Practice	**Observed general pattern**	**Practice status (in relation to strategic context)**	**Extent of replication of identified contingency mechanisms**
	CL ND		
Process QM			
Formalised New Product Introduction Process (NPI)		Contingent (via context variables Rate of New Product Introduction, Internal Item Variety, and Degree of Product Customisation)	Strong theoretical and literal replication.
Zero Defects (ZD)			
Changeover Inspection (CI)			
Real Time Feedback (RTF)			
In-Process Off-Line Feedback (IOF)			
Overall-Process Off-Line Feedback (OOF)			
Cross-Funct. Design Efforts		Universal	Strong literal replication.
Workforce Management			
Employee Empowerment		Weakly contingent (strategic context has weak influence via Complexity of Work Tasks)	Strong theoretical replication, moderate literal replication.
Employee Involvement			
Supplier Involvement		Universal	Strong literal replication.
Customer Focus		Contingent (via Degree of Product Customisation and Scope for Service Differentiation)	Strong theoretical replication, moderate literal replication.

8.8 CHAPTER SUMMARY

The present chapter used the results of the data reduction stages of Chapter 7 as well as other rich case data to address the two components of the research question: i) Are quality management practices contingent on a plant's strategic context? (testing); and ii) If so, what are the mechanisms by which strategic context affects those practices? (explaining).

To answer the first part of the research question, I used correlation analysis to test for association between a plant's overall strategic context and the pattern of use of practices. To address the second part of the research question I adopted a theory building mode to identify the detailed mechanisms leading to the observed pattern of use of practices, thereby producing explanations for the empirical observations. Causal network analysis was used to uncover these mechanisms.

A third and final piece of analysis further verified the validity of the conclusion - arrived at in Chapter 7 when reducing the data on research controls - that the pattern of use of practices was determined by efficiency (cost-benefit) concerns. This analysis validated the mechanisms identified in the second piece of analysis, by confirming that they determined the observed pattern of use of practices via the application of a cost-benefit (efficiency) logic.

The analyses indicated that:

- process quality management practices (NPI, ZD, CI, RTF, IOF, OOF) are strongly contingent on strategic context, via the context variables rate of new product introduction, internal item variety and degree of product customisation. This finding received strong theoretical and literal replication.

- workforce management practices are weakly contingent on strategic context. Strategic context plays only a minor role in determining the use of workforce management practices, which depend heavily on the following non-strategic factors: flatness of organisational structure, degree of complexity of work tasks, level of skill and quality mindset of the workforce, and the characteristics of the local pool of labour. This finding received strong theoretical replication, but only moderate literal replication.

- customer focus practices are strongly contingent on strategic context, via context variables degree of product customisation and scope for service differentiation. This finding received strong theoretical replication, but only moderate literal replication.
- cross-functional design efforts and supplier involvement practices are independent from strategic context. These findings received strong literal replication.

9. CONCLUSIONS

This study set out to empirically investigate whether Quality Management (QM) practices are contingent on a plant's manufacturing strategy context (testing); and if so, to explain how a plant's strategic context affects these practices (explaining). The investigation was based on the examination of the use of QM practices across a spread of strategic contexts. This was done by conducting case-studies in the UK electronics industry representing a spread of strategic contexts. In Chapter 7, the resulting qualitative case data was the object of a preliminary analysis in preparation for deeper stages of analysis. In Chapter 8, I specifically analysed the data to address the two components of the research question. In this process, I have discussed the empirical findings related to the different sets of QM practices. This final chapter draws on those findings to present the contribution of the study at several levels: contributions to the Operations/ Quality Management field, managerial implications and methodological contributions. The chapter closes by indicating the study's limitations and suggestions for future research.

9.1 CONTRIBUTIONS TO THE OPERATIONS /QUALITY MANAGEMENT FIELD

9.1.1 Broad contributions to the Operations/Quality Management field

This section outlines the broad implications of the study to the Operations/Quality Management field. Because they strongly inform practice, more detailed contributions to this field are presented in section 9.2 as part of the discussion of the study's managerial implications.

The main contribution of the study is an increased understanding of the influence of strategic context on QM practice. The findings indicate that while some practices are contingent on strategic context, others approach universal status (cross-functional design efforts, supplier involvement). Among the contingent practices, some are strongly influenced by strategic context (process management and customer focus practices), while others suffer only a weak influence and are affected mainly by non strategic contextual factors (workforce management practices). The study strongly suggests that, overall, QM practices are contingent on a plant's strategic context, and identifies mechanisms by which this takes place.

The study also increased our understanding of how the cost-benefit mechanisms linking strategic context to the use of QM practices that were identified produce their effects. The study revealed that there are specific difficulties in the use of several QM practices associated with particular strategic contexts. While some of the difficulties may be overcome by the adoption of adequate coping strategies enabling a high level of use of the associated practices (e.g., the difficulties posed by the Niche Differentiator context to the use of practice Real Time Feedback (RTF)), others cannot be overcome, preventing a high level of use of the practices in question (e.g., in a Niche Differentiator context the reduced integration with the design party prevented the high use of new product introduction (NPI) practices, regardless of the attempts to mitigate the associated difficulties). In addition, the study found that while the low use of some practices in a particular strategic context results from the obstacles posed by that context (e.g., practice NPI in a Niche Differentiator context), the low use of other practices results from their reduced need in the context in question (e.g., Customer Focus practices in a Cost Leader context). Therefore, the mechanisms linking strategic context to the use of QM practices seem to operate via the interplay between the need for a given practice in a particular context, the difficulties posed by that context to the use of the practice in question, and the effects of coping/mitigating strategies that may be adopted to deal with those difficulties.

At a more general level, the study lends support to the existence of links between a plant's manufacturing strategy and the pattern of use of best practices. This finding is in agreement with the contingency view of the strategic choice paradigm and in contrast with the universalistic approach of the best practice paradigm. This suggests that the concept of best practice should be replaced by the concept of "best in class practice" indicating the need to link best practice to context.

The study also highlights the importance of the interactions between individual QM practices, forming an internally coherent QM practice configuration matching a plant's strategic configuration. The results indicate that interactions between practices do seem to play an important role in determining the overall pattern of use of practices (e.g., the substitution effects among the different process feedback practices). In addition to these direct interactions between practices, the influence of strategic context also seems to impose genuine trade-offs on the use of several practices. For example, while a high degree of customisation is conducive to the use of Customer Focus practices, it creates obstacles to the use of Formalised New Product Introduction (NPI) practices.

Finally, from a scientific perspective, the study extends and refines existing theory on QM, by informing the development of a more sophisticated descriptive contingency theory. This more complete theory should closely stipulate the contexts in which the use of the several QM practices is expected to produce benefits.

9.1.2 Contributions to specific Quality Management research

The study offers contributions to several research streams in the QM field: the implementation of QM practices, QM practice-performance relationships, links of QM with management theory, and QM practice contingencies (these research streams were reviewed in Chapter 2).

At the implementation level, the findings indicate that there are specific difficulties in the use of several QM practices which are associated with particular strategic contexts. These difficulties must be clearly differentiated from those eventually arising from the *process* of implementation of QM practices, because they may demand different courses of action. In particular, strategic context difficulties may be seen as requiring "structural fixes" (what to do) along one or several of the following avenues: the mix of QM practices to adopt, the modification of adverse strategic context characteristics, and the adoption of adequate coping/mitigating strategies to deal with the difficulties posed by the strategic context. These measures are clearly different from measures attempting to facilitate the implementation process (how to do it), such as the sequencing of the adoption of practices (e.g., Reger et al., 1994). This distinction helps to structure the current chaotic wealth of QM implementation advice and may lead the way to developing clearer guidelines for the implementation of QM practices in different contexts.

At the practice-performance level, the findings lend support for the suggestion by some authors (Powell, 1995; Dow et al., 1999) that the weakness of links between the use of some QM practices and firm performance observed in some studies is caused by them being context dependent (refer to section 2.2.2). In fact, the present study found that strategic context leads to the low use of some practices. The results also suggest that strategic context and the interaction between individual practices should be taken into consideration in developing models linking the use of QM practices to performance. This would increase the explanatory power of the existing practice-performance models which typically examine universal associations between QM and performance.

At the management theory level, the uncovering of contingencies affecting QM practice suggests that the field might benefit from some insights from the general contingency approach of management theory. Future research should examine the compatibility of the contingency effects found in this study with management theory's existing prescriptions.

Finally, at the level of QM practice contingencies, the study increases our understanding of the influence of a major facet of the organisational context on quality management and enlarges the existing sparse body of knowledge in this area.

9.2 MANAGERIAL IMPLICATIONS

The study's results can be used to inform the implementation of QM programs at different levels. Firstly, findings suggest that there is the need to adapt the level of use of several practices to a plant's strategic context: process management practices, workforce management practices and customer focus practices. The results presented in Chapter 8 provide guidelines for this adaptation.

Secondly, the study uncovered several interaction effects between individual QM practices that need to be taken into account by plants in selecting the mix of practices to have in place. These effects are:

- the substitution effect between the two off-line process feedback practices: In-Process Off-Line Feedback (IOF) and Overall-Process Off-Line Feedback (OOF). For example, if a plant increases the use of practice OOF it will be able to reduce the use of practice IOF.
- the effect of the use of new product introduction (NPI) practices on the use of most of the downstream process management practices via the impact it has on how well processes are understood. For example, an increase in the use of practice NPI is expected to allow for a reduction in the use of practices Changeover Inspection (CI), Real Time Feedback (RTF) and In-Process Off-Line Feedback (IOF) due to increased process knowledge.
- the varying need for strong relationships with customers depending on the degree to which they are involved in new product design/introduction. For example, a high customer involvement in new product design/introduction requires close customer relationships.
- the facilitating effect of strong customer relationships on the collection of information on customer needs and on the dissemination and responsiveness to that information.
- the association between the level of collection of information on customer needs and the level to which it is disseminated and reacted to in the plant.

Thirdly, the study reveals that there are specific difficulties in the use of several QM practices which are associated with particular strategic contexts. The highest number of difficulties is associated with the Niche Differentiator strategic context, and refers to the use of process QM practices, supplier involvement and workforce management practices. These difficulties are caused mainly by the complexity of the processes and the high degree of customisation.

Besides the adaptation of the level of use of different practices, the study uncovered several strategies that might be used to cope with or mitigate the difficulties posed by the Niche Differentiator's strategic context. Concerning process QM practices, these include the use of intensive information processing, the reduction of the high variety of problems to generic categories of process related problems, the identification of the most important problems to prioritise improvement efforts, the dynamic adaptation of quality control procedures to match different levels of product complexity and defect rates, the adoption of specific organisational structures directed at dealing with the difficulties, and the development of long-term co-operative relationships with customers. This latter strategy basically attempts to mitigate the adverse effects of a high degree of customisation (production to a customer supplied design), attempting to move a plant closer towards a Cost Leader type context in which all the design and introduction process is conducted internally. Concerning supplier involvement practices, the use of several strategies seemed to overcome the obstacles posed by Niche Differentiator contexts: closer integration with customers; the increase of purchasing power by reducing the supplier base, identifying common parts across products and industry level arrangements (e.g., consolidation of purchasing activities); and pre-collaboration supplier audits. Lastly, concerning workforce management practices, the simplification of work tasks may offer some (limited) benefits. However, more than this strategic factor, it was found that the use of workforce management practices required a flat organisational structure, a local pool of labour with favourable characteristics, and workforce with high levels of skill and a quality mindset. It was also found that while a plant may increase the use of involvement practices by creating adequate internal conditions (e.g., via training activities to increase the level of skill of the workforce), this is more difficult to accomplish with empowerment practices because their use depends not only on internal conditions, but also on externally determined conditions (namely, the characteristics of the pool of labour).

Finally, the study identified several critical strategic context characteristics which seem to strongly affect QM practices: degree of product customisation, scope for service differentiation, rate of new product introduction, internal item variety and the complexity of work tasks. Although these characteristics are inherent to a plant's strategic context - thus being difficult to change in the short term - they do provide an extra degree of freedom offering limited opportunities for plants to try to match QM practice to their strategic context. The causal networks presented in Chapter 8 provide guidelines for ways in which these characteristics could be modified to facilitate the use of specific QM practices.

These findings will hopefully contribute to increase the success rates in the implementation of QM programs.

9.3 METHODOLOGICAL CONTRIBUTIONS

This study has developed a framework for conducting contingency research into QM practice that can be readily adapted to the examination of contingencies affecting other Operations Management maturing best practices (Chapter 4). This is important in a research area such as the one of QM practice contingencies, where empirical research has been sparse and mostly descriptive, and where there is a lack of methodologies to move beyond description to inference.

The study also suggests that strategic context and the interaction between individual practices are factors that should be taken into consideration in designing empirical research in QM, for example, by including them as control or moderating variables (e.g., in models linking the use of QM practices to performance). In addition, the study found that both process level and plant level contextual characteristics affect QM practices. This suggests that empirical studies in QM should find ways of reconciling these two distinct units of measurement, similarly to what was done in the present study.

9.4 LIMITATIONS AND SUGGESTIONS FOR FUTURE RESEARCH

Besides the suggestions for general further research in the QM field that were put forward in Chapter 2, the study's empirical component raises its own issues for future research. These are inevitably intertwined with the study's limitations and contributions.

Starting with the scope of applicability, I believe the study's findings can be the object of reasonable generalisation to manufacturing plants in discrete goods industries. The replication logic that was used permits analytical generalisation, i.e., the generalisation of a particular set of results to some broader theory (Yin, 1994). Although the single industry design undoubtedly reduces generalisability, one is still able to make theoretical - as opposed to statistical - inferences about other industries based on this single industry study. In fact, one would expect to observe the same positioning of plants along the strategic context spectrum in most discrete good industries (e.g., Hayes and Wheelwright, 1979a) and one would also expect that the strategic forces shaping QM practice identified under carefully controlled conditions in the electronics industry would also be in play in other industries (although its effects might be felt alongside other industry specific variables). In the present study, the effects of these strategic forces, although empirically grounded, had their abstraction level raised to the general characteristics of strategic configurations, beyond the immediate cases. The particular set of findings related to process QM practices had their generalisability further enhanced by receiving support from existing theory in the Operations Management field. Nevertheless, further single industry studies should be conducted to ascertain whether the findings replicate in other discrete goods industries. Further testing of the scope of applicability of the study's findings could also include conducting similar studies in continuous processing industries and the service sector.

The overall configurations of QM practice put forward by this study should be further tested using different methodologies. This could include the conduction of large scale cross-sectional studies to examine whether a plant's adherence to the QM practice configuration proposed to match its strategic context increases performance.

The identified influence of strategic context on workforce management practices via the degree of complexity of work tasks received only moderate literal replication in the present study. This was due to the fact that the research sample did not encompass a plant exhibiting complex work tasks and a workforce with high skill and quality mindset levels (refer to section 8.4.4). Further research should conduct observations in such a plant to ascertain whether this result can be fully replicated. Similarly, the mechanisms by which degree of product customisation and scope of service offer were found to influence customer focus practices received only moderate literal replication. This was due to the research sample encompassing only one plant representing each of the following two combinations: "medium scope for service differentiation/ low degree of product customisation" and "low scope for service differentiation/ low degree of product customisation" (refer to section 8.6.4). Further research should conduct observations in more plants representing these two combinations.

Several additional future research leads are prompted by the study's findings, rather than its limitations. As a by-product of addressing its specific research question, the study uncovered several coping/mitigating strategies that plants had in place to address the difficulties faced in the use of QM practices. This is an area which has not been explored enough in the QM field and which could further assist the implementation of QM programs. Further exploratory work should be conducted towards the direct identification and devising of coping/mitigating strategies to deal with the difficulties posed by a plant's strategic context.

The study also uncovered several interaction effects between QM practices. This had already been identified in the review of the literature as an area requiring more research. The study's findings, revealing important interaction effects, reinforce this need. The study did not address potential interactions between QM practices and other Operations Management best practices. Although this should not be very restrictive, given the breadth of best practices that were examined under the QM banner, further research should also address these potential links. The study's findings regarding process QM practices received support from the Operations Management literature. It would also be interesting to examine the compatibility of these and the other findings of the study with theory in other related fields.

Finally, the uncovering of strong strategic context effects on QM best practice begs the extension of contingency research into other sets of maturing Operations Management best practices. Chapter 4 provides a research framework which could be readily extended to underpin such research. The set of practices under the Lean Production theme (some of which overlap with QM practices) would be a natural candidate.

These are likely to be promising avenues for taking research into the links between strategic context and best practice both in the QM and the broader OM field forward into the next millennium. This study will hopefully contribute to affirm QM as a major best practice tool set that should be in place, taking into account its identified contingencies, in most, if not all, organisations.

9.5 CHAPTER SUMMARY

The main contribution of the study is an increased understanding of the influence of strategic context on QM practice. The findings indicate that while some practices are contingent on strategic context, others approach universal status (cross-functional design efforts, supplier involvement). Among the contingent practices, some are strongly influenced by strategic context (process management and customer focus practices), while others suffer only a weak influence and are affected mainly by non strategic contextual factors (workforce management practices).

The study also highlights the importance of the interactions between individual QM practices, forming an internally coherent QM practice configuration matching a plant's strategic configuration.

The study also offers contributions to several QM research streams: the implementation of QM practices, QM practice-performance relationships, links of QM with management theory, and QM practice contingencies.

At a managerial level, the study's results can be used to inform the implementation of QM programs at different levels: how to adapt the level of use of different practices to a plant's strategic context; which strategies to use to cope with or mitigate the difficulties posed by strategic context on the use of QM practices; and which critical strategic context characteristics might be modified to facilitate the use of QM practices.

The study has also made methodological contributions by having developed a framework for conducting contingency research into QM practice and by having highlighted the need to control for strategic context in empirical research in QM practice.

The study's findings are considered to be generalisable to manufacturing plants in discrete goods industries. Future research should further test the scope of validity of the study's findings.

APPENDICES

APPENDIX 1.

Definition of Quality Management Practices.

1. <u>*Product Design/Introduction*</u>. Comprises two groups of practices:
   1.1 Cross-Functional Design Efforts. Refers to co-operation and input into the design process across functional boundaries *within the plant.*
   1.2 Formalised New Product Introduction Process (NPI). Refers to the degree of formality and comprehensiveness in the introduction of a new product into production. Includes:
   - thorough reviews of product designs before the product is produced and sold, prototyping, and special tools and techniques such as Taguchi design methods, Quality Function Deployment, and Failure Mode and Effects Analysis.
   - design for manufacturibility (e.g., design simplification and minimisation of part count; adaptation of design characteristics to the plant's processes)
   - increasing the understanding of the "science" of the processes with the a priori fool-proofing of processes, independently of products.

2. <u>*Real Time Feedback*</u> *(RTF).* The existence of formal windows of observation on the state of control of the process (e.g., reading process variables, inspecting products for defects). Either by collecting and recording data and subsequently comparing it with an "in-control standard" (e.g., SPC charts, defect levels at which the process is considered out of control), or by informal observation of trends (with no actual recording of data), provides real time feedback on the state of control of the process.

3. <u>*Off-Line Feedback*</u> *(OF).* The extent to which quality data from product inspections, testing, customer complaints, etc., is analysed off-line (e.g., weekly or monthly). It considers the availability, easy access and friendly presentation of different analyses of data.

4. <u>*Zero Defects*</u> *(ZD).* The use of mistake-proofing, autonomation, source inspection and successive and self-checking mechanisms. These are a priori mechanisms to prevent errors from being made.
   The *mistake-proofing* philosophy considers that all human beings have lapses in attention. The system, not the operator, is at fault when defects occur. Mistake-proofing methods attempt to build the function of a checklist into an operation so that the operator cannot perform it wrongly. *Autonomation* involves the use of "intelligent machines" that stop automatically when processing is completed or when an abnormality occurs. The machines are equipped with automatic stopping devices, baka-ioke (idiot-proof) devices, fixed position stopping or some other feature to eliminate the possibility of large amount of defects being produced. With *successive checking,* subsequent processes are designed so that they physically cannot operate on defective parts produced by preceding processes. *Self checking* uses the same principles of

successive checking, but requires that the worker performing the operation check his or her own output, to which poka-yoke devices are often critical.

5. *Workforce Management*. Comprises Employee Involvement and Employee Empowerment (EMP) and refers to production workers. Employee Involvement involves the use of suggestion schemes (SS), problem-solving teams (PST) (both with the participation of production workers), and recognition for quality improvement (RQ). Employee Empowerment refers to shifting the responsibility for quality decisions to production workers and providing a supporting framework, such as the necessary resources and technical support, to assist them in such decision making. The emphasis is on worker autonomy and proactiveness and on locating decisions at the lowest level of the organisation.

6. *Supplier Involvement*. The amount and type of interaction which occurs with suppliers. Includes the careful selection of quality minded suppliers, regular assessment of the supplier performance, development of close relationships with a small number of suppliers, co-operation in logistics activities (e.g., standardisation initiatives, communication links, exchange of data, inventory arrangements, frequency of deliveries, incoming inspection), and involvement of suppliers in new product design/ introduction.

7. *Customer Focus*. Involves the establishment of links between customer needs and satisfaction and internal processes. This entails:
   - Establishing strong relationships with customers, by emphasising partnership arrangements, direct customer contacts (face to face meetings, plant visits) and integration of the plant's operations with customers (logistics co-operation, single sourcing arrangements, mutual technical assistance, organisation of the plant's activities around customers) (CRELATS).
   - Customer involvement in new product design/ introduction (CDESIGN).
   - Collection of the following information via frequent and close interaction with customers:
     - Latent customer needs: forward looking information, for example, about new requirements, services or technologies needed by existing and potential customers (LATENT).
     - Existing customer needs: information on the importance placed by existing customers on several requirements (e.g., price, delivery, etc.) and the plant's performance across those (EXIST).
   - Dissemination of information collected on customer needs within the organisation and responsiveness to that information (DISSEM).

APPENDIX 2.

Overview of Plants at which Field Work was Conducted.

The overview presented here makes some references to the operations associated with the assembly of Pnnted Circuit Boards (PCBs). The reader is referred to Appendix 4 for a description of these operations.

Plant 1

The plant has 450 employees and its latest annual turnover was £25m. The plant is part of a business unit of a multinational company. It develops and manufactures electricity and gas digital meters. Meters are either standard (offering a metrology function which measures electricity currents or gas flows with no options) or modular (a standard core meter with the possibility of adding functional modules to provide extra features, such as pre-payment options, remote communication and setting, etc.). The PCB is a core component of the meters. It is responsible both for the metrology function and for the features in the interface between the user and the meter (e.g., pre-payment options, different charging rates, etc.). The customers for electricity meters are regional electricity companies whose core business is to distribute and supply electricity to consumers. Customers for gas meters include the UK gas pipeline company which owns and maintains the infrastructure delivering gas right to the consumer's meter, and a few small independent companies.

The plant is divided into four manufacturing cells: 1) the PCB assembly lines, comprising two assembly lines each performing surface mount and through-hole assembly operations in this sequence (one line is dedicated to electricity and the other to gas meters); 2) gas assembly (mechanical assembly operations, mostly manual, by which the finished PCB is assembled together with all the other gas meter parts); 3) electricity assembly (the same, for electricity meters); and 4) assembly support (comprising the fabrication of mechanical parts, including activities such as compression, injection moulding and pressing). After the PCBs are assembled, they are forwarded to the respective mechanical assembly cells for integration with all the other components of the meter.

Plant 2

The plant has 123 employees and its latest annual turnover was £11m. It is part of a group which specialises in the provision of systems to manage human resources at their place of work or in the community. The plant manufactures integrated access control systems (systems which allow one to decide who goes through which doors in a building and at what times). An access control system is made up of three physical components: door controllers, readers and proximity devices (the latter are very simple devices comprising no PCBs). When a proximity device is presented to the reader, the door controller is activated to operate the door. There is a narrow range of products under each of the component groups: 5 door controllers, 2 readers, and 2 proximity devices. In addition, the plant offers a software system which allows the administration of a network of the above hardware units to control doors and other security equipment in one or several sites.

The plant's shop floor is divided into six cells. The six cells are: 1) surface mount assembly of PCBs; 2) through-hole assembly of PCBs; 3) mechanical assembly of parts (including PCBs) into boxes making up the final controllers; 4) mechanical assembly of readers (including the constituent PCBs); 5) manufacture of proximity devices; 6) final product customisation. All cells work on a customer-supplier basis. The surface mount, through-hole and customisation cells are service cells, and they offer services to the other cells which are "product" cells (these process particular product lines: controllers, readers and proximity devices). The products are sold through dealers to the end-users (these include hospitals, electricity companies, universities, police forces, financial institutions, breweries, and many more) in the UK and overseas (export markets account for 38% of turnover). The dealers provide the installation service of the products in the end-users' premises (programming the computers and laying cables). Given the nature of the products, the plant offers training and technical support for both installers and end-users.

Plant 3

The plant has 226 employees and its latest annual turnover was £60m. The plant is part of a multinational corporation which develops and produces analogue and digital document processing machines (e.g., copiers, printers, production printing, etc.). The plant assembles PCBs to conceptual design for the other corporate plants (12 customers, located both in the UK and overseas). These other plants then assemble the PCBs into electronic modules which in turn are assembled into final product units. Final product units are sold to end users via direct sales or distributors. The PCBs are supplied by the plant on a competitive, free market basis under which the other plants in the group can choose freely where to source their PCBs from (including plants external to the group). Within this arrangement, the plant competes with medium/high volume electronics subcontractor companies. Equally, the plant is free to sell PCBs outside the corporation. The plant has very recently introduced a subcontracting service (design and production of PCBs to customer supplied conceptual design) to external customers, but no orders have yet been placed.

The plant produces PCBs to a conceptual design provided by a corporate design group. The respective PCB may be intended for production in more than one plant (e.g., both in Europe and the US; that is, Plant 3 may not be the only plant producing a particular PCB design). The physical design is either performed by Plant 3's design team alone or in co-operation with a corporate design group. There are four global corporate design groups (two in the US, one in the UK and one in Japan). It is estimated that, in the case in which the physical design is developed in co-operation with a corporate design group, it can be influenced by the plant at an 80% level in the case of the UK group (due to physical proximity and the existence of global design standards which match the common processes of the several global manufacturing plants), at a 60% level in the case of the US groups (due to the global design standard), and very little in the case of the Japan group (which has only recently subscribed to the global design standard). The trend, however, is towards the whole of the physical design to be undertaken by the plant's design team. The customers have no input into the definition of test strategies, provision of testing equipment or materials. These decisions are all under the plant's responsibility.

The plant floor comprises two areas: surface mount PCB assembly and manual through-hole PCB assembly. The surface mount PCB assembly area includes 8 surface mount assembly lines catering for PCBs of different technologies. For technical reasons it is not possible to run certain products on certain lines (for example, one of the lines is 10 years old and cannot process very small components; it is used mainly for simple products like keyboards; these of course, can be routed to other lines as well). No equipment in the plant is particularly dedicated. Individual products have variable routes with each product having a preferred assembly line (chosen on the basis of its technology and production volume) and at least one alternative line. The actual line a product goes through is decided at the beginning of the day in which the respective order is due to be produced. Therefore, a particular operation for a product is not always performed in the same work post/machine, although there is a set of pre-defined alternative lines in which it can be performed. This "mix and match" of orders to equipment as management put it, had the objective of maximising equipment utilisation due to very high depreciation costs.

The manual through-hole PCB assembly area is quite large because of the high mix of PCBs. Automatic equipment is not justified. This area is organised into 4 assembly flow lines.

Plant 4

The plant has 170 employees and its latest annual turnover was £15m. The plant is an Electronics Manufacturing Services provider (PCB assembly subcontractor). The services consist in the assembly of PCBs to a physical design which may be complemented by a mechanical assembly service by which PCBs are incorporated into a final product unit (thus the plant's final product may be a PCB or a whole final product unit). Typically, the plant's direct customers may incorporate the products produced by the plant into larger pieces of equipment and/or sell them directly to end-users (the plant's customers' customers). The plant has a strong and strict focus on the investment goods market (professional-type, high-end electronics). This may encompass products for different industrial applications such as telecommunication, data, medical, life sciences and instrumentation. Even though customers may belong to different industries, because they all demand investment goods, their requirements and PCB technologies are very similar. Customers develop the conceptual design and also provide the physical PCB layout themselves (either having developed it in-house or having subcontracted it out), or subcontract this operation to the plant, who then subcontracts it out,

usually to a design company located on site. Several customers provide in addition, functional test equipment, but only a few provide electronic components. Customers also have an input into the product testing strategies as these are priced as a separate service.
The plant is organised into cells following a functional layout. There are 8 customer cells some of them catering for more than one customer (there are 11 customers in total). These cells comprise manual through-hole PCB assembly and the mechanical assembly operations. These cells share the following resources organised into service cells:
- Surface Mount Cell - comprises the surface mount PCB assembly operations.
- Automated Through-Hole operations
- Expensive electrical test equipment

Plant 5

The plant has 224 employees and its latest annual turnover was £16m. The plant is an Electronics Manufacturing Services provider (PCB assembly subcontractor). The services consist of the assembly of PCBs to a customer supplied physical design which may be complemented by a mechanical assembly service by which PCBs are incorporated into a final product unit (thus the plant's final product may be a PCB or a whole final product unit). Typically, the plant's direct customers may incorporate the products produced by the plant into larger pieces of equipment and/or sell them directly to end-users (the plant's customers' customers). The plant supplies these services to the industrial (69% of revenues), communications (13% of revenues) and instrumentation (12% of revenues) market sectors. These are characterised in the electronics industry as low to medium volume sectors, less price sensitive. There aren't major differences between these sectors in what concerns volumes, technological complexity, quality requirements, and order winners in general. The plant explicitly avoids the high volume price-sensitive sectors such as the consumer and automotive electronics, and sectors for which very high levels of conformance quality are less important (e.g., high volume, very low cost commodity products). Besides the PCB physical designs, several customers also provide several of the required electronic components and functional test equipment. Customers also have an input into the product testing strategies as these are priced as a separate service.
The plant is organised into cells following a functional layout. This arrangement was reported as having the objective of maximising capacity utilisation and the return on the capital invested. There are three customer cells and two service cells. The customer cells comprise the manual through-hole and mechanical operations, and each deals with orders for a specific set of customers (the plant has a total of 147 customers). These three customer cells share the services of the two service cells. These are the Surface Mount cell and the Automatic Through Hole cell. The surface mount cell comprises the PCB surface mount assembly equipment, whilst the through-hole cell comprises the PCB through-hole automatic assembly equipment. These two cells are called service cells because the customer cells are treated as internal customers, using their services. The service cells are seen as capital assets which need to be highly utilised.

Plant 6

The plant has 60 employees and its latest annual turnover was £3m. The plant is a PCB assembly subcontractor. It assembles PCBs to a customer supplied physical design which may be complemented by a mechanical assembly service by which PCBs are incorporated into a final product unit (thus the plant's final product may be a PCB or a whole final product unit). The plant does not focus on any particular market sector, working with a broad range of customers for both low and high technology applications, with the low technology end (unsophisticated customers) providing most of the revenue. The main competitive criteria is speed of delivery, which customers seem to be willing to trade off for price and even quality.

Over the last 12 months there have been significant changes in the organisational structure of the company, with a new Managing Director appointed and two thirds of the previous management team leaving. Sales have grown in the last few years and financial performance has been stable.

The plant is organised in a functional layout, with three main areas: surface mount assembly, through-hole assembly and test.

APPENDIX 3.

The Case Study Protocol.

0. Introduction

This protocol describes the field procedures to be followed for each case study.

1. Pre-Visit Preparation

The Production Director, Quality Director, or a person in equivalent position of the chosen plant should be sent a letter with a general description of the study and areas to be addressed, and soliciting their participation (see Annex 1 for a sample letter). A few days later they should be contacted by phone at which point it will be determined whether they join the study. For participating companies a "project champion" should be identified who will act as the main co-ordinating link between the researcher and the plant. Each participating plant will be the object of a case-study involving several visits to the manufacturing site on separate days.

Before the visits begin, archival sources should be investigated to provide background information on the company or site. These may include annual reports, press clippings, company history, databases (e.g., ABI, Financial Times Index, Bloomberg), and general information about the industry (e.g., trade magazines).

2. On-Site Data Collection

In the initial contact with the site, the researcher should seek the project champion's help to identify several persons knowledgeable about the areas addressed by the study with whom semi-structured interviews will be conducted. The researcher should also at this stage identify the Main Product Line and the Dominant Process on which some of the subsequent data collection efforts will focus. Where there are clearly defined and stable product lines, the Main Product Line is defined as the product line exhibiting the highest production volume. Where the concept of individual stable products does not apply, it is defined as the set of products representative of the most commonly supplied technology. This is the typical situation for a plant manufacturing to a customer provided design. Typically, such a plant offers capabilities across a number of set technologies (for example, PCBs for applications in the sectors of telecommunications, industrial products, instrumentation, etc.). The Main

Product Line should consist of the set of products in the most common technology category (i.e., the one corresponding to a "typical" customer order).

The Dominant Process should comprise the PCB assembly lines which are used to produce the Main Product Line.

The researcher should also brief the project champion on the questionnaire included in Annex 2. The questionnaire should be filled in by respondents chosen by the researcher with the help of the plant's project champion. It requests general plant information, as well as information specific to the main product line and the dominant production process. The names of the main product line and dominant process should be clearly written in the gaps provided in the questionnaire's instructions page. Thus, respondents will be clearly and unequivocally instructed to consistently refer to the main product line and the dominant process when filling in the respective questionnaire questions.

The researcher should collect information in four major areas:

A) The plant's business and manufacturing context.
B) The use of several quality management practices in the plant.
C) Research controls.
D) Rich information enabling the understanding of the observed use of quality management practices.

The next sections specify in detail how the data should be collected.

A. <u>Business and Manufacturing Context</u>

The following table shows the context areas to be addressed, the questions that the researcher must keep in mind and that must be answered about each area, the unit of measurement to which the questions should refer to, and the field procedures and potential sources of information for answering those questions. The questions marked with "(Q)" are also addressed directly in the questionnaire.

Context area	Unit of measurement	Questions	Field Procedures/ Sources of Information (*)
Identification of Main Product Line and Dominant Production Process	Plant	- Where there are clearly defined and stable product lines, the Main Product Line is defined as the product line exhibiting the highest production volume. Where the concept of individual stable products does not apply, it is defined as the set of products representative of the most commonly supplied technology. The Dominant Process should comprise the PCB assembly lines which are used to produce the Main Product Line.	- Interviews (PM, ME, PTM) - Documentation (product brochures) - Direct Observation (plant tour)
Business Environment	Plant	- Key characteristics of the business environment (industry, growth rate of the markets served, market share, etc.) - Major changes in customer demands and business conditions in past few years	- Interviews (PTM, MKTG) - Archival Sources (background information on the industry)
Competitive Strategy	Plant	- Markets the company competes in, types of customers (industry, size, number). - How the company competes in the market. - Market aims: - market coverage: few vs. many markets - customer focus: few vs. many customers - product focus: emphasis on physical attributes vs. emphasis on service - Number of customers served by plant (Q)	- Interviews (PTM, MKTG) - Questionnaire
Dominant Order-Winners and Qualifiers	Main Product Line	- Order-winners and qualifiers for major customers of main product line (Q).	- Questionnaire - Interviews (PTM, PM, MKTG): discuss answers given in Section B of the questionnaire.
Degree of Product Customisation	Main Product Line	- Nature of customisation (extent and predictability). - Consequences of customisation to manufacturing (Dominant Process)	- Documentation (product brochures) - Interviews (PM, MKTG) - Direct Observation (plant tour)

Context area	Unit of measurement	Questions	Field Procedures/ Sources of Information (*)
Rate of New Product Introduction	Plant	- Average life cycle of products (Q) - % of sales from products introduced in last 5 years (Q) - Proportion of business unit revenues spent on R&D (Q) - Product changes occurred in plant in the last five years. - Stability of product designs both across new product introductions and during a product's life cycle. - Consequences of the introduction of new products to manufacturing.	- Documentation (product brochures) - Interviews (QM, PM, ME, MKTG, DSG) - Questionnaire
Typology of Dominant Process	Dominant Process	- Process steps, layout, product routes, investment in assembly equipment (Q). - Yearly production volume in units (Q) - Number of production workers (Q) - Throughput: the average rate at which electronic components are placed on the bare boards (Q)	- Interviews (QM, PM, ME, WK) - Questionnaire - Direct Observation (plant tour)
Total Production Volume	Plant	- Yearly production volume of plant in units (Q) - Sales value of production (£000) (Q)	- Questionnaire
Rate of Process Change	Dominant Process	- The rate of change in the dominant process caused by the introduction of new products, product customisation, engineering and customer change orders.	- Interviews (QM, PM, ME) - Direct Observation (plant tour)
Degree of Standardisation	Dominant Process	- Level of detail of manufacturing work procedures (workmanship standards) - Existence of written operating procedures accessible to workers on the shop floor (e.g., assemblers and inspectors) - Degree of standardisation of process parameters/procedures	- Interviews (QM, PM, ME, WK) - Direct Observation (plant tour)
Internal Run Sizes	Dominant Process	- Average production batch size (Q)	- Questionnaire

Context area	Unit of measurement	Questions	Field Procedures/ Sources of Information (*)
Internal Item Variety	Dominant Process	- Consequences when an item/ part changeover occurs to quality control activities, manufacturing work procedures, and equipment. Description of set-up operations. - Is equipment dedicated to a single or few similar parts or does it have to deal with many different parts? - Number of unique board types (different part numbers) in dominant process (Q) - Number of different board sizes in dominant process (Q) - Lead pitches (centre-to-centre distance of component leads) of the boards being produced in the dominant process. (Q) - The average number of components (surface mount and through-hole) per board (Q) - The average number of different <u>types</u> of components on the same board (Q)	- Interviews (QM, PM, ME, WK) - Direct Observation (plant tour)
Workforce Skill Level	Plant	- % of multi-skilled employees - % of workforce holding a technical or engineering degree (Q) - Plant's skill level compared to industry - Training (frequency, systematic vs. ad-hoc, specific in- depth vs. broad skill base, training in quality improvement) - Employee appraisal.	- Interviews (QM, PM)
Organisational Structure	Plant	- Number of production workers vs. other (staff) (Q) - Number of people employed in several categories (e.g., management, quality control, engineering, etc.) (Q) - Number of hierarchical levels in production and tasks assigned to each level. (Q) - Number of different job classifications (Q) - Organisational chart	- Interviews (QM, PM, PTM) - Questionnaire - Documentation (organisational chart)
Organisation of the Quality Function	Plant	- Existence of a separate Quality Department - Number of people working in the Quality Department	- Interviews (QM) - Documentation (organisational chart)
Nature of Quality Problems	Dominant Process	- Most frequent causes of quality problems (design-related, incoming materials, or manufacturing processes and equipment) - Most frequent quality problems in the main assembly line and experienced by the main product line in the field.	- Interviews (QM, PM, ME)

Context area	Unit of measurement	Questions	Field Procedures/ Sources of Information (*)
Quality Performance	Plant/ Dominant Process	Recent Trends: -Evolution of defect rates, scrap, rework, warranty costs and customer satisfaction over last 3 years - Plant Current performance: - % items passing inspection without rework (Q) - Dominant Process - % of internal scrap and rework (Q) - Dominant Process - Solder defect rates (defects in the soldering of components to the boards) (Q) - Dominant Process - Warranty costs as a % of sales (Q) - Plant - Customer satisfaction (Q) - Plant	- Interviews (QM) - Questionnaire
Labour Intensity	Dominant Process	- Role of operators in the process.	- Interviews (QM, PM, ME, WK) - Direct Observation (plant tour)
Turnover Rate for Production Workers	Plant	- Annual % turnover rate for production workers (Q)	- Questionnaire
Overall Performance of Manufacturing	Plant	- Overall Performance of Manufacturing relative to other plants in industry (perceptual) (Q) - Evolution of operational performance over last 3 years (inventory, lead times, on-time delivery, productivity, cost) - Strong and weak areas of manufacturing performance.	- Questionnaire - Interviews (PTM, PM)
Plant Performance on Relevant Competitive Dimensions	Plant	- Performance on order-winners and qualifiers relative to the competition. (Q)	- Interviews (PTM, PM, MKTG) - Questionnaire
Financial Performance	Plant	- Profit, Assets, ROI, Sales, and other financial indicators.	- Interviews (PTM, PM, MKTG) - Documentation (annual report, financial statements)

- (*) Refer to the end of the protocol for a definition of the abbreviations used.
- The questions marked with "(Q)" are addressed directly in the questionnaire.

B. Use of Quality Management Practices

The following table shows the quality management practices to be addressed, the questions that the researcher must keep in mind and that must be answered about each practice, the unit of measurement to which the questions should refer to, and the field procedures and potential sources of information for answering those questions.

Practice	Unit of measurement	Questions	Field Procedures/ Sources of Information (*)
Real Time Feedback	- Dominant Process	The researcher should characterise the several ways in which real time feedback is obtained from the process (e.g., location of feedback points, data collected and use made of it). This could include the reading of process variables (e.g., solder paste height), inspecting products for defects, etc. Either by collecting and recording data and subsequently comparing it with an "in-control standard" (e.g., SPC charts, defect levels at which the process is considered out of control), or by informal observation of trends (with no actual recording of data), these practices provide real time feedback on the state of control of the process. The researcher should also ascertain whether these practices are linked to real time data analyses and corrective action mechanisms. Interesting questions to ask respondents would be: "How do you know when something is wrong in the process?"; "Could you describe the sequence of events that takes place when something is found to be wrong?"	- Interviews (QM, PM, ME, WK) - Direct Observation (plant tour)
Zero Defects	- Dominant Process	Existence of zero defects mechanisms such as automated inspection (on-line quality control), processes equipped with mechanisms that prevent the possibility of a large amount of defects being inadvertently produced, processes equipped with mechanisms to encourage or force the proper performance of an operation, processes designed so that they cannot physically operate on defective parts, workers are trained and have adequate resources to check the quality of their own output.	- Interviews (QM, PM, ME, WK) - Direct Observation (plant tour)
Off-Line Feedback	- Dominant Process	The researcher should investigate the extent to which data providing feedback on process quality (e.g., from product inspections, testing, customer complaints, customer returns, quality costs, etc.), is stored and analysed off-line (e.g., weekly or monthly). The researcher should consider the level of detail of the data, the methods use to analyse it, and the data availability, easy access and presentation.	- Interviews (QM, PM) - Documentation (internal quality documents)

Practice	Unit of measurement	Questions	Field Procedures/ Sources of Information (*)
Workforce Management	- Plant	- Empowerment: quality related responsibilities assigned to workers; degree to which workers are involved in the implementation of suggestions and process improvements; resources (e.g., technical support) available to assist workers in solving problems and quality-related decision making; autonomy which workers have in quality-related decision making. - Suggestion schemes: mechanisms available for workers to contribute with suggestions; extent of participation of workers and benefits derived (e.g., number of workers involved; number of suggestions per year; quality of suggestions). - Problem solving teams: structures available in the plant for workers to be involved in team problem solving and the extent to which they are actually involved. Composition of the teams; type of teams; tasks handled by teams; resources given to teams. - Recognition for quality: extent to which employees are assessed on quality; mechanisms to provide recognition for quality.	- Interviews (QM, PTM, PM) - Direct Observation (plant tour) - Documentation (minutes of meetings)
Supplier Involvement	- Main components of main product line	- Supplier selection process - Assessment of supplier performance (post-selection) - Nature of relationships with suppliers (long term vs. arms length) - Co-operation in logistics activities (standardisation initiatives, communication links, exchange of data, inventory arrangements, frequency of deliveries, incoming inspection) - Co-operation in product design/introduction	- Interviews (QM, PTM, PM, PURCH)
Customer Focus	Plant	- Characterisation of relationships with customers (existence of partnership arrangements, direct customer contacts, level of integration of the plant's operations with customers (logistics co-operation, single sourcing arrangements, mutual technical assistance, organisation of the plant's activities around customers). - Customer involvement in new product design/ introduction. - Collection of the following customer information: - Latent customer needs: forward looking information, for example, about new requirements, services or technologies needed by existing and potential customers. - Existing customer needs: information on the importance placed by existing customers on several requirements (e.g., price, delivery, etc.) and the plant's performance across those. - Mechanisms for the dissemination of information collected on customer needs within the organisation and responsiveness to that information.	- Interviews (QM, PTM, PM, MKTG, DSG)

Practice	Unit of measurement	Questions	Field Procedures/ Sources of Information (*)
Product Design/ Introduction	Plant	The researcher should arrive at a descriptive account of the process of introduction of a new product into production. This should address the degree of formality and comprehensiveness of the process: - the use of thorough reviews of product designs before the product is produced and sold, prototyping, and special tools and techniques such as Taguchi design methods, Quality Function Deployment (QFD), and Failure Mode and Effects Analysis (FMEA). - the use of design for manufacturibility (e.g., design simplification and minimisation of part count; adaptation of design characteristics to the plant's processes) - the existence of initiatives for increasing the understanding of the "science" of the processes with the a priori fool-proofing of processes, independently of products. It should also address the extent that different functions co-operate in the product design/introduction process.	- Interviews (QM, PTM, PM, ME, DSG)

(*) Refer to the end of the protocol for a definition of the abbreviations used.

C. <u>Research Controls</u>

The following table shows the formal control variables to be addressed, the questions that the researcher must keep in mind and that must be answered about each variable, and the field procedures and potential sources of information for answering those questions. All questions refer to the plant as a whole.

Control Variable	Questions	Field Procedures/ Sources of Information
Efficiency Drive for the Adoption of Quality Management Practices	Importance of quality (conformance and design) as a competitive priority. History of quality management in the plant: - Time since formal process of quality improvement started. - Description of general quality management practice adoption sequence since then. - Main reasons for the introduction of quality initiatives. - Main goals of initiatives, extent to which goals have been met. - Difficulties experienced during process of adoption and the current use of quality management practices and reactions to those difficulties. - The extent to which changes in customer demand and business conditions have affected quality and quality management in the plant. - Major lessons learnt.	- Main interviews with the QM, PTM and PM, complemented with interviews addressing information specific to other managers' functional areas.
Awareness of Quality Management Practices	- Main sources of information on quality management - Affiliation with quality associations. - Participation in seminars, workshops, other training - Background of the production and quality managers	- Main interviews with the QM, PTM and PM, complemented with interviews addressing information specific to other managers' functional areas.

Maturity in Quality Management	External indicators of quality management maturity: - Certification by ISO9000 or another major quality standard - Receivership of quality awards - Being a supplier to a major electronics manufacturer - Being mentioned as a best practice company in practitioner magazines or best practice company lists. Quality Culture: - Visibility of quality principles (e.g., existence of a comprehensive quality mission; quality principles appear in mission statement, themes and slogans; quality regularly discussed in management meetings) - Evaluation of plant management on quality. - Personal involvement of plant management in quality improvement projects. - Setting of quality goals.	- Main interviews with the QM, PTM and PM, complemented with interviews addressing information specific to other managers' functional areas. - Documentation (quality mission, written quality policy, customer care policy statement, warranty policies) - Archival Sources (e.g., practitioner magazines, lists of best practice companies)

D. <u>Rich Information Enabling the Understanding of the Observed Use of Quality Management Practices</u>

After the researcher enquires about the use of a specific quality management practice following the procedures described in Section B, he/she should also collect any relevant information about the use of the practices. Of interest, is information contributing to the understanding of the reasons behind the observed patterns of use of practices. Examples of possible questions include:

- If practice is not used at all in the plant:
  - Was it ever considered for adoption?
  - What reasons prevent its use (difficulties/ barriers)?
- If practice is at least somewhat used, probe further:
  - When was the practice introduced?
  - What was the major reason for its introduction?

- What difficulties are currently experienced in using it?
- What strategies are in place to deal with those difficulties?
- What were the goals of the practice? Have the goals been met? What was the result of the initiative?
- How satisfied is the respondent with the outcome of the practice from a cost benefit perspective? How would the respondent characterise the success of the practice taking into account the implementation effort and the resulting benefits (if any)?
- What were the major lessons that were learnt from the implementation of the practice?
- Does the respondent think the plant should increase or decrease the use of the practice? What reasons prevent an increase in the use of the practice (difficulties/ barriers)?

In the final stages of the field work, the researcher should select one or several respondents with a good overview of quality management practice in the plant (usually the Quality Manager or Director). The researcher should orally summarise the use of several quality management practices that he/she observed in the plant, if necessary with the aid of a brief list of titles. The researcher then should ask the respondents if there are any quality practices (or activities) with which the plant is experiencing difficulties. The researcher should then probe the respondent on the difficulties experienced, the likely reasons for those, and on any strategies that are in place to deal with those difficulties. The objective here is to get a broad picture of the effectiveness of individual quality management practices, in particular the identification of clear successes and failures.

3. Post-visits Stage

A report should be produced as soon after the visit as possible. It should contain all notes and documents categorised by research variable and organised into a coherent text within each category. It should also include any reflections by the researcher about case-study questions attempting to integrate the available evidence and to converge upon the facts of the matter or their tentative interpretation.

Abbreviations used

QM: quality manager/director or equivalent position.
PTM: plant manager or equivalent position.
PM: production manager/director or equivalent position.
ME: manufacturing engineer or equivalent position.
MKTG: marketing/sales manager/director or equivalent position.
DSG: person associated with product design/development and new product introduction.
PURCH: purchasing manager or equivalent position.
WK: shop-floor worker.

Annex 1
Typical letter requesting participation of a plant in the study

Dear [...]

Re: Total Quality Management in the Electronics Industry Research Project

The Centre for Operations Management at London Business School is currently carrying out a study of quality management practices in the electronics industry. The research involves a series of case studies of UK electronics manufacturing companies with the overall aim to develop understanding of how companies adapt standard quality management programs and concepts to their particular business and manufacturing contexts.

Information abounds on what quality practices plants should adopt to become "world class manufacturers" and achieve the high levels of quality required by today's markets. Unfortunately, there isn't much guidance available to companies on how to adapt standard quality management concepts and practices to their particular contexts. The "TQM in the Electronics Industry" project addresses this important issue. By conducting a series of case studies of UK electronics manufacturing companies, we aim to provide guidelines on how companies can adapt standard quality programs to their competitive contexts in order to achieve the required quality levels in the most economic manner.

As you are a leading electronics manufacturer in the UK, we would highly value an opportunity to include [company name] in our study. Including your company would involve us conducting field research at your site. The lessons learned from studying your plant and other sites will be used to produce customised feedback to your company, as well as a report with the main findings of the project.

In our research we are interested in discussing with you the extent to which several quality management practices are used in your plant, and how effective they have been. We would also like to learn how your plant's business and manufacturing characteristics have shaped your quality management activities. A sample of areas and questions covered in the research has been enclosed. Concerning shop floor quality activities, we are especially interested in your Printed Circuit Board (PCB) assembly lines and would appreciate if a tour of these lines could be arranged.

Full confidentiality will of course be respected. All data collected in this research will remain at London Business School and will not be disseminated in such a manner that it identifies participating companies.

We will contact you in the near future to discuss your participation in the study.

Thank you for your co-operation.
Yours sincerely,

Encl. Sample of areas to be covered in the study.

This list describes some of the areas to be included in the study. This may help you in identifying who would be most appropriate for us to meet.

Area	*Sample of issues covered*
General Quality Management	• Process of adoption of quality practices • Organisation of the quality function • Employee involvement activities (e.g., suggestion schemes, teamwork) • Quality performance measures (PCB assembly yields and solder defect rates; warranty costs; customer satisfaction)
Quality Control in the Printed Circuit Board (PCB) assembly lines	• Statistical Process Control (SPC) activities • Zero Defects activities • Inspection and test of PCBs; collection and analysis of quality data • Most frequent quality problems
Characteristics of the PCB assembly lines	• Layout; assembly, inspection and test equipment; inspection and data collection points • Type and complexity of assembled PCBs • Production control, product mix
Relationships with customers and suppliers	• Criteria for supplier selection • Assessment of customer satisfaction
Printed Circuit Board design process	• Organisation of the design and the new product introduction processes • Use of design practices such as Design for Manufacturing (DFM) and Quality Function Deployment
Company background	• The markets that you operate in • Key success factors in these markets • Organisational structure

Annex 2

Questionnaire

Total Quality Management in the Electronics Industry
Research Project
1998

Centre for Operations Management
London Business School

London
Business
School

Total Quality Management in the Electronics Industry 1998

The Centre for Operations Management at London Business School is currently carrying out a study of quality management practices in the electronics industry. The research involves a series of case studies of UK electronics manufacturing companies with the overall aim to develop understanding of how companies adapt standard quality management programs and concepts to their particular business and manufacturing contexts.

PLEASE NOTE that *all answers will be treated with full confidentiality*. All data collected in this research will remain at London Business School and will not be disseminated in such a manner that it identifies participating companies.

The questionnaire is divided in four sections:

SECTION A	***Plant Background***
SECTION B	***Competitive Priorities***
SECTION C	***Main Printed Circuit Board (PCB) Assembly Line***
SECTION D	***Quality Performance***

When responding to questions related to the main product line or the main printed circuit board (PCB) assembly line please refer to the following:

Main product line: ______________________________

Main PCB assembly line: ______________________________

When the questionnaire is completed, please mail it in the postage paid envelope enclosed.

THANK YOU VERY MUCH FOR YOUR COOPERATION!

SECTION A: Plant Background

A1. What is the approximate yearly total production volume of the plant? Units ___________

A2. During the last fiscal year, what was the sales value of production? (£000) ___________

A3. Approximately how many customers does this plant serve? Number ___________

A4. How many people are employed in each of the following categories at this plant:

Production Workers	Number ___________
Plant Management	Number ___________
Quality Assurance	Number ___________
Manufacturing Engineering	Number ___________
Direct Labour Supervisors	Number ___________
New Product Design/Redesign	Number ___________
Other Staff	Number ___________

A5. What is the approximate number of people in your plant holding a technical or engineering degree? Number ___________

A6. How many different job classifications (or pay grades) do you have in your plant? Number ___________

A7. What is the annual turnover rate for production workers? % ___________

A8. During the last three years, approximately what proportion of business unit revenues was spent on Research and Development (average percentage of total revenues)? % ___________

A9. What is the average life cycle of your products? Months ___________

A10. What percentage of plant sales are from products introduced in the last 3 years? % ___________

A11. What is the approximate yearly production volume of the main product line in your plant (see instructions page)? Units ___________

A12. What was the component placement volume of your plant's PCB assembly operations last year?

<50K	51-100K	101-500K	501-1M	1-25M	25-50M	50-75M	75M+
❑	❑	❑	❑	❑	❑	❑	❑

A13. How would you rate the overall performance of manufacturing in your plant based on the performance of other plants in your industry?

Very Poor	Poor	Average	Good	Very Good
❑	❑	❑	❑	❑

SECTION B: Competitive Priorities

Consider the importance of the competitive criteria listed below to the major customers of your main product line (see instructions page). Competitive criteria can be classified in two categories:

Qualifiers: those criteria that your plant must meet for a customer even to consider you as a possible supplier. Complying with these criteria will enable your plant to be on your customers' short-lists; however, simply providing or attaining these criteria does not win orders. To provide Qualifiers your plant needs only to be as good as competitors.

Order-Winners: those criteria that win the orders. To provide Order-Winners your plant needs to be better than competitors.

Please classify each of the criteria listed below either as a Qualifier (Q) or as an Order-Winner (OW), by ticking the appropriate box under the heading "Type".
Next, please rank the criteria you have labelled as Order-Winners, according to their importance to win orders from your major customers. Assign the number "1" to the most important, "2" to the second most important, and so on. For example, if you have identified 5 order-winners, you should assign the number "1" to the most important, down to "5" to the least important.
Finally, please indicate how your plant compares to its competition in terms of the identified Order-Winners by circling the appropriate 1-7 number.

Competitive Criteria	Type: Qualifier (Q) or Order-Winner (OW)? Q	OW	Order-Winners (OWs): Ranking of OWs (1: Most important; N: Least Important (N = number of OWs))	Comparison to competition: Poor: low end of industry			Average: same as rivals			Superior: better than rivals
have **low selling prices**	❑	❑	[ ]	1	2	3	4	5	6	7
offer products with superior **design quality (design innovation)***	❑	❑	[ ]	1	2	3	4	5	6	7
offer products with superior **manufacturing quality (conformance to engineering specifications)**	❑	❑	[ ]	1	2	3	4	5	6	7
offer **a large number of new products**	❑	❑	[ ]	1	2	3	4	5	6	7
offer **fast deliveries**	❑	❑	[ ]	1	2	3	4	5	6	7
offer **dependable (on-time) deliveries**	❑	❑	[ ]	1	2	3	4	5	6	7
provide a **wide product range**	❑	❑	[ ]	1	2	3	4	5	6	7

* Refers to the ability to provide a product with superior capabilities, features, and/or operating characteristics.

SECTION C: Main Printed Circuit Board (PCB) Assembly Line

Please consider the main PCB assembly line in your plant (see instructions page).
Concerning this line, please indicate:

C1. the approximate yearly production volume of the line (number of PCBs) Units ___________

C2. the approximate capital investment in the following categories of equipment·

a) assembly (printing, component placement, soldering, cleaning) (£000) ___________
b) inspection (e.g., laser and X-ray equipment) (£000) ___________
c) in-circuit (electrical) testing (e.g., bed of nails, manufacturing defect analyser) (£000) ___________
d) functional testing (running the PCBs through the connector) (£000) ___________

C3. the average component placement rate of the line Components per hour ___________

C4. the number of production workers regularly working on the line Number ___________

C5. the average production batch size Units ___________

C6. the number of unique board types (different part numbers) assembled on the line Number ___________

C7. the number of different board sizes assembled on the line Number ___________

C8. the approximate number of components (surface mount and through-hole) for a typical board assembled on the line Number ___________

C9. the approximate number of different types of components for a typical board assembled on the line Number ___________

C10. the type of lead "pitch" (centre-to-centre distance of component leads) for the average surface mount component

Standard Surface Mount 0.050" (1.27mm) - 0.030" (0.75 mm)	Fine Pitch 0.025" (0.65mm) - 0.020" (0.51mm)	Ultra Fine Pitch Below 0.020" (0.51mm)
❑	❑	❑

SECTION D: Quality Performance

D1. What are the warranty costs as a percentage of costs of sales for your plant? % __________

D2. How satisfied are your customers with your plant's products?
(please circle the appropriate alternative)

Disappointed		Satisfied		Delighted
1	2	3	4	5

D3. Regarding your main PCB assembly line (see instructions page), please provide an estimate of the following quality measures.

Quality Measure	
Percentage of boards that pass final inspection without rework	__________ %
Percentage of internal scrap and rework	__________ %
Solder defect rates (defect rates in *parts per million* solder joints - PPM)	__________ PPM

Thank you for your help!

We greatly appreciate your time and effort. Please once again note that your answers will be treated with full confidentiality. You will receive a report with the project results as soon as it is available.

Please return this questionnaire in the postage paid envelope provided to:

TQM in the Electronics Industry Project
c/o Rui Sousa
London Business School
Sussex Place, Regent's Park
London NW1 4SA

Tel: 0171 - 262 5050 Ext. 3546
Fax: 0171 - 724 7875
E-mail: rsousa@lbs.ac.uk

APPENDIX 4.

Description of the Printed Circuit Board (PCB) Surface Mount Technology Assembly Operations.

PCBs are flat pieces of copper covered in laminate (bare boards) which have conductive tracks connecting various electronic components that are mounted on the board. Very simply put, electronics products consist of a set of PCBs connected together inside a box. The inputs for the PCB assembly process are bare boards and electronic components and the outputs are boards populated with electronic components. Components can be of two types: Through-Hole (TH) and Surface Mount (SM). TH components are affixed to the board by inserting their leads into holes available on the boards followed by soldering (there is a mechanical and soldering attachment to the board). SM components are affixed to the board by simply placing their leads on top of solder paste on the board followed by soldering (there is a soldering attachment only). Before Surface Mount Technology was developed, all boards comprised TH components only. With the advent of Surface Mount Technology, SM components began to be used, but TH components were not completely abandoned, so that a typical board today will comprise both TH and SM components. Typically, the assembly of SM components (the "surface mount assembly operations") for a single sided pure SM PCB (a PCB with SM on one of its sides only) comprises the following stages performed in sequence (Prasad, 1997):

1. *Screen Print*. Solder paste is screened onto the board on the exact positions where the SM component leads are to be soldered to the board. This is performed by pressing solder paste onto the board through the apertures of a stencil tool (the stencil is aligned with the board and the apertures correspond to the locations where solder paste is to be deposited).
2. *Pick and Place*. SM components are placed on their exact position on the board. They are held in place by the solder paste. This operation can be performed manually, but it is typically performed by placement machines which are programmed with the type of components and locations on the board at which each of them should be placed. These machines hold the components required for the population of a board in a bank of "feeders", one for each type of component and each having a limited capacity in terms of the number of components it can hold.
3. *Reflow Soldering*. The board with the components placed on top of it goes through a reflow oven. The high temperature reflows the solder paste and provokes the soldering of the component leads to the board. The temperature profile required for each board (the "solder profile") is programmed into the oven.

Other types of PCBs include PCBs with SM components only on both sides, SM and TH components on the top side and SM components on the bottom, and TH components on the top and SM components on the bottom (Prasad, 1997). The assembly processes for these board types involve a combination of the above basic stages followed by TH assembly operations (not described here). After a PCB is complete it may be mechanically assembled together with other PCBs in a mechanical box forming a final product unit (e.g., an industrial controller).

Main Set-Up Operations

When a different board goes through the assembly process, these are the main set-up operations that may need to be performed:

1. Screen Print. The stencil tool needs to be replaced, and the new stencil aligned with the new board.
2. Pick and Place. A new machine placement program needs to be loaded into the machine. If the components for the new board do not exist in the existing feeder bank, new feeders must be added to the existing bank and/or replace existing feeders in case no extra feeder slots are available. Existing feeders may also have to be placed in different positions in the machine, even if no new feeders have been added.
3. Reflow Oven. A new solder profile may need to be loaded onto the machine, especially if the new board has a very different thermal mass from the previous one.

The pick and place set-up is typically the major operation to be performed.

The Product Design

One needs to distinguish between two different designs related to a PCB. The *conceptual design* consists in an electronic circuit schematic defining the future electronic behaviour of the PCB. It embodies the definition of the functions and features of the associated electronic product which can comprise several PCBs. This design does not influence directly the manufacturibility of the resulting physical PCBs. The *physical design* of a PCB is the translation of the conceptual design into a physical product, defining the types of components used, how the different components defined in the circuit schematic are physically laid out and connected (e.g., distances between conductive tracks), the materials used, etc. This design determines the manufacturibility of the physical PCB directly (e.g., the number of electrical nodes that will be accessible to conduct electrical tests).

Typical Testing Technology

There are essentially two types of tests that may be conducted on a PCB after it has been assembled: electrical and functional. An electrical test consists in several probes making physical contact with accessible electrical points on the board to measure several electrical properties. The main equipment is general purpose, but usually requires a fixture which is board specific. An electrical test is usually faster and has higher diagnostic capability than a functional test. A functional test exercises several functions of the PCB by running it through the connector, simulating its use in the final application. The equipment is board specific. None of the tests guarantees 100% fault coverage (the electrical test may not cover 100% of the electrical connections and does not cover the systemic aspects of the functioning of the PCB; the functional test may not cover all the possible combinations of stimuli that the PCB might be subject during its use). The two types of tests can be used alone on in conjunction one with the other. When they are used jointly, the electrical test takes place first; a PCB may pass electrical test and fail functional test.

APPENDIX 5.

Definition of Data Reduction Codes and Respective Association with the Research Variables.

Codes related to the research controls

These codes are used to reduce the data on the research controls, as described in Chapter 7.

Code	Provides information on:
DRIVE	drive for adoption of a particular QM practice.
QAWARE	awareness of QM practices by the plant.
QCULTURE	extent to which a quality culture is embedded in the plant.
QEXTIND	external indicators of quality maturity.
QHISTORY	history of adoption of quality management in the plant.

Codes related to context

These codes are used to reduce the data on strategic context, as described in Chapter 7. The context variables are defined in Chapter 5.

Code	Provides information on:
BUSENV	plant's business environment.
COMPL	complexity of the dominant process, how well it is understood.
CPT_ST	plant's competitive strategy.
CUSTM	"degree of customisation" context variable.
DOMPROC	characterisation of the dominant process.
FPERF	"financial performance" context variable.
IIV	"internal item variety" context variable.
LABOUR	"labour intensity" context variable.
MAINCHAIN	identification of the main product line supply chain.
MPERF	"overall performance of manufacturing" context variable.
ORGFLOOR	organisational structure in the shop floor.
ORGQUAL	"organisation of the quality function" context variable.
ORGSTRUCT	"organisational structure" context vanable.
OW	"dominant order winners and qualifiers" context variable.
OWPERF	"plant performance on relevant competitive dimensions" context variable.
PRANGE	product range.
PROCHG	"rate of process change" context variable.
PVOL	"total production volume" context variable.
QPERF	"quality performance" context variable.
QPROB	"nature of quality problems" context variable.
REPT	"degree of repetitiveness" context variable.

Code	Provides information on:
RNPI	"rate of new product introduction" context variable.
RSIZE	"internal run sizes" context variable.
SKILL	"workforce skill level" context variable.
STD	"degree of standardisation" context variable.
WKTURN	"turnover of production workers" context variable.

Codes related to the use of quality management practices

These codes are used to reduce the data on the use of the several quality management (QM) practices, as described in Chapter 7. The individual QM practices are defined in Appendix 1 and are subsequently refined in Chapter 7.

Process QM practices:

Code	Provides information on:
PROC	use of process QM practices. It is a macro code aggregating all the individual process QM practices.
NPI	use of Formalised New Product Introduction Process practices.
ZD	use of Zero Defects practices.
CI	use of Changeover Inspection practices.
RTF	use of Real Time Feedback practices.
IOF	use of In-Process Off-Line Feedback practices.
OOF	use of Overall-Process Off-Line Feedback practices.
DIAGN	the feedback potential of an RTF, IOF or OOF practice.
DC	points at which data is collected in the dominant process; used in conjunction with codes IOF and OOF.
AN	analyses of quality data conducted by the plant.
CA	corrective action mechanisms associated with practices providing feedback on processes (RTF, IOF, OOF).

Cross-Functional Design Efforts:

Code	Provides information on:
CROSSF	use of cross-functional design efforts.

Workforce Management:

Code	Provides information on:
WORKFORCE	use of workforce management practices. It is a macro code aggregating all the individual workforce management practices.
EMP	use of empowerment practices.
SS	use of suggestion schemes.
PST	use of problem solving teams.
RQ	use of recognition for quality initiatives.

Supplier Involvement:

Code	Provides information on:
SUPPL	use of supplier involvement practices. It is a macro code aggregating all the individual supplier involvement practices.
SELECT	the process of selection of suppliers.
ASSESS	assessment of supplier performance.
SRELATS	nature of supplier relationships.
LOGS	co-operation with suppliers on logistics activities (standardisation initiatives, communication links, exchange of data, inventory arrangements, frequency of deliveries, incoming inspection).
SDESIGN	co-operation with suppliers in product design/introduction.

Customer Focus:

Code	Provides information on:
CFOCUS	use of customer focus practices. It is a macro code aggregating all the individual customer focus practices.
CRELATS	nature of the relationships with suppliers.
CDESIGN	customer involvement in new product design/introduction.
LATENT	collection of information on latent customer needs.
EXIST	collection of information on existing customer needs.
DISSEM	dissemination of customer information within the organisation and responsiveness to that information.

Codes related to the difficulties experienced by plants in the use of individual quality management practices

These codes are not directly related to the three main sets of research variables (research controls, strategic context and degree of use of QM practices). They are used directly to support the explanatory data analysis conducted in Chapter 8.
The codes are used in conjunction with a code relative to the use of a particular QM practice.

Code	Provides information on:
DIFF	difficulties experienced in the use of a QM practice.
STRAT	coping/mitigating strategies used by the plant to deal with the difficulties experienced in the use of a QM practice; used in conjunction with the code DIFF.
INFO	INFO coping/mitigating strategy; used in conjunction with the codes PROC and STRAT. (*)
GEN	GEN coping/mitigating strategy; used in conjunction with the codes PROC and STRAT. (*)
PRIOR	PRIOR coping/mitigating strategy; used in conjunction with the codes PROC and STRAT. (*)

Code	Provides information on:
DYN	DYN coping/mitigating strategy; used in conjunction with the codes PROC and STRAT. (*)
CUST	CUST coping/mitigating strategy; used in conjunction with the codes PROC and STRAT. (*)
ORG	ORG coping/mitigating strategy; used in conjunction with the codes PROC and STRAT (*)
TECH	TECH coping/mitigating strategy; used in conjunction with the codes PROC and STRAT. (*)

(*) These coping/mitigating strategies are associated with process QM practices and are defined in Chapter 8.

Codes related to rich case data on the use of quality management practices

These codes are not directly related to the three main sets of research variables (research controls, strategic context and degree of use of QM practices). They are used directly to support the explanatory data analysis conducted in Chapter 8.
The codes are used in conjunction with a code relative to the use of a particular QM practice.

Code	Provides information on:
EFFECT	perceived effectiveness of the use made of a QM practice.
STR_CTX	influence of the plant's strategic context on the use of a QM practice.
OTHER_CTX	influence of non-strategic context factors on the use of a QM practice.
PEOPLE	plant personnel associated with the use of a QM practice.
RICH	rich information on the use of a QM practice.
HYP	exploratory hypothesis/explanation concerning the understanding of reasons for the reported level use of a QM practice.

APPENDIX 6.

Template for the Tabular Displays used for the Reduction of Research Control Data.

Control Variable	Characterisation of the control variable	Summary	Compliance with control? (Yes/No)
Efficiency Drive for the Adoption of Quality Management Practices	Importance of Quality as a Competitive Priority [relevant codes: OW] History of Quality Management in the Plant : - Description of general quality management practice adoption sequence. - Main reasons for the introduction of quality initiatives. - Main goals of initiatives, extent to which goals have been met. - Degree of experimentation during the adoption process. [relevant codes: DRIVE, QHISTORY]		
Awareness of Quality Management Practices	- Main sources of information on quality management - Affiliation with quality associations - Participation in seminars, workshops, other training - Background of the production and quality managers [relevant codes: QAWARE]		

Control Variable	Characterisation of the control variable	Summary	Compliance with control? (Yes/No)
Maturity in Quality Management	Time since formal process of quality improvement started. [relevant codes: QHISTORY] External Indicators of Quality Management Maturity: - Certification by ISO9000 or another major quality standard - Receivership of quality awards - Being a supplier to a major electronics manufacturer - Being mentioned as a best practice plant in practitioner magazines or best practice plant lists. [relevant codes: QEXTIND] Quality Culture: - Visibility of quality principles (e.g., existence of a comprehensive quality mission; quality principles appear in mission statement, themes and slogans; quality regularly discussed in management meetings) - Personal involvement of plant management in quality improvement projects; evaluation of plant management on quality. - Setting of clear quality goals. - Existence of mechanisms for closed loop corrective action. [relevant codes: QCULTURE]		

APPENDIX 7.

Template for the Tabular Displays used for the Reduction of Context Data.

Context Variable	Unit of Measurement	Measurement items/ Characterisation of the context variable (a)	Summary (b)
Business Environment	Plant	- Key characteristics of the business environment. - Major changes in customer demands and business conditions in past few years.	Descriptive summary. Used as background information.
Competitive Strategy	Plant	- Markets the company competes in, types of customers (industry, size, number). - How the company competes in the market. - Market aims: - market coverage: few vs. many markets - customer focus: few vs. many customers - product focus: emphasis on physical attributes vs. emphasis on service - Number of customers served by plant.	Descriptive summary. Used as background information.
Dominant Order-Winners and Qualifiers	Main Product Line	- Order-winners and qualifiers for the major customers of the main product line.	Categorisation according to the resemblance with one of the strategic configurations. Used to classify plants.
Degree of Product Customisation	Main Product Line	- Nature of customisation (extent to which customers influence and/or determine product/service characteristics relevant to manufacturing). Emphasis is on the consequences of customisation to manufacturing.	- L-H categorisation, applying rule R1.2. Used to classify plants.

Context Variable	Unit of Measurement	Measurement items/ Characterisation of the context variable (a)	Summary (b)
Rate of New Product Introduction	Plant	- Instability of product designs, both across new product introductions (1(L)-3(H) rating) and during a product's life cycle (1(L)-3(H) rating). Overall item rating is determined by the application of rule R2 to the two individual ratings. - Consequences of new product introductions to manufacturing: Application of rule R1.1 to the value "Internal Item Variety rating / Average Product Life Cycle rating" to yield a 1(L) to 3(H) rating. Internal Item Variety rating: as indicated below in the table. Average Product Life Cycle rating: obtained by applying rule R1.1 to the life cycle time periods. The more products a manufacturing process produces and the shorter are their life cycles, the more manufacturing is subject to new product introductions.	- L-H categorisation, applying rule R2 to the two individual items. Emphasis is on the consequences to manufacturing of the introduction of new products. Used to classify plants.
Choice of Main Product Line Supply Chain	Main Product Line Supply Chain	- The Main Product Line is defined as: i) when there are clearly defined and stable product lines, as the product line exhibiting the highest production volume. This is the typical situation for Cost Leaders; or ii) when the concept of individual stable products does not apply, as the set of products representative of the most commonly supplied technology. This would be the typical situation for a Niche Differentiator manufacturing to customer design. Typically, the plant would offer capabilities across a number of set technologies (for example, PCBs for applications in the sectors of telecommunications, industrial products, instrumentation, etc.). The main product line would consist in the set of products in the most common technology category (i.e., the one corresponding to a "typical" customer order). - The Dominant Process is defined as the PCB surface mount assembly line used to produce the Main Product Line.	This is not a contextual variable per se. It is used to define the measurement unit for several contextual variables.

Context Variable	Unit of Measurement	Measurement items/ Characterisation of the context variable (a)	Summary (b)
Typology of Dominant Process	Dominant Process	- Layout (dedicated line vs. functional), product routes (fixed vs. variable).	- L-H categorisation, applying rule R1.2. "L" represents the extreme "line layout, fixed routes" (line process), H the extreme "functional layout, variable routes" (jobbing process), and M a high volume batch process. Used to classify plants.
Total Production Volume	Dominant Process	- Total number of PCBs assembled in one year, adjusted for the number of physical PCB assembly lines in the dominant process.	- L-H categorisation, applying rule R1.1. Used to classify plants.
Degree of Repetitiveness	Plant	- Not measured directly. It is inferred from other context variables as follows: 1/(Degree of Customisation rating x Rate of New Product Introduction rating x Internal Item Variety rating). The higher the customisation, rate of new product introduction and internal item variety (with compounding effects), the lower is the degree of repetitiveness.	- L-H categorisation, applying rule R1.1. Used as background information.
Rate of Process Change	Dominant Process	- Not measured directly. It is inferred from other context variables as follows: Degree of Customisation rating x Rate of New Product Introduction rating.	- L-H categorisation, applying rule R1.1. Used as background information.
Degree of Standardisation	Dominant Process	- Level of detail of manufacturing work procedures. - Existence of written operating procedures accessible to workers on the shop floor (e.g., assemblers and inspectors). - Degree of standardisation of process parameters/procedures. - Division of labour.	- Qualitative summary. Used as background information.

Context Variable	Unit of Measurement	Measurement items/ Characterisation of the context variable (a)	Summary (b)
Internal Run Sizes	Dominant Process	- Average production batch size, as "experienced" by the process = (down time for a set-up)/ (average work content of a batch), (L-H, reverse coded). average work content of a batch = average total number of components to be placed = average number of components per board x average batch size Note: The down time for a set-up is used as a proxy for the complexity of the changeover. The work content of a batch is used as a proxy for the time it takes for the batch to be processed. The longer the down time for a set-up relative to the batch processing duration, the shorter is the size of the run, "as experienced by the process". Many short batches of very similar products, requiring very quick or no set-ups, could be considered as a long run.	- L-H categorisation, applying rule R1.1 (L-Short runs; H-Long runs). Used to classify plants.
Internal Item Variety	Dominant Process	- Number of unique board types (different part numbers). (L-H, rule R1.1) - Number of different board sizes. (L-H, rule R1.1) - Average number of components per board: this is a measure of the size of the differences between individual boards. More components increase the scope for differences between individual boards (e.g., more complex set-ups of placement machines, different thermal masses, wider spreads of component locations on the board, bigger differences between the interactions between components, etc.). (L-H, rule R1.1) - Average number of different types of components per board: same as previous. (L-H, rule R1.1) - Difficulty of the set-up operations: this is a combination of the sheer item variety and the plant's ability and resources put into simplifying set-ups. This item captures variety as "experienced" by the process. (L-H, rule R1.2)	- L-H categorisation, applying rule R2 to the five individual items. Used to classify plants.

Context Variable	Unit of Measurement	Measurement items/ Characterisation of the context variable (a)	Summary (b)
Workforce Skill Level	Plant	- Training: - frequency; systematic (on-going) vs. ad-hoc - specific skills in depth vs. broad skill base - specific training in quality control/ quality improvement - Perceptual skill level compared to industry. - Existence of multi-skilled employees. - Employee appraisal.	- Qualitative summary. Used as background information.
Organisational Structure	Plant	- Number of production workers vs. other (staff). - Number of people employed in several categories (e.g., management, quality control, engineering, etc.). - Number of hierarchical levels in production. - Number of different job classifications. - Organisational chart.	- Qualitative summary. Used as background information.
Organisation of the Quality Function	Plant	- How the quality function is organised and its relation to the plant's organisational structure.	- Qualitative summary. Used as background information.
Nature of Quality Problems	Plant/ Dominant Process	- Most frequent causes of quality problems (design-related, incoming materials, or manufacturing processes and equipment).	- Qualitative summary. Used as background information.
Quality Performance	Plant/ Dominant Process	- Current defect rates in dominant process: - % items passing final inspection without rework - % of internal scrap and rework - Current plant wide quality performance: - Warranty costs as a % of sales. - Customer satisfaction reported by management on a 1 (disappointed) -5 (delighted) scale. - Recent trends in quality performance.	- Qualitative summary. Used as background information.

Context Variable	Unit of Measurement	Measurement items/ Characterisation of the context variable (a)	Summary (b)
Labour intensity	Dominant Process	- Number of purely manual process steps/total number of process steps.	- L-H categorisation, applying rule R1.1. Used as background information.
Turnover Rate for Production Workers	Plant	- Annual % turnover rate for production workers.	- L-H categorisation, applying rule R1.1. Used as background information.
Overall Performance of Manufacturing	Plant	- Overall Performance of Manufacturing compared to other plants in industry (perceptual). - Evolution of operational performance over recent years (inventory, lead times, on-time delivery, productivity, cost).	- Qualitative summary. Used as background information.
Plant Performance on Relevant Competitive Dimensions	Plant	- Performance on Order-winners and Qualifiers relative to the competition.	- Qualitative summary. Used as background information.
Financial Performance	Plant	- Profit, Assets, Return on Investment, Sales over recent years.	- Qualitative summary. Used as background information.

(a) - The information used to fill in this column is obtained by searching for pieces of raw data associated with the codes corresponding to the several context variables (see Appendix 5).
- (L-H): indicates that the measurement item is classified into three levels: Low (L), Medium (M), and High (H) according to the observations made across all cases. The rules used to arrive at the L, M, H scores are described in Chapter 7.

(b) The summary takes the form of a qualitative description or a Low (L), Medium (M), High (H) score, based on the observations made across all cases. The rules used to arrive at the L, M, H scores are described in Chapter 7. As is explained in Chapter 7, some of the variables are explicitly used to classify plants into one of three strategic context configurations (Niche Differentiator, Broad Differentiator and Cost Leader), while others are used as only as rich background information.

APPENDIX 8.

Templates for the Tabular Displays used for the Reduction of Data on the Use of Quality Management Practices.

Process Quality Management Practices

Formalised New Product Introduction Process (NPI)

Description of the NPI process	Characterisation	Degree of use
Detailed description of the sequence of steps in the NPI process. [relevant codes: PROC NPI]	Textual characterisation of the NPI process along the following dimensions: - formalisation of process - extent to which the emphasis is on solving all problems before production begins - existence and adherence to design for manufacturibility guidelines - time from the availability of the physical design to the shipment of the first units to customers	H, M or L, applying rule R1.2 to the characterisation of the practice.

Zero Defects (ZD)

List of ZD mechanisms identified in the dominant process	ZD intensity	Degree of use
Textual description of each mechanism. [relevant codes: PROC ZD]	No. of ZD mechanisms/No. of steps in the dominant process	H, M or L, applying rule R1.1 to the ZD intensity figure.

Changeover Inspection (CI)

List of CI checks identified in the dominant process	CI intensity	Degree of use
Textual description of each check. [relevant codes: PROC CI]	No. of CI checks/ No. of steps in the dominant process	H, M or L, applying rule R1.1 to the CI intensity figure.

Real Time Feedback (RTF)

RTF points in the dominant process	Real time analyses performed	Real time corrective action mechanisms
Textual description of RTF point. [relevant codes: PROC RTF CA]	Textual description of the real time analysis conducted on the feedback received.	Textual description of corrective actions taken as a response to the feedback received.

The above table provides evidence of mechanisms to obtain real time feedback from the process and real time mechanisms to act upon it. Based on the table, an RTF intensity figure is calculated as follows:

- Each instance of provision of real time feedback is counted as 0.5 (dampening factor) if the respective data is collected only for a sample of boards (e.g., sample inspections, data collected for only some products) or 1, if it is collected for all boards (e.g., 100% inspections for all products). The scores of all instances are added and divided by the number of steps in the dominant process to arrive at a measure of RTF intensity.

The intensity figure in turn is converted into a Low, Medium and High degree of use rating using rule R1.1.
The sensitivity analysis described in the annex to this appendix shows that this procedure is very robust in respect to the values of the dampening factor around the chosen figure of 0.5. That is, the H, M, L ratings for the research sample are affected very little by the choice of a particular value for the dampening factor.

In-Process Off-Line Feedback (IOF)

Sources of data from the dominant process	Off-line analyses performed	Corrective action mechanisms
Textual description of sources of in-process data subjected to off-line analyses. [relevant codes: PROC IOF DC AN CA]	Textual description of the off-line analyses conducted on the data collected.	Textual description of corrective actions taken as a response to the feedback received.

The above table provides evidence of mechanisms to obtain IOF feedback from the process and mechanisms to act upon it. The IOF instances are then converted into a measure of the intensity of use of the practice, by dividing the number of identified IOF instances by the number of steps in the dominant process. This measure is in turn converted into a Low, Medium and High degree of use rating using rule R1.1.

Overall-Process Off-Line Feedback (OOF)

Sources of data	Off-line analyses performed	Corrective action mechanisms
Textual description of sources of end of process data subjected to off-line analyses. [relevant codes: PROC OOF DC AN CA]	Textual description of the off-line analyses conducted on the data collected.	Textual description of corrective actions taken as a response to the feedback received.

The above table provides evidence of mechanisms to obtain OOF feedback from the process and mechanisms to act upon it. The OOF instances are then converted into a Low, Medium and High degree of use rating using rule R1.2 (the use of OOF practices is difficult to quantify, reason for which rule R1.2 was used).

Cross-Functional Design Efforts

Description of the use of the practice	Characterisation	Degree of use
Detailed textual description of the role of the functions internal to the plant that are involved in product design/introduction. [relevant code: CROSSF]	Extent to which relevant functions co-operate in product design/introduction.	H, M or L, applying rule R1.2.

Workforce Management

Empowerment (EMP)

Responsibilities assigned to production workers	Empowerment intensity	Degree of use
List of responsibilities assigned to production workers. [relevant codes: WORKFORCE EMP PEOPLE]	Number of responsibilities assigned to production workers.	H, M or L, applying rule R1.1 to the intensity figure.

Suggestion Schemes (SS)

Description of suggestion initiatives	Characterisation	Degree of use
Detailed textual description of the structures available to production workers to make suggestions (not necessarily formal suggestion schemes), and the extent to which workers actually participate (by making use of those structures). Includes any reported problems concerning weak participation of workers. [relevant codes: WORKFORCE SS PEOPLE]	Condensed textual summary of the previous information along two dimensions: - strength of suggestion structures - actual worker participation	H, M or L, applying rule R1.2 to the characterisation of the use of the practice

Problem Solving Teams (PST)

Description of existing structures for team problem solving	Characterisation	Degree of use
Detailed textual description of the structures available for team problem solving and whether production workers actually participate in those structures. [relevant codes: WORKFORCE PST PEOPLE]	Condensed textual summary of the previous information along two dimensions: - number of team problem solving structures with participation of workers - level of participation of workers	H, M or L, applying rule R1.2 to the characterisation of the use of the practice

Recognition for Quality (RQ)

Description of existing structures for quality recognition	Recognition for quality intensity	Degree of use
Detailed textual description of the ways available to recognise workers for good performance and/or behaviour on quality. [relevant codes: WORKFORCE RQ PEOPLE]	Number of quality recognition initiatives in place.	H, M or L, applying rule R1.1 to the intensity figure.

Supplier Involvement

Description of the use of the practice	Characterisation	Degree of use
<u>Supplier selection</u> Detailed textual description of the supplier selection process. [relevant codes: SUPPL SELECT]	Condensed textual summary of the previous information along the following dimensions: - thoroughness of selection process. - importance of quality and strategic aspects as selection criteria, as opposed to short-term criteria.	H, M or L, applying rule R1.2.
<u>Supplier assessment</u> Detailed textual description of the supplier assessment process. [relevant codes: SUPPL ASSESS]	Qualitative assessment of the thoroughness of the supplier assessment process.	H, M or L, applying rule R1.2.
<u>Nature of relationships</u> Detailed textual description of the nature of the plant's relationships with suppliers, including the plant's espoused policy and evidence of the nature of the relationships, such as the existence of efforts to reduce the supplier base, exchange of information, technical co-operation, mutual plant visits, length of relationships, provision of feedback on supplier performance, sourcing policy, etc. [relevant codes: SUPPL SRELATS]	Qualitative assessment of the nature of relationships (close vs. arms-length).	H, M or L, applying rule R1.2.
<u>Co-operation in logistics activities</u> Detailed textual description of logistics co-operation activities such as communication links, exchange of data, standardisation initiatives, inventory arrangements, frequency of deliveries, incoming inspection, etc. [relevant codes: SUPPL LOGS]	Qualitative assessment of the level of logistics integration.	H, M or L, applying rule R1.2.
<u>Co-operation in product design/introduction</u> Detailed textual description of co-operation activities in product design/introduction. [relevant codes: SUPPL SDESIGN]	Qualitative assessment of the level of co-operation.	H, M or L, applying rule R1.2.

Customer Focus

Description of the use of the practice	Characterisation	Degree of use
<u>Customer relationships</u> Detailed textual description of the nature of the plant's relationships with customers, including the plant's espoused policy and evidence of the nature of the relationships, such as the extent to which the plant tailors services to individual customers, the extent to which the plant's activities are organised around individual customers, the importance placed on repeat business, the customers' sourcing policy, frequency and richness of contacts with customers, extent of logistics integration, etc. [relevant codes: CFOCUS CRELATS]	Condensed textual summary of previous column.	H, M or L, applying rule R1.2.
<u>Customer involvement in product design</u> Detailed textual description of the customer's role in product design/introduction, in particular, the extent of the plant's interaction with customers and the aspects that customers can influence in the design/introduction process. [relevant codes: CFOCUS CDESIGN]	Condensed textual summary of previous column.	H, M or L, applying rule R1.2.
<u>Collection of information on latent customer needs</u> Detailed textual description of the existing mechanisms for collecting information on the latent needs of customers (forward looking information, for example, about new requirements, services or technologies needed by existing and potential customers). [relevant codes: CFOCUS LATENT]	Condensed textual summary of previous column, with characterisation of the overall strength of the observed mechanisms.	H, M or L, applying rule R1.2.

Description of the use of the practice	Characterisation	Degree of Use
<u>Collection of information on existing customer needs</u> Detailed textual description of the existing mechanisms for collecting information on the existing needs of customers (information on the importance placed by existing customers on several requirements (e.g., price, delivery, etc.) and the plant's performance across those). [relevant codes: CFOCUS EXIST]	Condensed textual summary of previous column, with characterisation of the overall strength of the observed mechanisms.	H, M or L, applying rule R1.2.
<u>Dissemination and responsiveness to customer information</u> Detailed textual description of the existing mechanisms to disseminate information collected on customer needs within the organisation and mechanisms for responding to that information. [relevant codes: CFOCUS DISSEM]	Characterisation of the strength and degree of formality of the observed mechanisms.	H, M or L, applying rule R1.2.

Annex to Appendix 8.

Sensitivity analysis for the dampening factor used in the rule to rate the degree of use of the Real Time Feedback (RTF) practice.

The following table shows the RTF intensity figures for the research sample and the respective H, M, L ratings for different values of the dampening factor used in the rule to arrive at the degree of use rating for RTF. The RTF intensity figures are derived from the data on the use of process quality management practices (including RTF) in the research sample. These data are shown in Appendices B-12 to B-16.
The results of the sensitivity analysis show that the rule used to obtain the RTF ratings is very robust to the value of the dampening factor around the chosen value of 0.5.

Dampening Factor	RTF ratings (*)				
	Plant 1	Plant 2	Plant 3	Plant 4	Plant 5
0.0	**M*** (0.50)	L (0.00)	L (0.20)	M (0.75)	H (1.43)
0.1	L (0.50)	L (0.03)	L (0.22)	M (0.75)	H (1.46)
0.2	L (0.50)	L (0.07)	L (0.24)	M (0.75)	H (1.49)
0.3	L (0.50)	L (0.10)	L (0.26)	M (0.75)	H (1.51)
0.4	L (0.50)	L (0.13)	L (0.28)	M (0.75)	H (1.54)
0.5	**L (0.50)**	**L (0.17)**	**L (0.30)**	**M (0.75)**	**H (1.57)**
0.6	L (0.50)	L (0.20)	L (0.32)	M (0.75)	H (1.60)
0.7	L (0.50)	L (0.23)	L (0.34)	M (0.75)	H (1.63)
0.8	L (0.50)	L (0.27)	L (0.36)	M (0.75)	H (1.66)
0.9	L (0.50)	L (0.30)	L (0.38)	**L*** (0.75)	H (1.69)
1.0	L (0.50)	L (0.33)	L (0.40)	**L*** (0.75)	H (1.71)

(*) The RTF intensities giving rise to the H, M, L ratings are shown in brackets. Ratings which deviate from the ones obtained using a 0.5 dampening factor are indicated by an "*".

APPENDIX 9.

Template for the Tabular Displays Used for the Reduction of Data on the Difficulties Experienced in the Use of Quality Management Practices and the Respective Coping/Mitigating Strategies in Place.

Reported difficulties and causes	Associated practices	Coping/mitigating strategies used
Textual description of the difficulties associated with the use of the quality management practices in question and respective causes (as reported by informants in the plant). [relevant codes: codes associated with the practices in question, plus codes DIFF, STRAT, INFO, GEN, PRIOR, DYN, CUST, ORG, TECH]	Indication of the practices affected, together with their degree of use rating obtained from the degree of use displays.	Textual description of the coping/mitigating strategies that were identified to be in place in response to the difficulties reported.

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