THE UNIVERSITY
of LIVERPOOL

THE PARAMETRIC MODELLING OF QUALITY DEVELOPMENT WITHIN MANUFACTURING ORGANISATIONS

Thesis submitted in accordance with the requirements of the University of Liverpool for the degree of Doctor in Philosophy by **Dennis Frederick Kehoe**

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TABLE OF CONTENTS

LIST OF FIGURES

CHAPTER 1

INTRODUCTION AND BACKGROUND

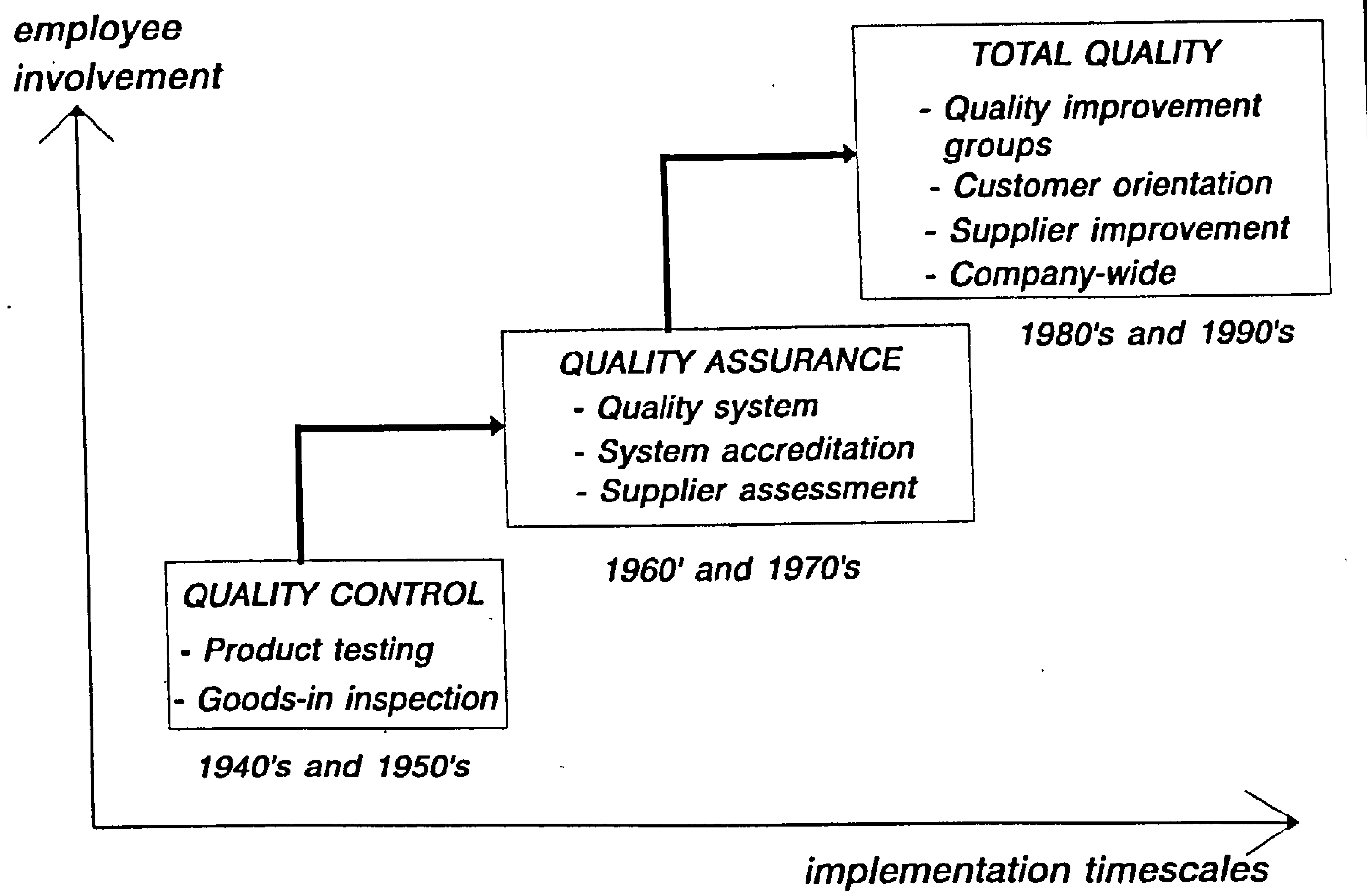
1.1. Research Background

During the 1980's the subject of Quality Management received rapidly increasing international attention, both as an important strategic business tool and as a fertile area of academic study and research.

As an element of business management, the issue of Quality became increasingly a critical competitive dimension, particularly in the U.K. during the years following the recession of the early 1980's. Prompted by both Government and competitor pressures many organisations, particularly in the manufacturing and distribution sectors adopted a more formal and professional approach to Quality Management. The attractiveness of adopting Quality improvement as an explicit business objective was brought about by the simultaneous benefits of improved market revenues, through increased customer satisfaction, and reduced operating costs through reduced waste.

The development from an "inspection" based approach to managing product or service Quality to an "assurance" based approach and finally to a "total" approach became a strategic objective for the Quality development of many organisations as illustrated in Figure 1.1.a.

Figure 1.1a The development of Quality management approaches (Source: Kehoe [1996])



The increasing maturity of Quality management as an important business performance improvement methodology was illustrated by a number of complimentary developments.

First, a more complete understanding of the comparative business effects of Quality development began to emerge as techniques for measuring the 'Cost of Quality' were standardised. The publication of the British Standard BS 6143 [12, 1992] in 1982 identified the relationship between Quality development and a reduction in the overall cost of Quality through an investment in appraisal and prevention costs rather than incurring internal and external failure costs.

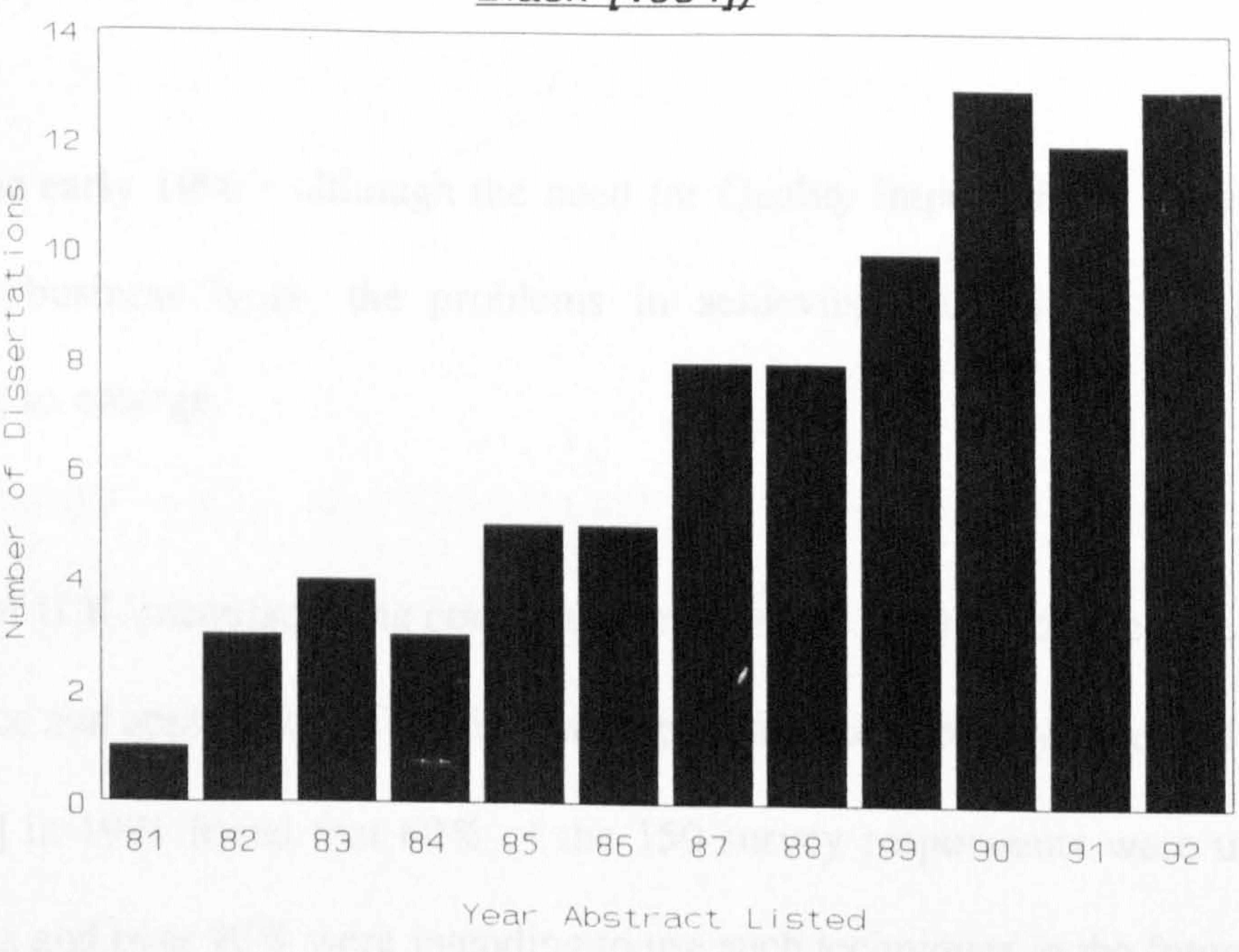
Second, the competitive pressure in manufactured goods, particularly from Japan, encouraged a more international viewpoint in terms of the possible approaches to Quality management. Based upon the ideas of Deming [27,1986] and Juran [55,1967] a more comprehensive approach to Quality management was available and was seen as a major contributor to the competitive success of many (most notably Japanese and American) organisations.

Third, based upon the increasing importance of the Quality profiles of companies, a number of assessment mechanisms emerged to evaluate the level of Quality development. The publication of BS 5750 in 1979 and the subsequent adoption and amendment to form the ISO 9000 series of standards [10,1994] in 1987 and the BS EN ISO 9000 series in 1994 has promoted the assessment and accreditation of supplier Quality systems worldwide. In the U.S. the Baldrige award [3,1995], in Japan the Deming award [26,1992] and in Europe the European Quality award [34,1991] have all been promoted as mechanisms for assessing excellence in the management of Quality. All of these assessment techniques stimulated organisations to improve the management of Quality and to promote the Quality of their products or services in the marketplace.

Finally, a whole host of Quality management tools, techniques and methodologies emerged to support the Quality development process. The expanding Quality "toolkit" provided organisations with a range of solutions which could be adopted to address any form of diagnostic or remedial situation.

In addition to the maturing situation in industry where the application of Quality management became widespread, the academic research interest and activity also expanded rapidly during the 1980's. Black [9,1994] identifies the dramatic increase in the number of citations listed in the Social Sciences Citation Index for each of the leading Quality gurus between 1976 and 1991 and the increase in Quality-related dissertations and theses between 1981 and 1992 (as illustrated in Figure 1.1.b) as indicators of increased research attention.

Figure 1.1b Management Dissertations on Quality 1981-1992 (Source: Black [1994])



Of the approximately 160 theses identified by Black, the majority of these described research into the application of specific Quality-related techniques (such as Statistical

Process Control, Quality Costs or Quality Circles) and only 10 were concerned with Quality management. In the U.K. since the early 1980's research groups have been established at a number of Universities (including Bradford, Liverpool, Sheffield Hallam and UMIST) examining the Quality improvement process and the range of activities collectively described as Total Quality Management (TQM).

1.2. Research Need

As the subject area of Quality management developed, the complexity of the process of Quality development became apparent. For most organisations Quality development requires change and the management of change is traditionally a complex and demanding process.

During the early 1990's although the need for Quality improvement continued to be a critical business issue, the problems in achieving Quality development were beginning to emerge.

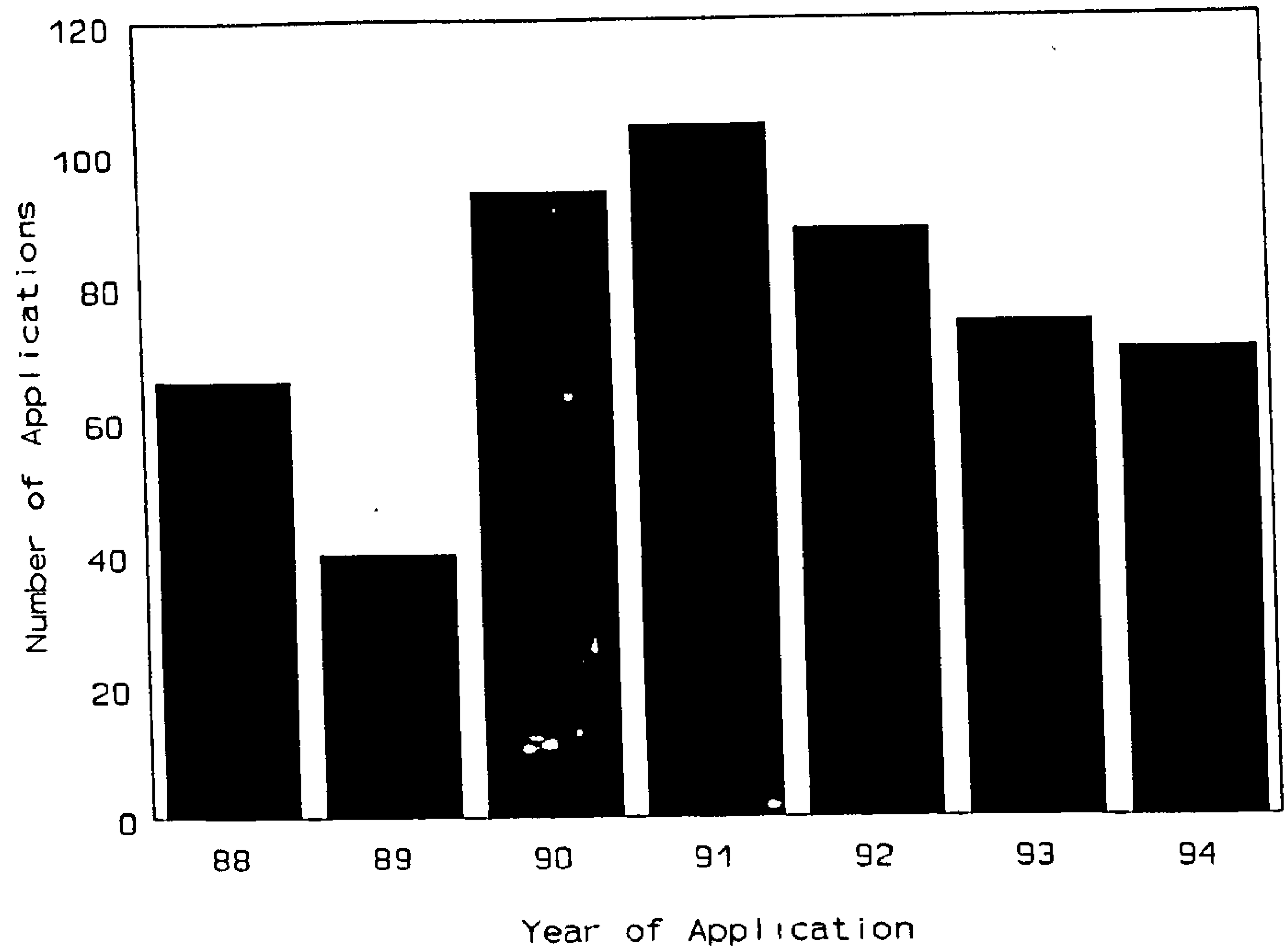
Surveys of U.K. manufacturing companies in the early 1990's indicated the increasing importance and application of Quality management. Research by Ingersoll Engineers [50,1991] in 1991 found that 60% of the 150 survey respondents were using TQM techniques and over 90% were intending to use such techniques in the future. Similar research by Benchmark Research [6,1992] in 1992 reported that 97% of the survey respondents thought that Quality improvement was the key issue over the next five years.

During the same period, however, a number of important surveys in both the U.K. and the U.S. began to illustrate that companies were experiencing difficulties with their Quality development process. The Economist [103,1992] in 1992 summarised a number of surveys indicating problems with Quality development.

> In a survey of 500 U.S. manufacturing companies only one third felt that their TQM programmes had a significant impact on their competitiveness (Arthur D.Little).
>
> Only a fifth of the 100 British firms surveyed believed their Quality programmes had achieved tangible results (A.T.Kearney).
>
> Of those Quality programmes that have been in place for more than two years, two thirds simply grind to a halt because of the failure to produce hoped for results (McKinsey).

Howe, Gaeddert and Howe [47,1992] identified a similar phenomenon in which companies would experience a certain amount of initial success in improving the manner in which Quality was managed within the business but find themselves unable to sustain this Quality development in the long term. A quantitive measure of the problems experienced by companies in sustaining Quality development was provided by The Economist [104,1995] in 1995 in terms of the decline in the number of U.S. companies applying for the Baldrige award illustrated in Figure 1.2.

Figure 1.2 The number of applications for the Baldrige Award reducing by one third since 1991 (Source: The Economist [1995])



The research literature on Quality development together with the experiences of organisations implementing Total Quality Management illustrate a lack of understanding of the process of development which companies undergo. This lack of a coherent framework for understanding the relationship between what organisations do (in terms of the application of Quality management tools, techniques and methods) and what happens in terms of development is fundamental to improving the management of Quality. By continually focusing upon 'doing' and not understanding what is 'happening' the majority of organisations lose interest and enthusiasm as one particular Quality activity or another eventually exhibits a diminishing return in terms of improved business performance.

There is a research need therefore to identify an appropriate model of Quality development which reflects the changes in the management of Quality as different Quality improvement activities are undertaken. Such a model would provide a coherent framework for understanding the relationship between the various Quality management activities and the role of these activities at various stages of Quality development. The model for Quality development should enrich the understanding of Quality management and should be rigorous enough to cover all aspects of the subject area and yet flexible enough to reflect the specific development of individual organisations.

1.3. Research Hypothesis

The hypothesis for this research was that a model of Quality development could be proposed and that this model or framework could be validated using a set of characteristic parameters which interpret Quality management activities in terms of a developmental process. This hypothesis therefore requires that the time-based Quality development of an organisation is related to the Quality management activities and that this change process can be illustrated parametrically.

The proposal and validation of a model of Quality development requires a framework describing all the main elements of Quality management and relates these to the stages through which an organisation's approach to Quality matures. To test the hypothesis requires both the classification of the tools, techniques and methods of Quality management and also requires a mechanism for measuring or describing Quality development.

Such a model of Quality development would assist organisations in the difficult task of Quality improvement and would provide a more coherent academic framework for understanding Quality management.

1.4. Research Objectives

The main aims of this research are:

- to establish an academic framework for understanding the Quality development process.
- to provide organisations with a practical and usable insight into developing the way in which Quality is managed over time and improvement sustained.

These research objectives are addressed through the identification of an appropriate structure to describe and classify the effects of the various Quality management tools, techniques and methodologies and then to be able to systematically 'position' organisations against this developmental model. The main research challenge is to establish the parameters which link the Quality management activities and the changes or developments which occur within organisations as a result.

1.5. Research Method

The research has been conducted in three main stages as illustrated in Figure 1.5.

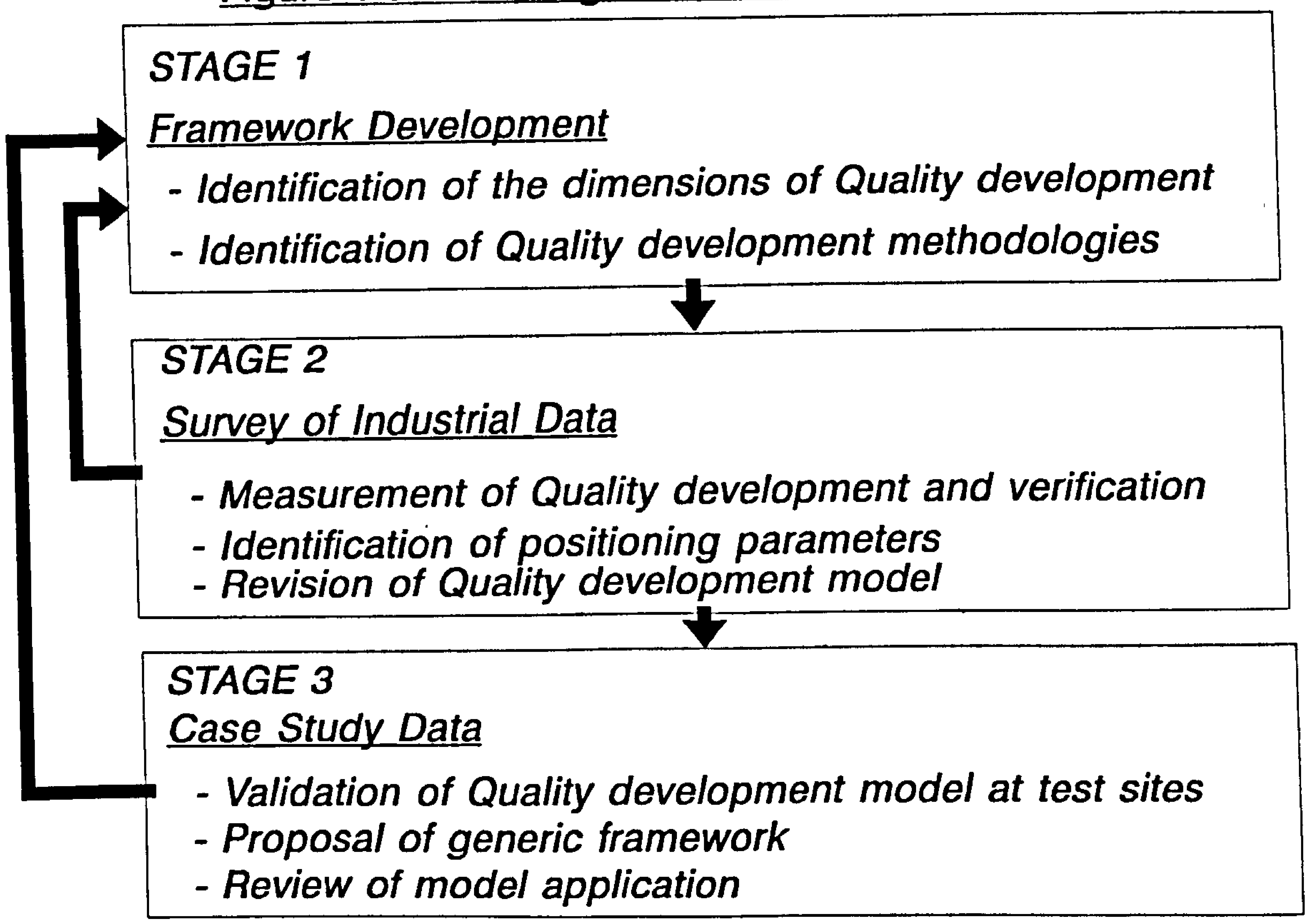


Figure 1.5 Main stages in the research method

The first stage of the research was derived over a number of years from teaching, researching and consulting in Quality management. The mapping of the various Quality improvement activities, their relationships and their effects led to the identification of characteristic phases of Quality development. These phases of development were identified through the pre-requisite relationships between the Quality improvement activities and also an examination of the business benefits derived from applying particular tools or techniques at different points in the organisational development lifecycle.

This developmental framework was also substantiated by the research of both Mann and Kehoe [73,1995] and Zain and Kehoe [109,1996]. In the first of these research programmes a model for Total Quality Management (TQM) development was proposed which identified certain core activities and the relative strategic and operational benefits of each of these activities. Although this research primarily identified the relationship between TQM activities and business benefits, the survey data and case study data indicated a 'third' dimension, namely organisational development.

The second research programme specifically set out to measure the Quality 'position' of a manufacturing company and again the research data illustrated differences between organisations and between industrial sectors indicative of a developmental process.

The second major stage of the research was to verify the theoretical development model identified in Stage 1 through various industrial surveys. Some of this data had been previously used to illustrate certain features of Quality Management, however, by mapping each of the industrial surveys onto an overall framework of Quality development a more coherent research output can be produced. In order to utilise the various industrial surveys, a number of key parameters were identified to characterise each of the phases of Quality development. The empirical data finally was used to refine the model of Quality development in preparation for the case study work in the final stage of the research.

The third and final stage of the research examined a number of industrial organisations over varying periods of time. These case studies illustrated the practical developments of organisations seeking Quality improvement and supported the model of development proposed in stages 1 and 2. Companies were selected to illustrate each of the proposed phases of Quality development and the application of the associated Quality improvement tools and techniques. The generic nature of the proposed Quality development model was endorsed by the variety of organisations case studied and the significant commonality when viewed using this framework.

1.6. Research Benefits

The main benefits of this research are twofold:

- by providing a coherent framework of Quality development, students and researchers can obtain a better understanding of the relationships between the plethora of Quality Management tools techniques and methodologies. This in turn will promote more coherent development of new techniques which build upon previous developments rather than promoting academic discord over the relative merits of one approach to another.

- by providing an understanding of the Quality development process, industrial organisation can view one Quality improvement activity in relation to another rather than as competing 'flavours of the month'. This will help prevent the current Quality 'paralysis' as organisations will see one Quality development leading and re-focusing to the next phase rather than simply experiencing the diminishing business benefits of a single aspect of development.

SUMMARY

- *Since the early 1980's Quality improvement has increasingly become an integral part of business development seeking enhanced internal and external competitiveness.*

- *The increased academic and industrial interest in Quality management has led to a research need for an improved understanding of the time-based relationships between Quality improvement activities and the corresponding organisational developments.*

- *The research hypothesis is that a model of Quality development can be identified which can be used to describe both the Quality improvement activities and the organisational maturity which takes place.*

- *The objectives of the research are therefore to provide an academic framework of understanding Quality development which can be used by organisations to track and sustain progress.*

- *The research was conducted in three stages, the intellectual development of the framework, the validation through industrial survey data and the illustration through industrial case studies.*

- *Finally the main beneficiaries of the research are academics wishing to understand the relationship between tools, techniques and methodologies and also industrialists who can improve their business planning.*

CHAPTER 2

BACKGROUND - LITERATURE REVIEW

This chapter presents the first of two parts of the critique and review of the literature and subject matter of Quality Management. This chapter provides a general review of the background literature on Quality Management in terms of the historical context and defined principles whilst Chapter 3 below considers the literature specific to the modelling and measurement of Quality development. Together the literature reviewed in these two chapters have formed the academic basis upon which the developmental framework proposed in this research is based.

Chapter 2 is structured in line with the predominant 'model' of Quality management proposed by John Oakland [83,1991] at the University of Bradford and adopted by Joe Cullen [22,1987] at Rover Group. This model of Quality Management proposed three dimensions, namely systems, people (or culture) and techniques as described below in Chapter 3. This framework is used to review the background literature on Quality Management.

2.1. Background Literature on Quality and Quality Management

As the subject area of Quality has received increasing academic and business interest over the past 30 or so years, so the literature has increased rapidly. Any serious review of literature in this subject area must consider contributions from a wide range of sources including books, journal articles, research papers, periodicals, business reports, consultants reports and press articles. Surveys into Quality management practice for example are undertaken by a whole range of organisations from research bodies, to government departments from trade associations to market research organisations and from industrial companies to newspapers. The literature reviewed here is therefore a subset of the writings in this subject area and has been selected to illustrate the current state of knowledge and to identify current areas of weakness.

2.1.1. The Historical Context of Quality Management

The history of Quality dates back to the origins of craftsmanship itself. Kehoe [57,1996] quotes King Hamurabi who in the third century B.C. formulated the earliest recorded Quality system by stating:

'if a builder builds a house which subsequently falls down, then his own house shall be destroyed. If the owner and his family are killed then the builder and his family shall be killed'

In the U.K., Johnston [53,1986] has traced the concept of Quality back to the 12th Century where Guilds 'disciplined strictly the Quality of their member's work'. Many of the engineering developments of the industrial revolution were led by advances in metrology. During the nineteenth century the military requirements for precise armaments led to the developments in tolerancing and fit and provided the major stimulus to the control of Quality.

Developments in the U.K. in the early part of the 20th century included the formation of the Technical Inspection Association in 1919 and the publication by the newly formed British Standards Institution of the first standard on Quality Control in the 1930's. During this period work by Fisher on the optimisation of agricultural yields led eventually to the techniques for the design of experiments formulated by Taguchi [101,1986]. Work in the U.S. during the 1930's by Dodge and Romig [30,1941] at the Bell telephone laboratories on statistical sampling pioneered the application of statistical methods to Quality control that were subsequently developed by Shewhart [97,1951] and by Deming [27,1986].

Dale, Lascelles and Plunkett [24,1990] identified four key stages of evolution after the second world war which were identified as Inspection, Quality Control, Quality Assurance and Total Quality Management. Feigenbaum [36,1983] proposed a similar series of historical developments and suggested 'major changes in the approach to quality-control work have occurred approximately every 20 years'. Feigenbaum identifies 'operator quality control' before 1900 followed by 'foreman quality control' around 1920 and 'inspection quality control' during the 1930's and 1940's. During the 1950's Feigenbaum identified the development of 'statistical Quality control' and in the 1970's the concept of 'Total Quality Control'. In the 1990's he envisaged 'Total Quality Management' as the predominant approach. These historical perspectives on the development of the approach to managing Quality relate the subject matter and do not address the developments which occur within organisations as described below in Chapter 3.

The post war developments in the application of statistical quality control were identified by Ishikawa [51,1982] as fundamental to the change in management approach in Japan and according to the European Foundation for Quality Management [34,1991] led to the Japanese 'promoting Quality at all levels'. During this period Juran [55,1967] introduced the concept of company wide quality control and identified a 'waive of enthusiasm for the use of statistical methods in quality control'. In 1951 the Deming Price was established to recognise Japanese companies exhibiting excellence in Quality management and eventually the Japanese approach to managing Quality became a world model for development.

Hutchins [48,1985] identified the introduction of Quality circles in Japan in 1961 as a key part of the involvement process and an indication of the cultural development necessary for progress in the management of Quality. The 1970's saw the first developments in terms of formalised Quality systems in the U.K. with the publishing of BS 5173 in 1974 which led to the development and publications of BS 5750 in 1979. In the early 1980's a number of popular writers, including Peters and Waterman [87,1982] and Crosby [21,1979] began to identify the linkage between Quality management and business performance and the next decade saw an explosive expansion in the literature of Quality Management. In the late 1980's and early 1990's a number of important 'blueprints' for organisational quality improvement emerged including the implementation strategy proposed by Cullen and Hollingum [22,1987], the people development program by Choppin [18,1991] and the leadership guide produced by Chang, Labovitz and Rosansky [17,1993]. By the mid 1990's, Quality management had become a populist movement and as a result of the perceived 'hype' a number of studies were commissioned to examine the deficiencies of the Quality movement. The Economist article quoted above in Chapter 1 identified many Quality improvement programmes were exhibiting problems as organisations struggled with the reality of Quality development. Howe, Gaeddert and Howe [47,1992] identified Quality development as a maturing process which requires to 'integrate quality processes and customer information into existing systems'. This research thesis attempts to provide such an integrating framework.

2.1.2. The Defined Principles of Quality Management

The extensive literature on Quality and Quality Management has generated a vast (and increasing) array of definitions for the basic terms used in the subject area. The word 'Quality' is derived from the Latin 'Qualitas' meaning 'of (or from) what' and is defined in the Oxford English Dictionary [84,1969] as:

'(noun) degree of excellence, relative nature of kind or character, general excellence'.

As the subject area has developed, the meaning of the term Quality as a management concept has matured and become abstracted from the use of the term in common speech. The maturing definition of the term Quality does reflect the developments in the approaches to managing Quality from the viewpoint of Juran [55,1967] who viewed Quality as 'fitness for purpose' through Crosby's [21,1979] definition of 'conformance to specification' and Deming's [27,1986] statistical view that 'Quality is a predictable degree of uniformity and dependability at low cost and suited to the market' to Taguchi's [101,1986] concept of 'the losses to society caused by the product after its delivery'. Bergman and Klejsjo [7,1994] provide a useful definition as the 'quality of a product is its ability to satisfy the needs and expectations of the customers'. The same reference also identifies the Quality dimensions of an article as being:

- reliability
- durability
- performance
- serviceability
- safety
- faultless
- environmental kindness
- aesthetics

During the 1980's the international standards bodies produced a working definition of Quality as 'the totality of features and characteristics of a product or service that bear on its ability to satisfy a stated or implied need' [14,1987]. Oakland [83,1991] contributed to this wider view of Quality in his definition as 'Quality in the eyes of the customers is always much more than just the Quality of the product or the basic service offered. (It concerns).....reliability, consistency, speed of delivery, accuracy of invoice, courtesy of telephone answering, value of information given, reputation of the company and so on'.

The definitions proposed during the 1990's reflect the increased emphasis upon customer orientation in the approach to the management of Quality. Choppin [18,1991] concludes that Quality should be viewed as 'meeting the negotiated requirements and expectations of the customer' and Dean and Evans [25,1994] similarly expressed Quality as 'meeting or exceeding customer expectations'. The maturing view of the concept of Quality reflects both the historical development of the subject area described above in section 2.1.1. and also the developmental view of Quality management proposed below in Chapter 4.

A further important principle of Quality Management is the concept of Quality Assurance which is defined in the standard BS 4778 [14,1987] as 'all activities and functions concerned with the attainment of Quality' and in ISO 8442 [14,1987] as 'all those planned and systematic actions necessary to provide adequate confidence that a product or service will satisfy given requirements for Quality'. This systems approach to Quality was described by Juran [55,1967] as the activity of providing, to all concerned, the evidence needed to establish confidence that the Quality function is being performed adequately' and by Evans and Lindsay [35,1996] as identifying appropriate Quality characteristics of final products, the factors that contribute to these characteristics and procedures for quantitatively evaluating and controlling these factors. These concepts of a Quality Assurance approach are summarised in the definition by Kehoe [57,1996] of Quality Systems as 'the organisational structure, responsibilities procedures and resources for implementing Quality management'.

The final concept of Quality management which is important to define in terms of this research thesis is the approach described as Total Quality Management (TQM). Previous research by Mann [71,1992] suggested that a universally agreed definition of TQM did not exist and that the definitions could be divided into two types; those which described TQM in terms of its ultimate goal and those describing TQM in terms of the activities or functions that need to be addressed to achieve its objective. Useful definitions do exist, however, which provide important insights to the level of Quality development which correspond to TQM. Pfau [88,1989] provides a widely used working definition of TQM as 'an approach to continuously improving the Quality of goods and services delivered through the participation of all levels and functions of the organisation'. These fundamental principles of improvement and involvement were also expressed in the definition proposed by Newall and Dale [81,1991] as 'a concept, the principles on which is to develop a Total Quality Culture, a journey which has no end and quality improvement is the enabling mechanism which must be continuous and companywide'.

The strategic role of TQM was recognised in the definition proposed by the DTI [28,1991] as 'a way of managing the effectiveness, flexibility and competitiveness of business as a whole' and by the report to the U.S. General Accounting Office in May 1991 which stated 'Total Quality Management (TQM) is a relatively new approach to the art of management. It seeks to improve product and service quality and increase customer satisfaction by restructuring traditional management practices. The application of TQM is unique to each organisation that adopts such an approach'. Atkinson [2,1990] linked the strategic and improvement principles in describing TQM as 'a strategic approach to producing the best product and service possible - through constant innovation and both the Deming Prize Committee and the British Quality Award executive committee attempted to define the fundamental principles of TQM against which development would be assessed as 'a system of activities to ensure the Quality of products and services in which products and services of the Quality required by the customers are produced and delivered economically' and 'a corporate management philosophy which recognises that customer needs and business goals are inseparable' respectively.

The fundamental principles which emerge from this array of definitions of TQM are that it represents a strategic philosophy of management which is customer orientated, requires the involvement of everyone through teamwork and necessitates continuous improvement.

2.1.3. The Business Context of Quality Management

The literature and research which relates Quality Management to competitive business advantage has also mirrored the development of the subject area.

The early post-war years saw Quality as a functional activity primarily addressed through inspection techniques and having little strategic business impact. Deming's [27,1986] pioneering work with Japanese industries during the 1950's stressed the strategic business importance of Quality management and the successes of Japanese manufacturers in world markets during the 1960's and 1970's began to reinforce the view that Quality management was a strategic tool. The experiences of Harold Geneen the Chief Executive of the ITT corporation were popularised by Crosby [21,1979] in 1979 as 'Quality is not only right, it is free. And not only is it free, it is the most profitable product line we have'. This link between business costs and the approach to Quality management became the primary driver for the widespread adoption of the need for Quality development during the 1980's. The formalisation of the standardised approach to measuring the cost of Quality was provided in 1981 with the initial publication of BS6143 'Guide to the determination and use of Quality related costs'. The 1980's saw the publication of a great many case studies and surveys indicating the business importance of a developed approach to Quality management. The European Quality Award sponsors were cited by Zain [108,1993] as identifying that 'in the 1980's companies began to realise that their only way of surviving in business was to pay much greater attention to Quality. In many markets, Quality has already become the competitive edge'. The PIMS Associates study [102,1986] of the impact of product Quality on corporate performances for 1200 U.S. companies in the early 1980's concluded 'product quality is the most important determinant of business profitability'. A U.K. study conducted by Develin and Partners [29,1989] of 307 companies identified that 59% of respondents indicated that they had started a TQM programme and a further 35% were considering a TQM programme. A detailed study by the U.S. General Accounting Office (GAO) of the 20 highest scoring companies in the 1988 and 1989 Baldridge Award is cited by Evans and Lindsay [35,1996] as identifying that 'in nearly all cases companies that used TQM achieved better employee relations, higher productivity, greater customer satisfaction, increased market share and improved profitability'. The GAO also produced a general framework identifying the mechanisms by which business benefits accrued from TQM activities and principles. Finally the survey of Mann and Kehoe [72,1994] of 43 TQM companies found that 66% believed TQM had increased market share and more than 50% believed that a result of the TQM policy, on average, a turnover increase of 8% per year had been achieved.

Amongst the most significant case studies identifying the business benefits of Quality development were the experiences of Proctor and Gamble and Digital Equipment quoted by Peters and Waterman [87,1982] in terms of the benefits of culture change and Motorola's improvements in employee productivity cited by Evans and Lindsay

[35,1996]. Wedge [106,1989] describes the Total Quality benefits enjoyed in the U.K. by Rolls Royce as being 'changed attitudes, a climate for continuous improvement, elimination of waste, enhanced supplier performance, efficient communication and customer satisfaction'. The experiences of Rank Xerox and GPT cited by Mann [71,1992] also confirmed the positive experiential evidence of the business benefits due to improving the management of Quality. One of the more influential composite case studies was undertaken by the consultancy group David Hutchins Associates [48,1985] which examined 5 companies who had implemented TQM and in each case identified improvements in Quality, market share and profitability.

The problems in actually quantifying the benefits of TQM were identified in a number of references during the 1990's including the paper by Newall and Dale [81,1991] which describes the problem in terms of 'the inability or unwillingness to speculate on the benefits of TQM is probably due to several reasons......consequently this has led to difficulties in isolating and identifying its effects'. These problems reflect the difficulties experienced by many companies during the early 1990's in identifying the contribution to business performance enhancement from a particular Quality development as discussed above in Chapter 1. This thesis attempts to provide a new framework for understanding this developmental process and thereby relating the maturing approach to Quality management to the associated business benefits.

2.2. Quality Management Systems

One of the key developments of Quality management considered in this research has been the systems approach characterised by the ISO 9000 [10,1994] series standard.

This systematic approach to Quality was primarily created to address the issues of consistency and conformance and as Stevens and Williams [99,1991] describe to 'instill confidence in customers that the intended product or service quality will be achieved'.

2.2.1. The Historical Development of Quality Systems

The main developments in terms of Quality systems thinking came from the U.K. in the 1970's where dissatisfaction was growing as to the effectiveness of product standards. The limitations of an inspection-based approach to Quality was being addressed around the world during the 1950's and 1960's and whilst the Japanese emphasis was upon the statistical control of product and process variation, the emphasis taken in the U.K. was upon the development of a systems approach and in particular systems assessment methodologies.

The initial attempts at developing a model for Quality System Management involved the publication in 1974 of BS 5173 and eventually, in 1979, of the initial version of BS 5750 'Quality Systems Model for Quality Assurance'. In 1982 the U.K. Government published a White Paper in which it proposed to specify conformance to BS 5750 as a requirement in Government contracts and in 1983 the International Standards Organisation recognised the need for an international version based upon the U.K. national standard. In 1985 the National Accreditation Council for Certification Bodies was established by the Secretary of State for Trade and Industry to establish competencies for bodies providing certification to BS 5750 and in 1987 these developments were brought together by the publication of a revised version of the standard as BS 5750 :1987 and the international equivalent ISO 9000. In 1994 the standards were again revised to include requirements for a more preventative approach and the U.K. Standard was published as BS EN ISO 9000 : 1994. The main benefits to business of the publication were described by Kehoe [57,1996] as 'they provide a common framework for assessing the management of Quality and this removes the variability of traditional customer assessments, they provide for an international "currency" in terms of the evaluation of a company's Quality management which is important in export markets (and) they provide an internal focus for Quality development which, because it is externally assessed, assists in the management of change process'. The important role of these Quality system developments was recognised by Oakland [83,1991] and by Evans and Lindsay [35,1996] in that 'certain generic characteristics of management practices can be standardised and that a well-designed, well-implemented and carefully managed Quality System provides confidence that the outputs will meet customer expectations and requirements'.

Perhaps the most comprehensive U.K. research survey was carried out by the Lloyds Register of Quality Assurance [66,1991] who interviewed 400 companies on the impact of ISO 9000 and found '89% of companies which have gained ISO 9000 approval say the standard has either met or exceeded their expectations (and) the benefits of ISO 9000 increase the longer the approval is held (and) complementary to TQM'. The same study also identified 'ISO is beneficial to small firms of which 83% reported an improvement in management control (and overall) only 3% of organisations reported that ISO 9000 increased their paperwork and only 6% said the standard was too costly'.

The 1990's have seen a number of references critical of the limitations of the Quality systems standard approach to Quality management and Zain [108,1993] cites Gould's [42,1991] reservations that Quality systems approval does not 'give the company the competitive edge it wishes to gain' and also the drawbacks associated with 'the lengthy and tedious procedures, amount of paperwork required, complexity of content and much delayed publication of standards have often made them ineffective and even obsolete because of the rapid development of technology' identified by Hashim and Khan [44,1990]. Bergman and Klefsjo [7,1994] quote an interview with Juran in which he remarks 'fulfil the requirements of ISO 9000 if necessary but do not let it disturb the Quality work'. The description of the role of Quality Systems in the process of Quality development provided in Chapter 4 below attempts to reconcile these differing views on the contribution of the system approach.

During the 1970's and 1980's parallel development in terms of industry-based Quality system assessment models were also taking place. In the motor manufacturing industry in particular companies such as Ford developed the Q101 [38,1987] and Q1 standards for systems assessment. The Q1 assessment developed in the 1980's is based upon five categories of 'adequacy of the Quality System, process capability review, internal Quality indicators, customer satisfaction and management commitment', and involves the quantitative assessment of each element (rather than the attribute approach of ISO 9000). The convergence of the motor industry standards such as Q1 and ISO 9000 was brought about in 1994 by the publication of the QS 9000 series standard [91,1995] which has been adopted by Ford, Chrysler and General Motors and encompasses all the requirements of ISO 9000 but includes additional requirements such as continuous improvement, manufacturing capability and the production part approval process.

2.2.2. The Principles of Quality Systems

The underlying principle of Quality Systems development has been to formalise all the elements within an organisation which contribute to the management of Quality. The definition of these elements (described below in Section 3) forms a system's framework which if effectively managed will ensure conformance to customer requirements.

The principles of Quality System design are described by McRobb [70,1989] and by Kehoe [57,1996] and are described in outline in ISO 9004 [10,1994]. Whilst ISO 9000 and QS 9000 both identify the required elements of a Quality Management System they do not provide a design methodology for the application within any given organisation. Kehoe [57,1996] describes the basic stages of the Quality system design process as 'objectives definition, product definition, process description, verification description and system co-ordination'. McRobb [70,1989] identifies the three basic elements of systems design as 'Quality Manual (policy), Quality Procedures (methods and responsibilities) and Quality Work Instructions (tasks and techniques)'.

The principles of implementing Quality systems is described by Stebbings [98,1995] in terms of the organisational, documentational and operational requirements and the approaches to implementing systems conforming to ISO 9000 have been described in surveys undertaken by Kehoe [58,1993] and by Connell [19,1994]. Current survey based research into post ISO 9000 Quality development strategies by Kehoe and Najmi [61,1996] has examined the relationship between implementation strategies and post-accreditation developments.

The principles of maintaining Quality Systems are described in the literature primarily in terms of the audit processes. The role of formal audits in the maintenance of Quality Systems is described in Fox [40,1995] as 'essential to the effective on-going operation of the system' and in section 4.17 of ISO 9000 [10,1994] internal audits are a requirement to 'ensure the effective operation of the system'. The principles of auditing are also described in Fox [40,1995] who describes both the organisational and technical benefits of 'closing the system's loop' to ensure that not only the system is functioning in the prescribed way but also that improvements and enhancements to the system are incorporated in the system's development. The benefits of effective system maintenance were identified by Eckstein and Balakrishman [33,1993] at Canada at Toronto Plastics Limited who reduced defect rates from 150,000 per million to 15,000 after one year of ISO implementation'. Evans and Lindsay [35,1996] also cite the experiences of DuPont, whose efforts to maintain their ISO 9000 Quality System resulted in 'increasing on-time delivery from 70 to 90 percent, decreasing cycle time from 15 days to 1.5 days increasing first-pass yields from 72 to 92 percent and reducing the number of test procedures by one third'.

The principles of Quality System design, implementation and maintenance are critical elements to the developmental model of Quality Management proposed below in Chapter 4.

2.3. Quality Management Culture

The literature describing the 'people' dimension of Quality Management is extensive and encompasses much of the management science literature including organisational theory, motivational theory and change management. For the purpose of this research, the review of management literature is restricted to the works relating to the creation and development of a Quality culture which is identified by Choppin [18,1991] as 'central to the ability of the company to perform efficiently and effectively' and has increasingly been used to describe the people dimension of Quality including such aspects as management style and leadership, teamworking, employee involvement and motivation, customer orientation and communication. The historical development of the nature of Quality culture reflects both the importance and the complexity of this aspect of Quality management.

2.3.1. The Historical Literature on Quality Culture

Most of the modern literature on the nature of Quality Management identifies the work of Frederick Taylor in the early 1990's on 'scientific management' and the adaption by Henry Ford as the starting point in terms of an explicit approach to management. The Taylor approach is described by Evans and Lindsay [35,1996] as the separation of the 'planning function from the execution function'. In this way management was established as a controlling function which in turn led to the management of Quality from a controlling (inspection orientated) perspective.

This approach to managing Quality was challenged in the post-war years by writers such as Deming [27,1986] who promoted the people centred approach. Deming summarised his philosophy as a 'system of profound knowledge' comprising 'an appreciation for a system, some knowledge of the theory of variation, the theory of knowledge and psychology'. This philosophy was developed from systems theory emerging from management scientists during the 1950's and suggested that people development and Quality development were fundamentally linked through training and the elimination of fear.

The development of the theory of motivation during the 1960's and 1970's cited by Cullen and Hollingum [22,1987] to include the work of Maslow, Herzberg and McGregor contributed to the defining of a Quality culture in terms of the involvement and motivation of the workforce. The motivation to produce Quality products and services became a core theme to the literature on Quality Management during the 1970's. Crosby [21,1979] identified the importance of an individual's attitude in suggesting 'people create most of their problems through their attitudes' and related this to the management approach by describing 'workers perform like the attitude of the management'. Important in the formulation of what were seen as 'positive' attitudes in Japanese companies was the contribution of teamworking in the form of Quality circles described by Juran [55,1967]. The 1970's and 1980's saw a considerable expansion in the literature describing the contribution of teamworking to the Quality culture.

Research by Dale [23,1983] examined the impact of Quality circles on Quality development within a group of U.K. companies in the early 1980's and identified a number of inhibitors to creating a Quality culture using the Japanese approach including 'middle management resistance and lack of adequate training'. The success of the Quality circle approach in Japan was reported by Kondo [64,1993] who identified a growth from 1962 when the first circles were introduced at the Japanese Telephone and Telegraph Corporation to over 300,000 registered circles by 1991 with more than 2 million employees involved. This success was contrasted to the findings of Hutchins [48,1985] in the U.K. which supported the work of Dale in identifying problems in simply transplanting the Japanese approach to teamworking to U.K. companies and particularly cited lack of management support as an inhibiting factor. The overall importance of teamworking in creating an involvement and improvement orientated culture was expressed by many writers during the 1980's including Besterfield [8,1994], Crosby [21,1979], Lawler and Mohrman [65,1985], Donovan [31,1986] and Belbin [5,1987]. This view of team-based improvement as a prevailing culture was also embodied in the concepts of Kaizen (Japanese for 'change to the better') as described by Imai [49,1986] which during the 1980's came to symbolise the philosophy of a Quality culture.

The importance of the customer orientation component of Quality culture has been emphasised in a great deal of the recent Quality management literature. The development of the Kano model of customer satisfaction described by Bergman and Klefsjo [7,1994] emphasises the dimensions of 'basic needs, expected needs and exciting experiences' and the role of corporate culture in providing these dimensions of customer satisfaction. Powers [89,1993] identifies corporate culture as the core of the Toyota customer satisfaction framework and this customer orientation was to become the 'number one strategic objective' during the 1990's for Toyota. The integration of customer orientation into the existing culture of an organisation is described in terms of the social movement model by Howe, Gaeddert and Howe [47,1992] which identifies the six components of the culture change necessary as 'visionary, formulative, rhetorical, activist, evaluative and integrative'. The required emphasis upon customer satisfaction and loyalty is also described as a critical component of the Quality culture by Dean and Evans [35,1996]. The customer component of an organisation's cultural orientation has also been included in the Quality assessment criteria of the Deming, Baldrige and European Quality awards as described below in Chapter 3.

The developments reflected in the literature on Quality culture from a 'controlled' approach to an 'enabled' approach in which empowerment, teamworking and customer orientation are fundamental to the framework of Quality development proposed in this thesis and described below in Chapter 4.

2.3.2. The Defined Principles of Quality Culture

The principles of Quality culture development are fundamental to the people dimension of Quality management. The Quality of a product or service is related to the inputs and controls provided by the people within the organisation and these inputs and controls are influenced by the values, attitudes and behaviour of people. The relationship between values, attitude, behaviour and culture is complex and described by Robson [93,1989] as the 'hard reality of Total Quality'.

Kehoe [57,1996] cites the widely used definition of organisational culture as 'the shared values and norms of behaviour of the individuals within the organisations' and Choppin [18,1991] describes a Quality culture as being 'people centred, incorporating the director's value-systems (and having) four levels of cultural influence; society, trade-based, company tradition and Total Quality input'. Further Choppin goes on to define the cultural values in terms of 'respect for humanity, respect for the individual, respect for honesty and respect for knowledge' and cites a quotation from Ishikawa who said in support of these values that 'companies exist in a society for the purpose of satisfying people in that society. This is the reason for their existence and should be their primary goal'.

Chang, Laboviti and Rosansky [17,1993] identify the Quality culture in terms of the critical inputs of 'the voice of the customer, the voice of the employee and the voice of the process' and suggested these components shaped the culture in world-class organisations.

The values of an organisation are defined by Evans and Lindsay [35,1996] as 'the guiding principles..... which are reinforced through conscious and subconscious behaviour at all levels in the organisation. The values are reflected in the attitudes which are defined by Choppin [18,1991] as the 'unconscious expression of the persons sense of reality' and Howe, Gaeddert and Howe [47,1992] suggest that psychological research indicates that 'attitudes are potential predictors of behaviour' and cite the work of R.A. Hindle who identified 'a number of behaviours that are indicative of committed (Quality) relationships including interaction, openness, effective communication and working together.'

2.4. Quality Management Techniques

The tools and techniques of Quality management represent what Black [9,1994] describes as the 'harder' elements of Quality development. The literature describing the development, the theoretical basis and the application of Quality related techniques is again extensive and for the purposes of this research the review of the techniques focuses upon their contribution to the approaches to Quality Management. The developmental model described in this research classifies the tools and techniques of Quality in terms of their role in the development process and hence provides an important new insight into the relationship between them. By reviewing the techniques in terms of their historical development viewed from the perspective of the contribution to the approaches to Quality Management rather than from the perspective of the underlying (often statistical) science contributes to the framework of understand the role of this dimension of Quality.

2.4.1. The Historical Literature on Quality Management Techniques

As with the critique of the literature describing the evolution of the concepts of Quality culture described above in Section 2.3. the development and adoption of the tools and techniques reflect the various stages of management emphasis. The techniques employed in managing Quality during the 20th century have primarily been enablers rather than drivers of development. Many of the techniques were developed or adopted from other branches of science or social science to meet the needs of the approaches to Quality management that were developing.

The pre-war developments in statistical sampling by Dodge and Romig [30,1941] were provided to support the inspection led Quality control philosophies predominant during this period. Thorndike [105,1941] provided a standardised form of chart based upon the poisson distribution and this development made the design of acceptance sampling plans a readily available industrial technique. The management of inspection activities was also supported by the developments undertaken in the post-war years under the American, Canadian, British (ABC) agreement which led to the publication of BS 6000 [11,1991] as a standard set of tables for the application of acceptance sampling by attributes.

The major contributions to the development of Quality management techniques during the 1950's and 1960's came from the evaluation and control of the statistical variation within processes. This focuses upon the control of the process rather than simply the evaluation of the (inspected) outputs of the process became the enabling techniques for the 'Plan-Do-Study-Act' philosophy for Quality improvement proposed by Deming [27,1986]. The original techniques for the statistical evaluation of the variation of processes were proposed by Shewhart [97,1931] and in particular the importance of distinguishing between 'assignable' and 'chance' causes. The work of Shewhart strongly influenced the contributions to the techniques of Quality development proposed by both Deming and Juran which formed the fundamentals of the Quality improvement philosophies of the 1960's (Japan) and 1970's and 80's (U.K.). Statistical process control and the application of Shewhart control charts became the basis of many of the techniques-driven Quality improvement programmes particularly in the motor manufacturing industries at companies such as Ford and Volvo as described in Bergman and Klefsjo [7,1994] and also in the award winning 'six-sigma' programme at Motorola [80,1989].

The developments in the tools and techniques associated with improvement through the reduction in process variability included the adoption of process capability indices as both a measure of variation and as a metric for improvement. The use of process capability indices in Quality management is described in Oakland [83,1991] and also in Kane [56,1986] who provides a comprehensive review of the application of capability techniques.

The second major group of tools and techniques developed and adapted for Quality improvement during the 1960's were the statistical tools associated with problem solving and in particular team-based problem solving. The most significant contribution here was the formulation by Ishikawa [51,1982] of the 'seven methods or QC tools' comprising 'data collection, histograms, pareto charts, Ishikawa diagrams, stratification, scatter diagrams and control charts'. These techniques were widely used within the QC Circles emerging in Japan in the 1960's and 1970's (as reviewed above in Section 2.3.1.) and the application of these techniques became fundamental to the operation of the QC circles and formed the core of the training requirements of Quality improvement. The sophistication of these tools was enhanced during the 1980's to reflect the maturing approaches to Quality management. The Japanese Vision of Scientists and Engineers compiled the seven new (or management) tools of Quality. These techniques were described in the book by Muzuno [78,1988] as the 'affinity diagram, relation diagram, tree diagram, matrix diagram, matrix data analysis, process decision program chart and arrow diagram'. A description of the role and application of the seven new management tools is described in Kehoe [57,1996].

Finally, during the 1980's and 1990's, there emerged a number of tools and techniques to support the design of products and processes and in particular to create more robust designs which prevent Quality problems and reflect the requirements of the customer. Particularly influential in developing systematic techniques to support design-led Quality development was the work of Sullivan [100,1986] in the formulation and operationalisation of Quality Function Deployment (QFD). This multi-stage methodology for linking the 'voice of the customer' to the product specifications and process controls significantly combined a mechanism for linking customer needs to team-based product design. The adoption of the techniques of QFD in a number of advanced Quality orientated companies during the 1990's illustrated the role of Quality management techniques in the facilitation of organisational developments.

Techniques for the experimental design of robust processes in which the signal-to-noise ratio was optimised were proposed by Taguchi [101,1986] and these tools represented an emphasis upon "off-line rather than on-line" approach to managing Quality. During the late 1980's the Taguchi Experimental design techniques began to be used in a number of advanced Quality planning applications particularly in areas of manufacturing where inherent product or process system complexity existed. A number of industrial applications of these techniques were described by Bendell et al [7,1994] which identified the role of advanced Quality planning in the design driven approach to Quality improvement. In particular the Taguchi Quality engineering techniques provided a structure for evaluating the approaches to design by identifying methods for system design, parameter design and tolerance design.

2.4.2. The Principle Role of Quality Management Techniques

The contribution of the tools and techniques of Quality to the prevailing approaches to managing Quality have been historically significant. Whilst certain authors such as Pascale, have described the application of Quality management techniques as 'the fashionable use of a series of flavours of the month' most writers including Ishikawa, Feigenbaum and Deming have described the role of the techniques as fundamental to the Quality development process.

The techniques adopted have facilitated and reflected the stages of Quality emphasis. The statistical inferencing techniques which formed the basis of acceptance sampling supported the inspected-led developments associated with a Quality control approach. The measurement and control of the statistical variation of manufacturing processes provided the basic techniques for the developments associated with a Quality assurance approach. Finally the problem solving and advanced Quality planning techniques supported the team-based developments associated with Total Quality Management.

The role of Quality management techniques and the contribution to Quality improvement is described by Besterfield [8,1994] both in terms of the underlying principles and also the application contexts. The individual techniques and their applicability to specific product or process Quality problems are comprehensively described by Bergman and Klefsjo [7,1994] but the literature generally relates the techniques of Quality management to application contexts rather than to the stage of Quality development maturity as proposed below in Chapter 4.

SUMMARY

- *The initial review of the Quality management literature is structured in terms of the historical context and defined principles in each of the three dimensions; systems, people and techniques.*

- *The literature on the development of Quality systems identifies the emergence of Quality Assurance standards including ISO 9000, QS 9000 and Q1 and the formalisation of a systematic approach to Quality management.*

- *The literature relating to the people dimension of Quality management reflects the development in management science, organisational theory and motivational theory during the twentieth century and in particular the emergence of key components and principles in establishing a Quality culture.*

- *The literature describing the development of the tools and techniques of Quality management reflects the emergence of methods to support and facilitate the changing approaches to managing Quality.*

CHAPTER 3

THE MODELLING OF QUALITY DEVELOPMENT

3.1. The Dimensions of Quality Development

3.1.1. The Dimensions of Quality Management

From the range of literature (reviewed above in Chapter 2) the most widely accepted 'model' of Quality management was the three dimensional framework proposed by Oakland [83,1991] at the University of Bradford and adopted by Cullen [22,1987] at Rover Group. The dimensions described by Oakland are the:

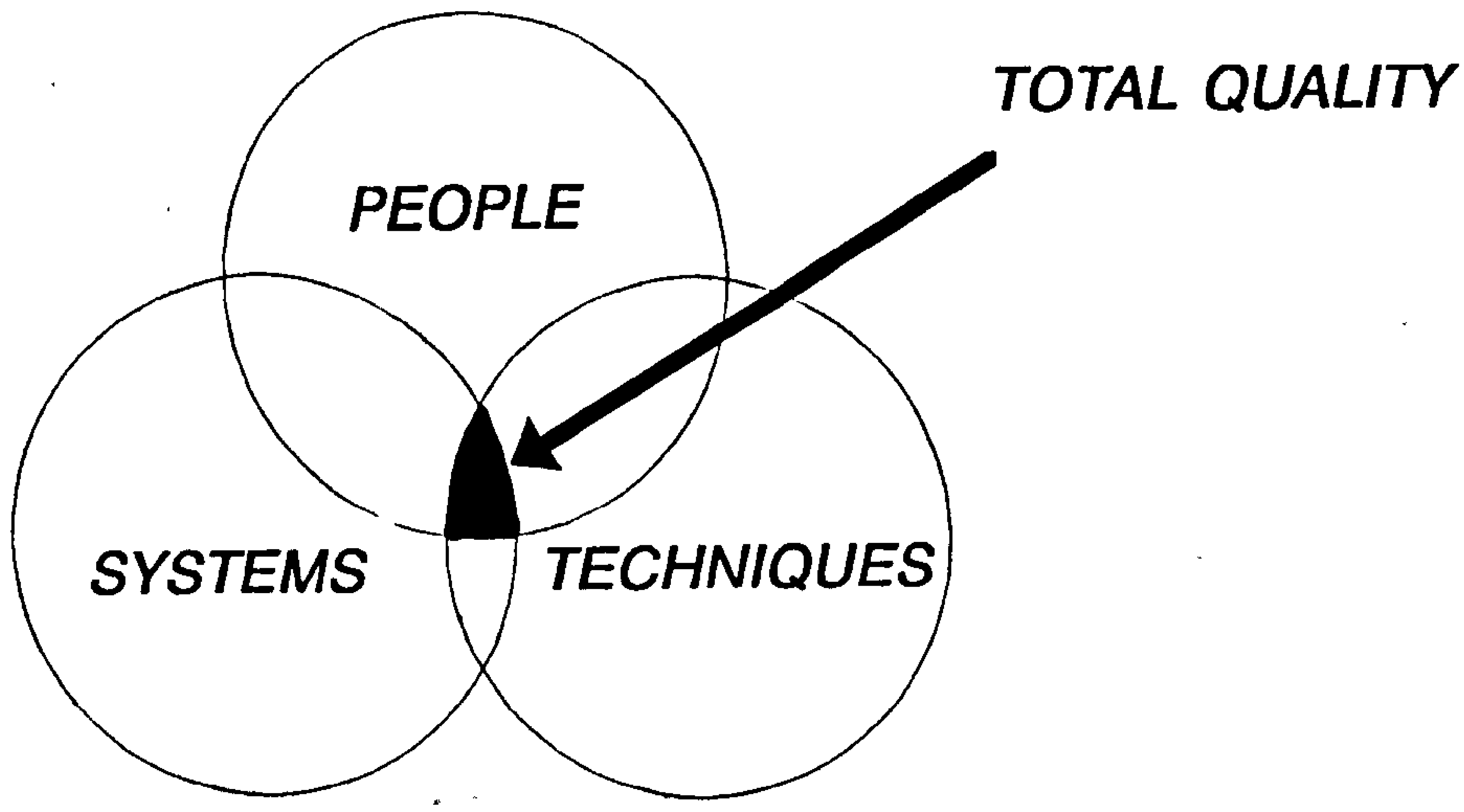
- **systems** dimension, in which the organisation must develop the basic operational procedures and coordination to support Quality management.

- **techniques** dimension, in which the organisation must employ in a coherent and logical manner the various tools of Quality management.

- **people** dimension, through which the organisational culture and attitudes to Quality must change and align the behaviour of the employees with the objectives of the business.

Cullen describes these dimensions as three interlocking sets of activities (as shown in Figure 3.1.1.a) which only generate a Total Quality organisation through the simultaneous progress in all three areas.

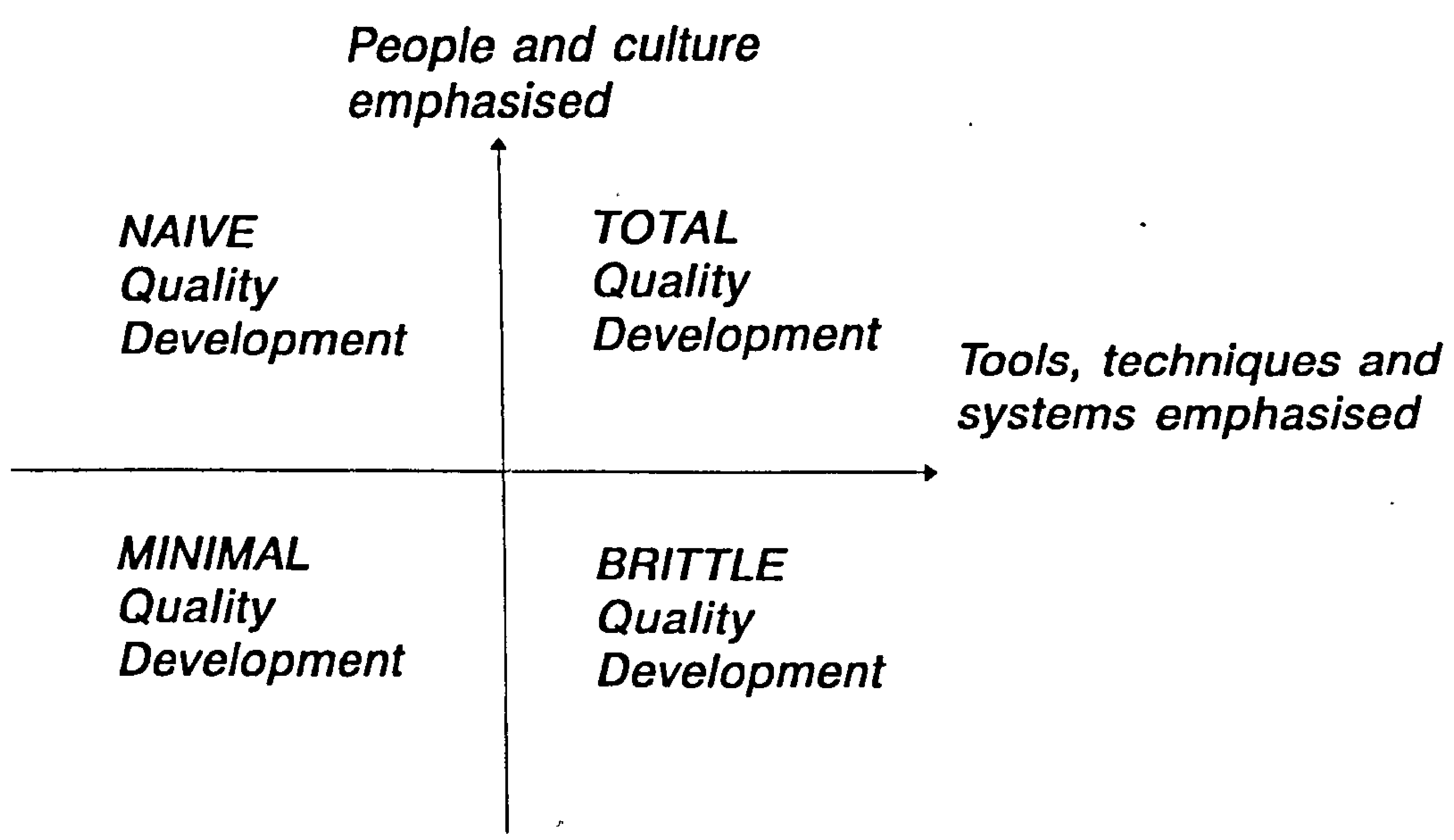
Figure 3.1.1a The dimensions of Quality Management (Source: Oakland [1991])



The importance of this view of Quality management is that it provides a logical classification system for the activities of Quality improvement together with pinpointing why Total Quality is such a difficult organisational state to achieve due to the need to simultaneously manage three interdependent factors. Whilst this concept has been useful in encouraging the industrial practitioners of Quality improvement to take a broad view of managing Quality, it does not model the interdependency of systems, techniques and people which is primarily one of precedence and timescales, in other words a developmental process. The importance of this model of Quality management is therefore in terms of the classification of activities and in the emphasis of the dependency of the three dimensions rather than as a model of Quality development. As a result these dimensions were used as part of the classification of development parameters described later in Chapter 5.

The same dimensions of Quality management have also been identified by PA Consulting [85,1990] in emphasising the need to address both the 'hard' and 'soft' issues of Total Quality. By identifying a two dimensional matrix as shown in Figure 3.1.1.b), P.A. Consulting characterised approaches to Total Quality in terms of an organisation's emphasis upon certain factors. The matrix was a result of research undertaken as part of consultancy services by P.A. Consulting and again identified the interdependency of factors as being critical for sustained Quality improvement.

Figure 3.1.1b The Quality development dependency matrix (Source: PA Consulting/Kehoe [1996])



The experiences of P.A. Consulting were also supported by the work of Robson [93,1989] who also identified progress in both the culture and the methods of Quality management as critical to an organisation's Quality development. From the research of Robson, which again was primarily consultancy based, the conclusion was made that most organisations fail to devote sufficient effort and resources to the cultural challenges of Quality development and lack an understanding of the relationships between the application of Quality tools and techniques and the impact upon employees attitudes and behaviour. This lack of understanding again represents a failure to comprehend the Quality development process in terms of the time based dependency of activities.

3.1.2. The Main Activities of Total Quality Management

Having identified the main 'directions' for development in terms of people, systems and techniques, the second important input to the research was the consideration of the completed 'picture' namely the features or characteristics of Total Quality organisations. By examining the end product, the validity of the Quality development model could be assessed both in terms of completeness and priority. If the main activities of Total Quality could be identified together with their relative importance then this would provide an important reference point for the proposed framework for Quality development.

Many of the standard texts simply state that Total Quality is a homogenous mixture of all the tools, techniques and methods of Quality management implemented within an organisational ethos of continuous improvement. Such a broad description self-evidently manifests itself in all Total Quality organisations as each is some unique combination of such factors. A more useful description of the primary elements of Total Quality was provided by the research of Mann [71,1992] whose 'TQM Quality Activity Model' identified through an extensive industrial survey five main components of Total Quality Management as shown in Figure 3.1.2.

Figure 3.1.2 The Total Quality Management Activity Model (Source: Mann [1992])

Again this research examined the characteristics of Total Quality and proposed an implementation framework without identifying the time-based dependency of the activities described. The relationships between the activities of Total Quality, the order in which these are implemented, the benefits which are accrued at each stage and the organisational changes which take place are in fact critical aspects of Quality development.

The Quality development model proposed below in Chapter 4 has been developed to reflect the composite set of activities identified in previous research in Total Quality Management but provides an important additional framework which is not evident by simply considering organisations in the 'fully developed' state. Through an improved understanding of how the application of certain activities impacts upon the Quality development process, organisations may improve the overall management of Quality.

3.1.3. The Stages to Quality Maturity

The third main input to identifying the features of Quality development comes from considering the previous work on describing the stages of a maturing Quality orientated company.

The most relevant Quality maturity model was proposed by Crosby [21,1979] in which he describes five stages of development as illustrated in Figure 3.1.3.a).

Figure 3.1.3a The stages to Quality Maturity (Source: Crosby [1979])

STAGE 1 - Ignorance	*No comprehension of quality as a management tool. Tend to blame quality department for quality problems*
STAGE 2 - Awakening	*Recognizing that quality management may be of value but not willing to provide money or time to make it all happen*
STAGE 3 - Enlightenment	*While going through quality improvement program learn more about quality management, becoming supportive and helpful*
STAGE 4 - Certainty	*Participating. Understanding absolutes of quality management. Recognise their personal role in continuing emphasis*
STAGE 5 - Wisdom	*Consider quality management an essential part of the company system*

Crosby's Quality Maturity Grid was part of a self-assessment mechanism through which organisations could identify their level of maturity in terms of characteristic statements which reflected an organisation's Quality viewpoint. This Quality Maturity Grid was an important input to the identification of the Quality development model described below in Chapter 4 as it highlighted two important features of this approach:

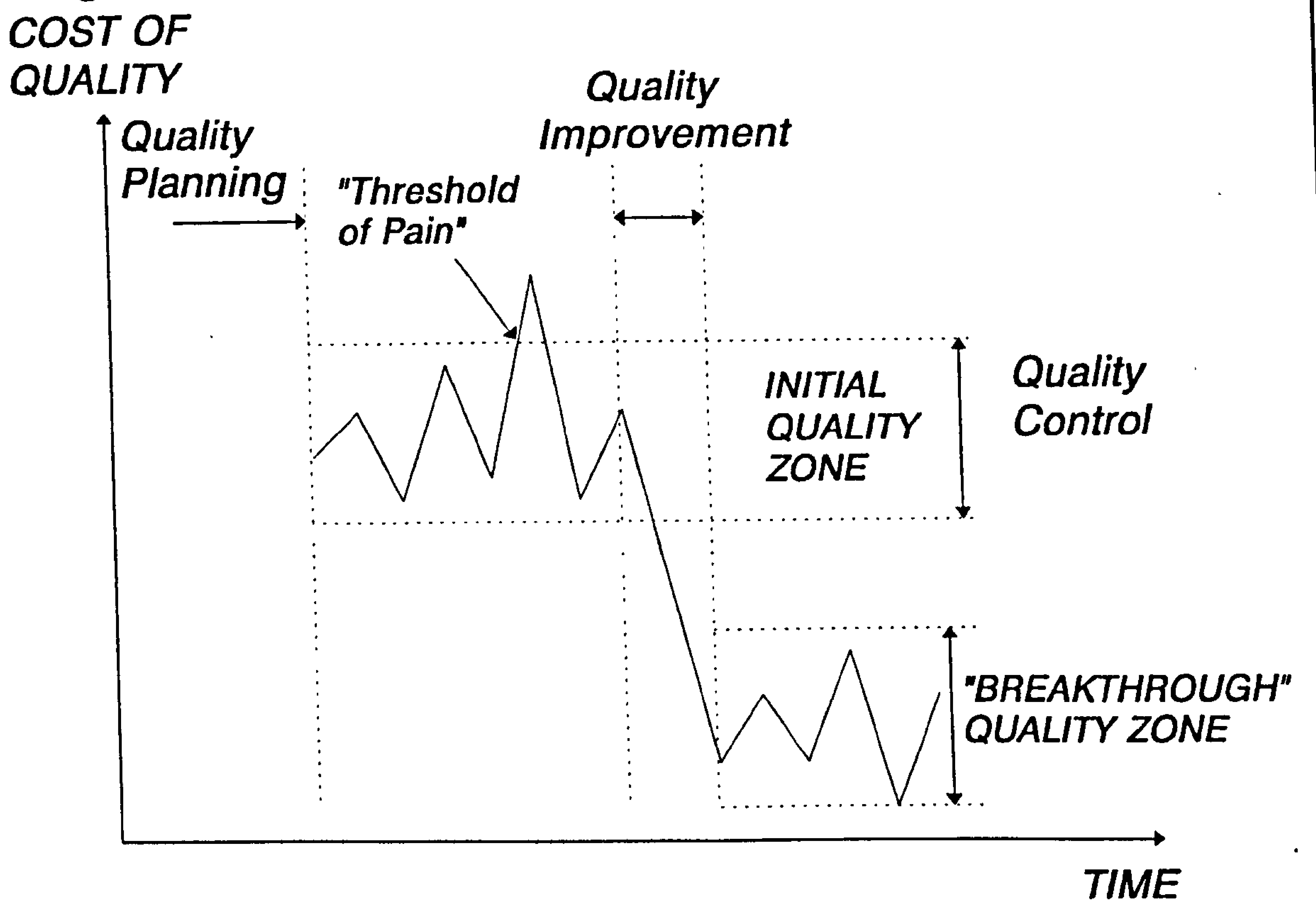
- it was an extremely useful tool for industrial companies to understand Quality management as a developmental process and to relate their own organisation's achievement to this spectrum of maturity.

- it could be used to characterise the organisations current position and therefore be used as a technique for measuring improvement.

The main disadvantages however in the Crosby model of Quality development were first that each of the stages of maturity were not systematically associated with certain Quality management activities and second the work was based on an individual's (albeit substantial) consultancy experience rather than through rigorous research validation. A final criticism of the Crosby approach is that it is primarily descriptive and therefore subjective and when tested extensively within a single organisation produces a range of viewpoints through the scoring mechanism used.

The second main contributor to identifying the concept of modelling the Quality development process was the work of Juran [55,1967] illustrated in Figure 3.1.3.b).

Figure 3.3.3b) The Juran Trilogy (Source: Juran [1979])



The Juran description of Quality development was more concerned however in identifying the motivation for change and the benefits resulting. As with the approach of Crosby, the Juran model provides a description of what happens to an organisation as the Quality development process occurs but does not readily relate this to what is done. The linking of Quality improvement activities to organisational change represents an important step forward in the modelling of Quality development.

3.2. The Approaches to Quality Development

3.2.1. Quality Development Strategies

A considerable amount of research has been devoted in recent years to the classification of approaches to Total Quality. This research, typified by the work of Tranfied et al [104,1994], Saraph et al [94,1989] and Black [9,1994], examined organisations who had implemented Total Quality programmes and attempted to classify features or groups of features which characterised the implementations. These researchers, however, were concerned primarily with the approaches to Total Quality and their classification rather than the identification of features or activities of Total Quality organisations as described in Section 3.1.2.

The work of Tranfield at the Sheffield Business School funded by the Application of Computers to Manufacturing Engineering (ACME) Directorate of the Science and Engineering Research Council (June 1990 to February 1993) identified three characteristic approaches to Total Quality and a fourth transformation approach as illustrated in Figure 3.2.1.

The three basic approaches, visionary, planning and learning used terms taken from Mintzberg's work on strategy formulation. The main significance of the work of Tranfield was twofold. First the Total Quality mindsets identified and positioned approaches to Total Quality primarily in terms of the person (or persons) driving the implementation. The visionary approach relied significantly on a committed senior manager, the planning approach was seen as promoted by engineers and technologists and the learning approach was identified as being led 'bottom-up' by an empowered workforce. The significance of the driving force behind the Total Quality implementation was seen in terms of the type of Quality improvement activities adopted within each of the three approaches.

Figure 3.2.1 The Total Quality Mindset approach (Source: Tranfield et al [1993])

Visionary Mindset (VTQ)	*Learning Mindset (LTQ)*
Planning Mindset (PTQ)	*Transformation Mindset (TTQ)*

The second significant feature of the research was that Tranfield identified the need for transformation. The primary output from the research was the TQM 2 Methodology which enabled managers to re-focus their Total Quality implementations by transforming their approach and adopting alternative mindsets. This work therefore also supports the concept of Quality management being a developmental process. By focusing, however, on the motivators of Total Quality as being the determinate factor in the approach adopted this framework is rather limiting as a model of development. To a certain extent the three approaches identified by

Tranfield are simply manifestations of an emphasis upon one or other of the three dimensions of Quality Management (systems, people and techniques) identified by Oakland and described above in Section 3.1.1. This research therefore was useful as a mechanism for the classification of approaches rather than a coherent model of development.

The research of Saraph in the United States also examined the approaches to implementing Total Quality and identified eight areas of development, namely:

- Leadership
- Reporting
- Process Management
- Design
- Suppliers
- Role of the Quality department
- Employee Relations
- Training

This research used these eight areas as a benchmark for development and again attempted to identify the most successful approaches. Again, however this work did not relate improvement activities to the stages of development, nor did it indicate the dependency between the implementation approaches used in each of the eight areas.

Finally the work of Black at the University of Bradford identified critical factors in the implementation of Total Quality and the significance of the interrelationships. The survey used by Black produced an empirical ranking of the relative importance of ten critical factors and also the 'strength' of the relationship between factors. This research therefore is concerned with the evaluation of Total Quality implementations and identifying the relative importance of certain factors during implementation rather than modelling the time based Quality development of an organisation. The work of Black has, however, been used to support the validation of the parameters used in the Quality development model proposed in this thesis as described below in Chapter 6.

The above work of Tranfield, Saraph and Black into the approaches to Total Quality has been used in this research to assist both in formulating the model of Quality development (Stage 1 in Figure 1.5 above) and also particularly in the validation of the framework (Stage 2). Primarily this work on implementation strategies assists the understanding of the responsibilities for Quality development and the resulting implementation characteristics.

3.2.2. Total Quality Implementation Frameworks

In addition to the research on the classification of Total Quality implementation strategies described above in 3.2.1., the other main input into Stage 1 (Figure 1.5. above) of the research was the work on frameworks for implementing Total Quality. These frameworks are proposed as 'route maps' for organisations implementing Total Quality and generally comprise of some form of diagnostic phase followed by a corresponding action plan.

The Total Quality framework proposed by Mann [71,1992] involved 15 components, ten of which related to developing the implementation approach and the remainder providing guidelines and measures for the implementation . Certainly this research identified, primarily through structured interviews, the main components of implementing Total Quality and the relationships between these components. This 'blueprint' for Quality development does not, however, describe the stages through which the developmental process must pass and does not identify the Quality activities and organisational changes which must take place at each stage. Such a framework therefore represents a Total Quality design aid rather than a process planning aid.

Cullen and Hollingum [22,1987] also proposed a framework for implementing Total Quality which identified many of the main activities together with timescales without emphasising the culture changes which must take place to support the developments. This mechanistic philosophy, whilst providing a relatively simple project plan for implementing Total Quality tended to ignore the relationship between activities and in particular did not take into account any organisational resistance through diminishing business improvement.

Chopin [18,1991] proposed a 'blueprint for Total Quality' based primarily upon the culture change necessary within an organisation. The development of a team-based culture and employee empowerment were central to the framework published by Chopin and although the blueprint for Total Quality contained a series of discrete steps, the main stages of Quality development were not formally identified neither was the relationship between culture change and the Quality improvement activities employed.

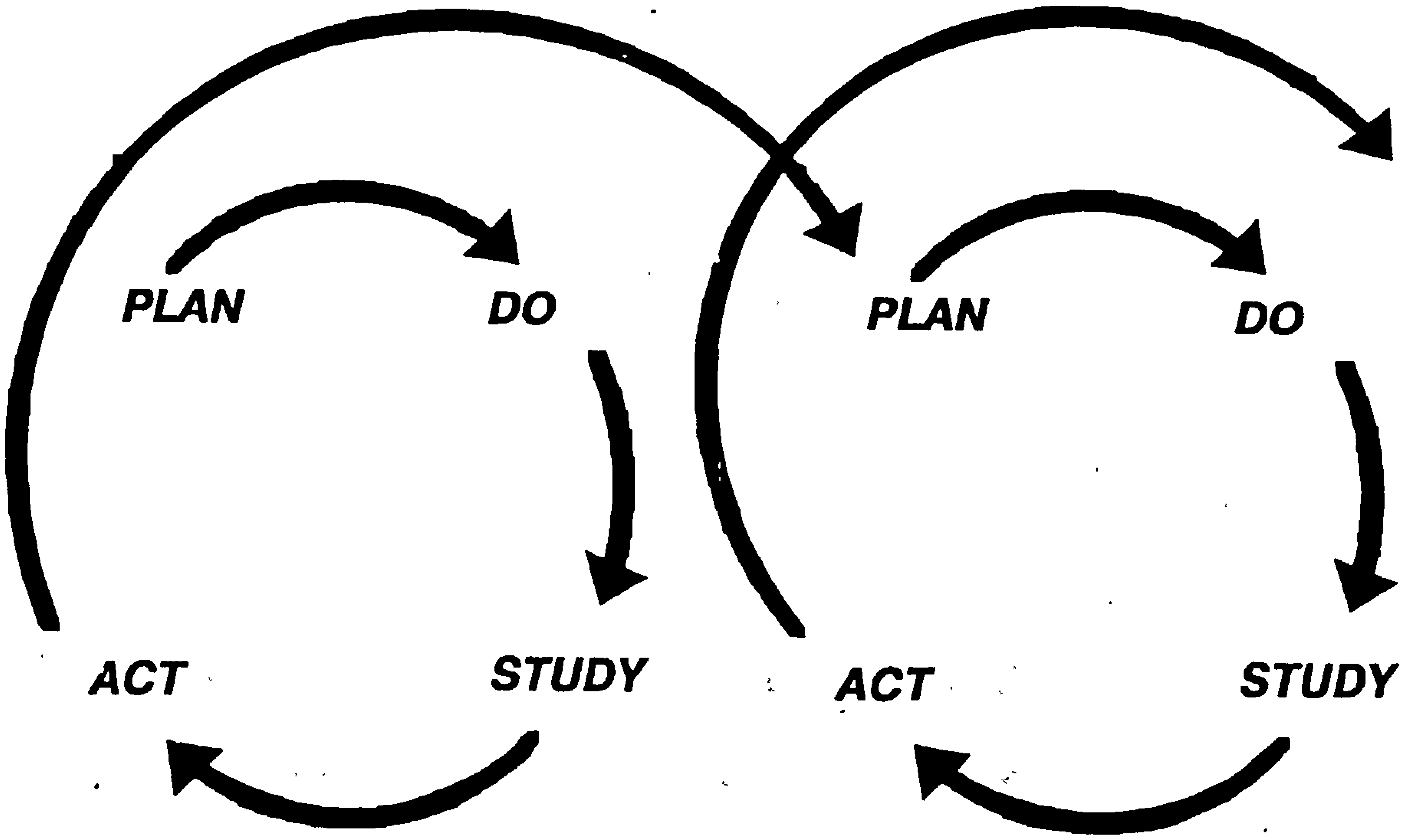
3.3. Methodologies for Quality Improvement

Popular during the 1980's were a series of Quality Improvement Methodologies adapted from the work of the so called American Quality Gurus, Dr.Edwards Deming, Joseph Juran and Philip Crosby. By presenting these ideas as methodologies, a step-by-step series of activities, they were promoted (primarily through consultancy) as proven developmental paths to Quality improvement. The international reputations of the originators of these methodologies certainly encouraged the adoption of a 'cookbook' approach to Quality development.

3.3.1. The Deming Methodology

Deming [26,1986] proposed a cycle of Quality development in terms of the Plan, Do, Check, Act model illustrated in Fig.3.3.1.

Figure 3.3.1 The Deming PDSA Model (Source: Kehoe [1996])



This repeating cycle of activities was intended by Deming to be employed throughout the Quality development process in conjunction with the 14 steps methodology for Quality improvement. In summary Deming's 14 step methodology involved:

1. Create and publish to all employees a statement of the aims and purposes of the company or other organisation. The management must demonstrate constantly their commitment to this statement.

2. Learn the new philosophy, top management and everybody.

3. Understand the purpose of inspection, for improvement of processes and reduction of cost.

4. End the practice of awarding business on the basis of price tag alone.

5. Improve constantly and forever the system of production and service.

6. Institute training.

7. Teach and institute leadership.

8. Drive out fear. Create trust. Create a climate for innovation.

9. Optimise towards the aims and purposes of the company the efforts of teams, groups, staff areas.

10. Eliminate exhortations for the workforce.

11. a) Eliminate numerical quotas for production. Instead learn and institute methods for improvement.

    b) Eliminate MBO. Instead learn the capabilities of processes and how to improve them.

12. Remove barriers that rob people of pride of workmanship.

13. Encourage education and self-improvement for everyone.

14. Take action to accomplish the transformation.

As with the work of Juran and Crosby described below, Deming's advice was fundamentally sound and gave a reasonable overview of the type of management actions which should take place during Quality development. The Deming methodology does not, however, identify the major changes which occur within the way Quality is managed during the development process nor do the 14 points illustrate the application of tools and techniques (other than statistical techniques) during each of the steps.

3.3.2. The Juran Methodology

Juran, like Deming, also emphasised the need for continuously working upon Quality development and identified three stages of improvement:

- Quality Planning
- Quality Control
- Quality Improvement

Juran suggested most organisations placed too much emphasis upon control and paid insufficient attention to planning and improvement and that some form of 'breakthrough' development was required to achieve substantial Quality improvement as illustrated above in Figure 3.1.3b).

Juran proposed a six stage improvement methodology aimed primarily at the identification and execution of improvement projects. The six stages are as follows:

i) Proof of Need

ii) Project identification

iii) Organisational breakthrough

iv) Diagnostic journey

v) Remedial journey

vi) Hold the gains

Juran suggested that the Quality improvement process was a primary management responsibility that required a developmental plan rather than simply reacting to a "threshold of pain".

The main contributions of Juran's work to this research has been in the identification of an improvement stage of development bringing about a step change in performance from an initial control stage and the indication that this process requires planning. These concepts are incorporated in the framework for Quality development proposed below in Chapter 4.

3.3.3. The Crosby Methodology

In terms of a Quality improvement methodology, Crosby describes this as a process rather than a programme to emphasise the continuous nature of improvement. The Crosby improvement process comprises 14 steps and is primarily a company-wide approach rather than an approach to solving an individual Quality problem. The 14 steps are summarised below in Figure 3.3.3.

Figure 3.3.3. Crosby's 14 step Improvement Process

Step	Process
1	Clear Management commitment to the process
2	Form Quality improvement teams with representation across the organisation
3	Quality problem identification through effective measurement against which future improvement can be measure
4	Evaluate the cost of Quality to provide the company-wide measure of progress
5	Quality Awareness through the organisation through increased communication
6	Corrective Action to resolve the Quality problems identified utilising problem solving tools and techniques
7	Establish an ad hoc committee to coordinate the 'zero defects' program
8	Train Supervisors in the Quality improvement process
9	Zero Defects Day to communicate the concept to all employees
10	Goal setting by the groups to establish the measurable improvement objectives
11	Problem Cause removal by encouraging the communication of problems and inhibitors to management

12	Recognition
13	Quality councils to coordinate and communicate the progress and improvements to the process
14	Do it over again after around 18 months to rejuvenate the process

Each of the methodologies proposed by Deming, Juran and Crosby emphasises the need for,

- a structured framework
- the use of problem solving tools
- the measurement of improvement
- the process to be continuous

Many organisations have adopted these approaches proposed by Quality 'Gurus' only to find that they need to be tailored to meet company specific needs. Increasingly as companies have matured and developed their improvement orientation they have adopted their own approach to Quality Problem Solving within the organisation.

3.4. Measures of Quality Development

3.4.1. Quality Assessment Methods

The measuring of Quality development is a further area of study which has received considerable international attention in recent years. Although the various assessment methods do not as such describe a model of Quality development, they do provide mechanisms for validation of the model as outline in Chapter 6. The five main international assessment methods are:

- the ISO 9000 Series Standards
- the Ford Q101 and Q1 Standards
- the European Quality Award
- the Baldrige Award
- the Deming Award

The first of these methods, the ISO 9000 series standards [10,1994], is the most widely applied Quality assessment mechanism with around 50,000 organisations having been successfully assessed worldwide by the end of 1994. The standard proposes 20 elements of supplier Quality development to be assessed and three levels of activity as shown in Figure 3.4.1.a).

Figure 3.4.1a The ISO 9000 Standard Assessment Model

Clause of ISO 9004	Description of Quality System Element	ISO 9001	ISO 9002	ISO 9003
4	Management Responsibility	4.1	4.1	4.1
5	Quality System	4.2	4.2	4.2

7	Contract Review	4.3	4.3	--
8	Design Control	4.4	--	--
17	Document Control	4.5	4.5	4.5
9	Purchasing	4.6	4.6	--
--	Purchaser Supplied Product	4.7	4.7	--
11.2	Product Identification and Traceability	4.8	4.8	4.8
10	Process Control	4.9	4.9	--
12	Inspection and Testing	4.10	4.10	4.10
13	Inspection, Measuring and Test Equipment	4.11	4.11	4.11
11.7	Inspection and Test Status	4.12	4.12	4.12
14	Control of Non-Conforming Product	4.13	4.13	4.13
15	Corrective Action	4.14	4.14	--
16	Handling, Storage, Packaging and Delivery	4.15	4.15	4.15
17.3	Quality Records	4.16	4.16	4.16*
5.4	Internal Quality Audits	4.17	4.17	--
18	Training	4.18	4.18	4.18
16.2	Servicing	4.19	4.19	--

20	Statistical Techniques	4.20	4.20	4.20

ISO 9000 assessment does not involve 'scoring' the level of development but merely classifies organisation's Quality systems as either acceptable or not. The scope of the standard together with the enormous international adoption of ISO 9000 does however indicate that this level of progress is a significant milestone for an organisation's Quality development and this has been incorporated in the model described below in Chapter 4.

The Ford Motor Company's Q101 standard [38,1987] is also a supplier Quality System assessment method which has been widely used through the motor manufacturing industry. The Q101 assessment does, however, provide a points score as illustrated below in Figure 3.4.1.b).

The significance of the Ford viewpoint on Quality system development is that a supplier organisation must achieve a minimum score of 50% for each of the 20 elements and average over 70% in total. The scoring guidelines published by Ford therefore provide a very clear indication of the characteristics of development in terms of people, systems and the application required and again these have been included in the model of Quality development proposed in Chapter 4 of this thesis.

Figure 3.4.1b The Ford Q101 assessment model

1) Planning for quality

i) Definition of responsibilities
ii) Formalised methods for Quality planning
iii) Review of Quality plan changes

Total marks planning = 30

2) Statistical methods

i) Use of SPC on significant parameters
ii) Use of preliminary statistical studies
iii) Use of process control charts
iv) Application of continuous improvement
v) Control of incoming products & services

Total mark statistics=50

3) General quality assurance

i) Defined audit functions and responsibilities
ii) Documented policy and procedures
iii) Documented work instructions
iv) Measuring and test equipment
v) Test equipment maintenance and calibration
vi) Control of inspection status
vii) Quality records
viii) Reaction to customer concerns

Total marks general = 80

4) In-process and outgoing

i) Defined inspection methods
ii) Documented re-work and scrap procedures
iii) Handling, storage and packaging procedures
iv) Housekeeping issues

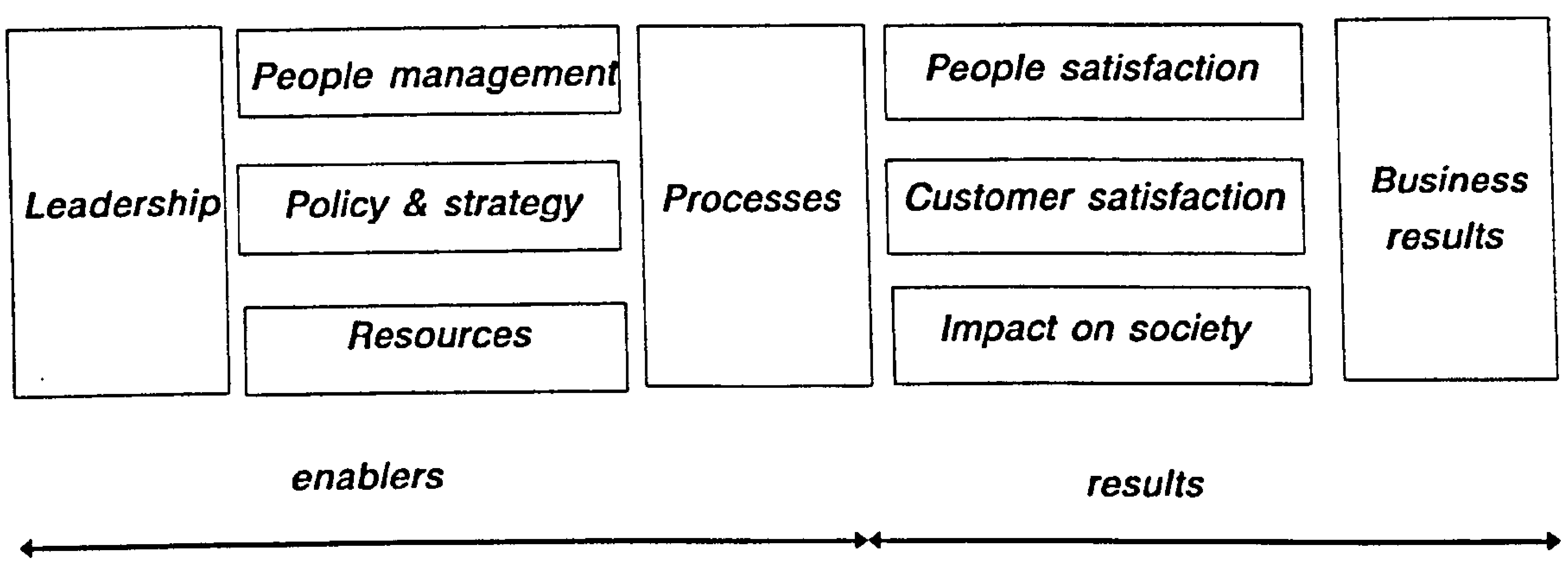
Total marks process = 40

Total marks for all 20 elements = 200

The three international award assessment methods the European Quality Award, the Baldrige Award and the Deming Award are all intended to recognise excellence in Quality development. So whilst these methods are generally used to identify 'best in class' they do provide important insights in terms of the structure of assessing Quality development and the relative prioritisation (reflected in the scoring guidelines) of each of the elements.

The European Quality Award (EQA) [34,1991] is published and administered within the European community by the European Foundation for Quality Management. The EQA identifies seven elements to Quality development as illustrated in Figure 3.4.1.c).

Figure 3.4.1c The European Quality Award assessment model(Source: Kehoe [1996])



The Baldrige Award [3,1995] is used in the U.S. to assess and reward excellence in Quality development for American companies. The assessment criteria are again grouped into main elements, each of which has a series of sub-elements for which scores are awarded as illustrated in Figure 3.4.1.d).

Similarly the Deming Award [26,1992] used in Japan also identifies critical aspects of Quality development and provides a scoring mechanism which reflects the relative importance of the elements as shown in Figure 3.4.1.e).

Figure 3.4.1d The Malcolm Baldrige Award assessment model (Source: Kehoe [1996])

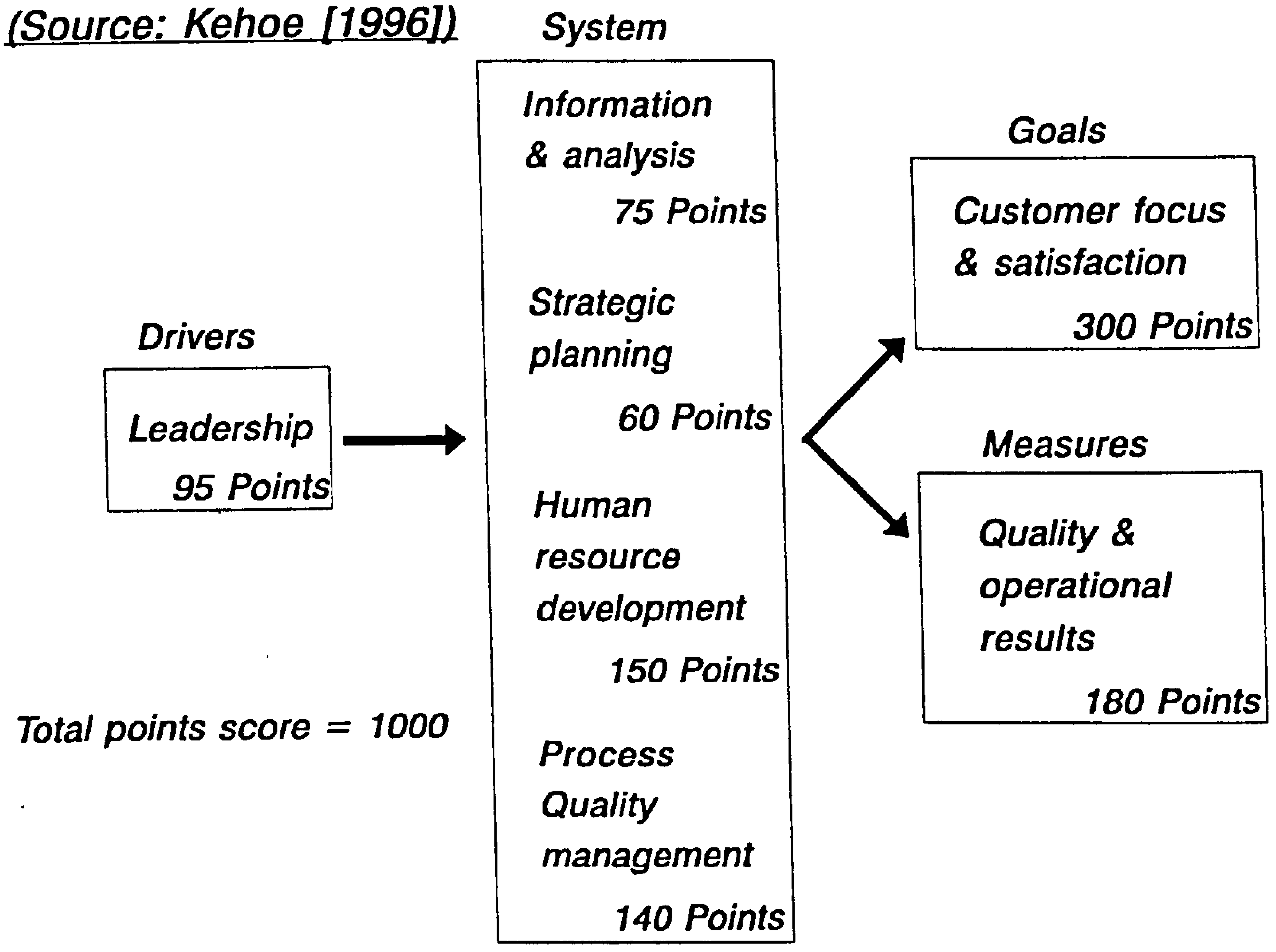
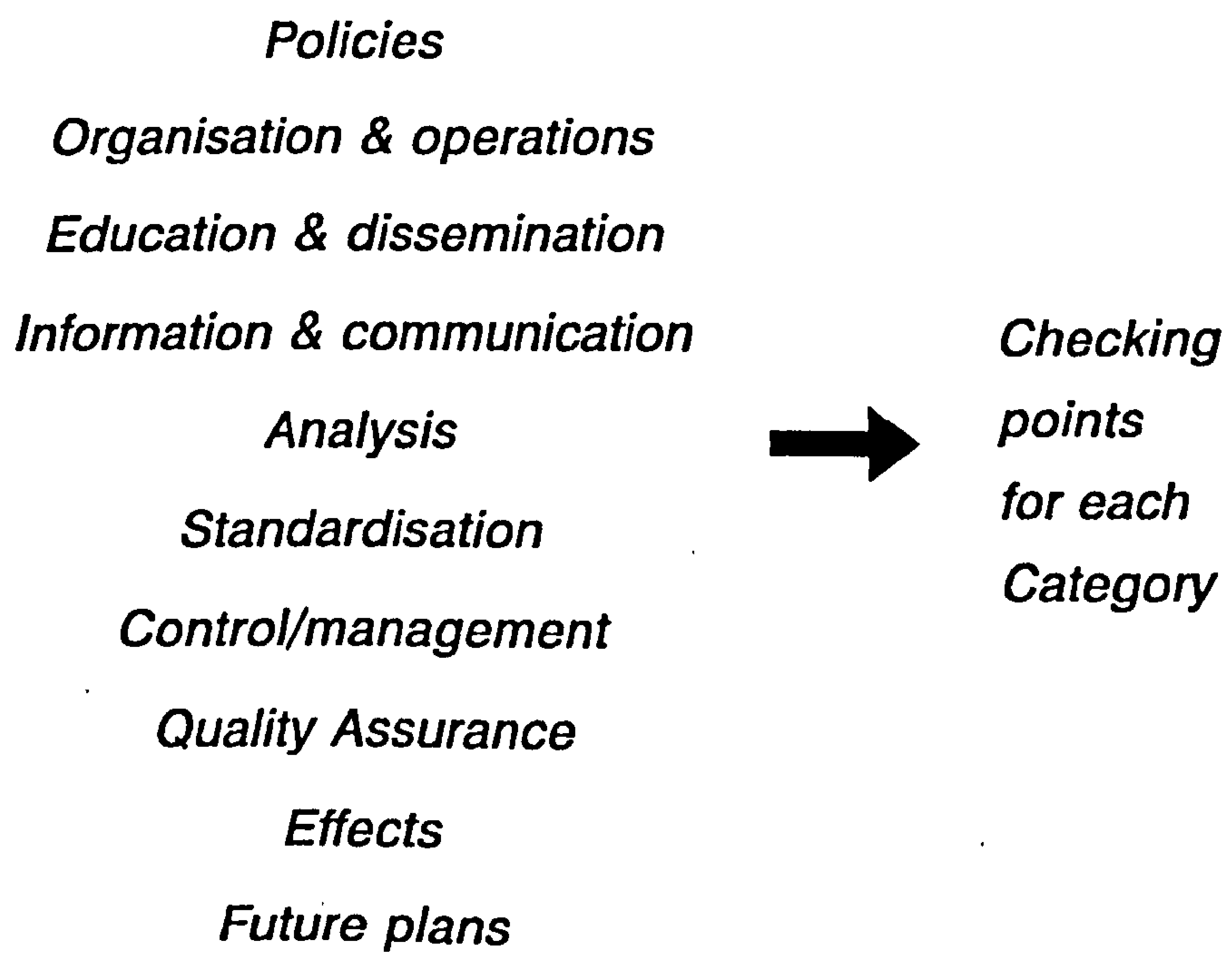


Figure 3.4.1e The Deming Award assessment model (Source: Kehoe [1996])



The main input to this research from the three international award assessment models has been in the use of their scoring systems to validate the proposed Quality development framework. Recent research at the University of Liverpool [1,1995] has attempted to establish a correlation between each of the 3 award assessment models and this survey data is also used in Chapter 6 below to illustrate the grouping of organisations within the parameters of the proposed Quality development model.

3.4.2. Quality Development Factors and Parameters

In terms of identifying Quality development parameters, a number of research programmes in recent years have identified individual factors which indicate organisational Quality development.

The two main approaches adopted by previous research has been:

- to identify those factors which are critical to Quality improvement
- to identify parameters which can be shown to correlate positively with Quality improvement.

The research of both Saraph in the U.S. and Black in the U.K. was primarily directed at the first of these approaches and both research programmes presented sets of critical factors based upon industrial surveys. The eight critical factors identified by Saraph were extended by Black through the use of factor analysis. Black proposed ten factors and through factor analysis provided a score for each factor which represented the relative importance of each as illustrated in figure 3.4.2.

Figure 3.4.2 Factor analysis of critical Quality development factors (Source: Black [1994])

Factor	*Relative Score*
Strategic Quality Management	*239*
Customer Satisfaction Orientation	*138*
People and Customer Management	*101*
Communication and Improvement Information	*94*
External Interface Managemnt	*88*
Quality Improvement Measurement Systems	*87*
Corporate Quality Culture	*83*
Supplier Partnership	*69*
Operational Quality Planning	*52*
Teamwork Structures	*49*

This data has been used in the validation of the Quality development model as described in Chapter 6 below.

The research of Zain [108,1993] was aimed a providing a set of factors which could be used across a range of industrial sectors to measure the Quality 'position' of an organisation. The Quality Measurement System (QMS) developed by Zain was again based upon industrial survey data and identified six areas each of which was further sub-divided into parameters which reflected 'effort' and those which reflected 'results'. Each of these parameters was given a weighting by Zain based upon the ARUB's programme (Accuracy, Reliability, Understanding and Bias) and again this data has been used in the validation of this research as described in Chapter 6 below.

SUMMARY

- *Previous research and published work on the modelling of Quality development included work identifying the dimensions, approaches, methodologies and measures of Quality development and these have been used directly as inputs to the model proposed within this thesis.*

- *The dimensions of Quality identified from previous work were systems, techniques and people and a range of Total Quality activities were also proposed.*

- *In terms of how organisations approach Quality development, the strategies and the implementation frameworks from Tranfield, Mann, Cullen and Chopin were identified.*

- *Methodologies for Quality development provided by the Quality gurus Deming, Juran and Crosby also indicated the importance of the sequence of developmental activities.*

- *Measures of Quality development, either in terms of critical factors or indicative parameters can be used quantitively to validate the model of development proposed in this research.*

CHAPTER 4

A FRAMEWORK FOR QUALITY DEVELOPMENT

4.1. The Stages of Quality Development

4.1.1. The Characteristics of Developmental Stages

In proposing a model of Quality development structured as a series of identifiably discrete phases, the question arises as to how to characterise a 'stage' of development. The key to the characterisation used in this research is the identification of changes in the way in which Quality is managed within an organisation as it develops. These changes can be primarily identified in terms of:

- the Quality related tools, techniques and activities employed within the organisation.
- the culture change in terms of shared values and management style which occurs within the organisation.

In constructing such a framework, clearly there will be overlap both in terms of the activities and the culture exhibited throughout the stages of development. So for example whilst the initial establishment of a system of Quality costing may be employed in an early stage of development as a mechanism for attracting management attention to the need for change, the same technique may be utilised at a later stage of development as a mechanism for pinpointing specific improvement activities. Similarly, the adoption of teamworking may have a minor role in establishing certain approaches at an early stage of development yet may be a fundamentally enabling cultural feature at a later stage of development. These overlaps, whilst important to recognise, do not detract from the overall objective of trying to provide a framework in which Quality management can be understood as a developmental process with identifiable stages in which to 'position' the various activities and changes.

In addition to the two primary characteristics of the stages of Quality development (namely what organisations do and what they become) a third characteristic is the pressure for change which drives an organisation from one state of development to the next or, in the absence of such pressure, leads to a lack of further development. The importance of all three of these characteristics was highlighted in a study by Vargas et al [105,1994] of Quality development programs in Spain which concluded that "Quality programs show a marked evolution in their contributions to organisational performance over time" and such are programs are "highly situational and contingent to the market and socio-economic circumstances faced by the individual forms".

4.1.2. The Sequence and Precedence of Quality Development

Explicit in the model of Quality development proposed in this research is the contention that the stages of development are sequential and require preceeding organisational change to have taken place. This sequential model does not imply that there is a single pathway for development but rather that the phases of Quality improvement can be logically grouped and ordered. This logical grouping and sequencing is a result of both the review of the literature described above in Chapters 2 and 3 and studies of industrial practice described below in Chapters 6 and 8.

The reasons for identifying three generic stages of development rather than representing Quality management as a continuous process of applying tools and creating organisational change are twofold. Firstly by grouping activities into generic stages the relationship between one set of activities, for example process definitions and process improvements can be more logically understood. Secondly many organisations, due to the presence or absence of internal and external drivers, choose to progress to a limited extent and this development needs to be recognised and identified as a valid improvement rather than dismissed as failure to make it all the way to the Quality management "destination".

The precedents of Quality improvement activities and culture change are complex. Whilst it is relatively easy to understand the need for one specific Quality improvement technique (for example measuring process variability) to be implemented prior to another (for example control charts), the relationship between the activities and the culture change is less easy to model. The developmental framework proposed in this research suggests that at the early stage of development the process is primarily techniques led and the culture change is predominantly a consequence of the improvement activities. In the final stage of development, the techniques are primarily used to support the changing culture rather than to create it.

The Quality development model proposed also reflects the needs identified in Howe, Gaeddert and Howe [47,1992] and also in Tranfield et al [104,1994] that Quality improvement programs need to be regenerative and require new initiatives and directions which are readily identified by senior management.

4.1.3. Requirements of a Descriptive Framework

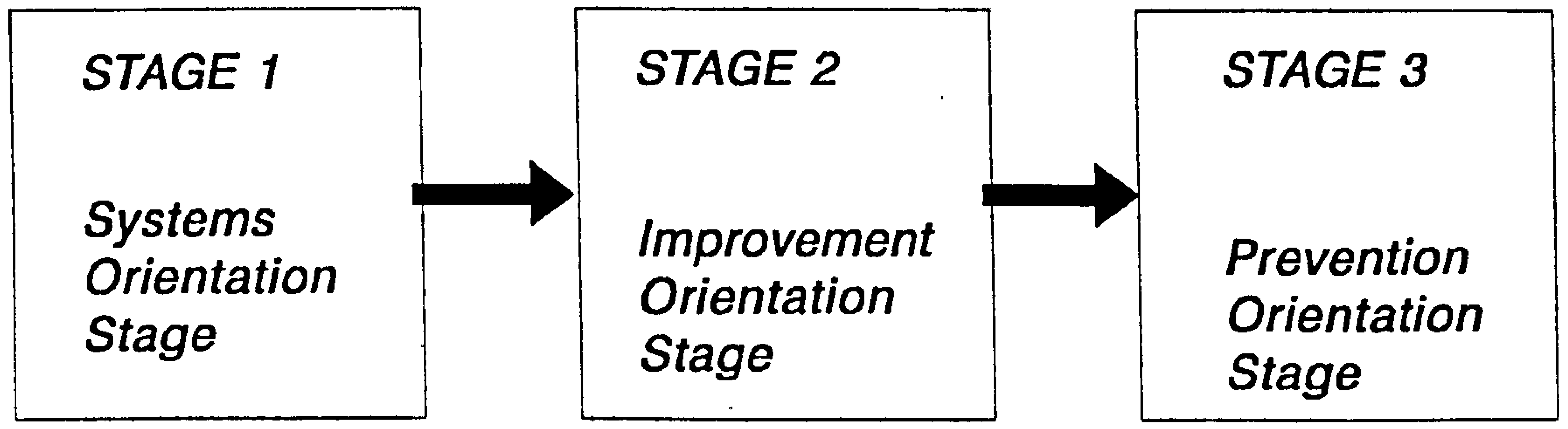
The usefulness of a framework describing Quality development lies in the ability of the model to encompass all the main elements of Quality management and also to reflect industrial practice. For the framework to be of use to students, researchers and industrial practitioners it requires:

- a comprehensive set of stages which can be used to position all the major Quality management techniques and activities.
- characteristic cultural 'identifiers' describing the main orientation of the organisation at each stage.
- a set of Quality related performance measures associated with each of the stages of development.
- a simple descriptor which identifies the primary focus of each of the stages of development.

In establishing the level of decomposition of the Quality development framework a compromise is required between the need to define a large number of stages, each of which can more uniquely define a given stage of development and the need to define as few stages as possible in order to provide more generic stages and hence a simpler model with fewer changes in emphasis required. Juran [55,1967] proposes three stages of development, Quality planning, Quality improvement and Quality breakthrough whereas Crosby [21,1979] proposes five stages, uncertainty, awakening, enlightenment, wisdom and certainty.

The framework proposed in this research has adopted a three stage model of development as illustrated in Figure 4.1.3.

Figure 4.1.3 The proposed stages of Quality development



4.2. Stage 1 - Systems Orientation

4.2. Characteristics of Developing a Systems Approach

The initial stage of Quality development is described in this research as the **'systems'** stage. This represents the establishing of the foundations for Quality improvement and for most organisations this stage involves for the first time a holistic approach to managing Quality.

The main objectives of Stage 1, developing a **systems** orientation are:

- to establish an organisation-wide definition and policy for Quality management.
- to establish "standards" for Quality in terms of both product/service and process requirement specifications.
- to promote a systems approach to managing Quality.

The primary focus for this stage of development is **internal** and Quality is perceived as "conformance to specification" and therefore efforts are directed at defining the specifications and ensuring the mechanisms of conformance. The primary drivers for the development of a systems orientation are external and this is reflected in an emphasis upon activities (what people do) rather than upon behaviour (how people act).

The importance of this initial stage of development has been reflected and indeed prompted by the extensive international promotion of Quality systems standards to assist both in the design and in the assessment of such systems. The level of ownership of the Quality development process is low at this stage and the main agents for internal development (usually consultants) and the main assessors of development (usually accreditation agencies) are external to the organisation.

Organisations developing a more systematic approach to Quality management typically enjoy the benefits of:

- external recognition of the progress made by the organisation.
- improved internal controls and hence a more planned approach to Quality management.
- a foundation for further Quality development.
- limited progress towards developing a Quality culture.

However, the limitations of this initial stage of Quality development are:

- no significant long term, competitive advantage is generated
- it does not necessarily promote ongoing Quality development.
- it is seen as a separate rather than integral part of the main activities of the organisation.

The first stage of Quality development represents an important if limited improvement in the management of Quality and primarily represents an enabling development. The data considered in Chapters 6, 7 and 8 indicate that the systems orientation stage of development is particularly important to small to medium sized enterprises who are seeking to gain regional (rather than national or international) quality competitiveness and who have limited resources to devote to the developmental process.

4.2.2. The Tools and Techniques of Developing a Systems Orientation

The main tools and techniques associated with developing a systems orientation are:

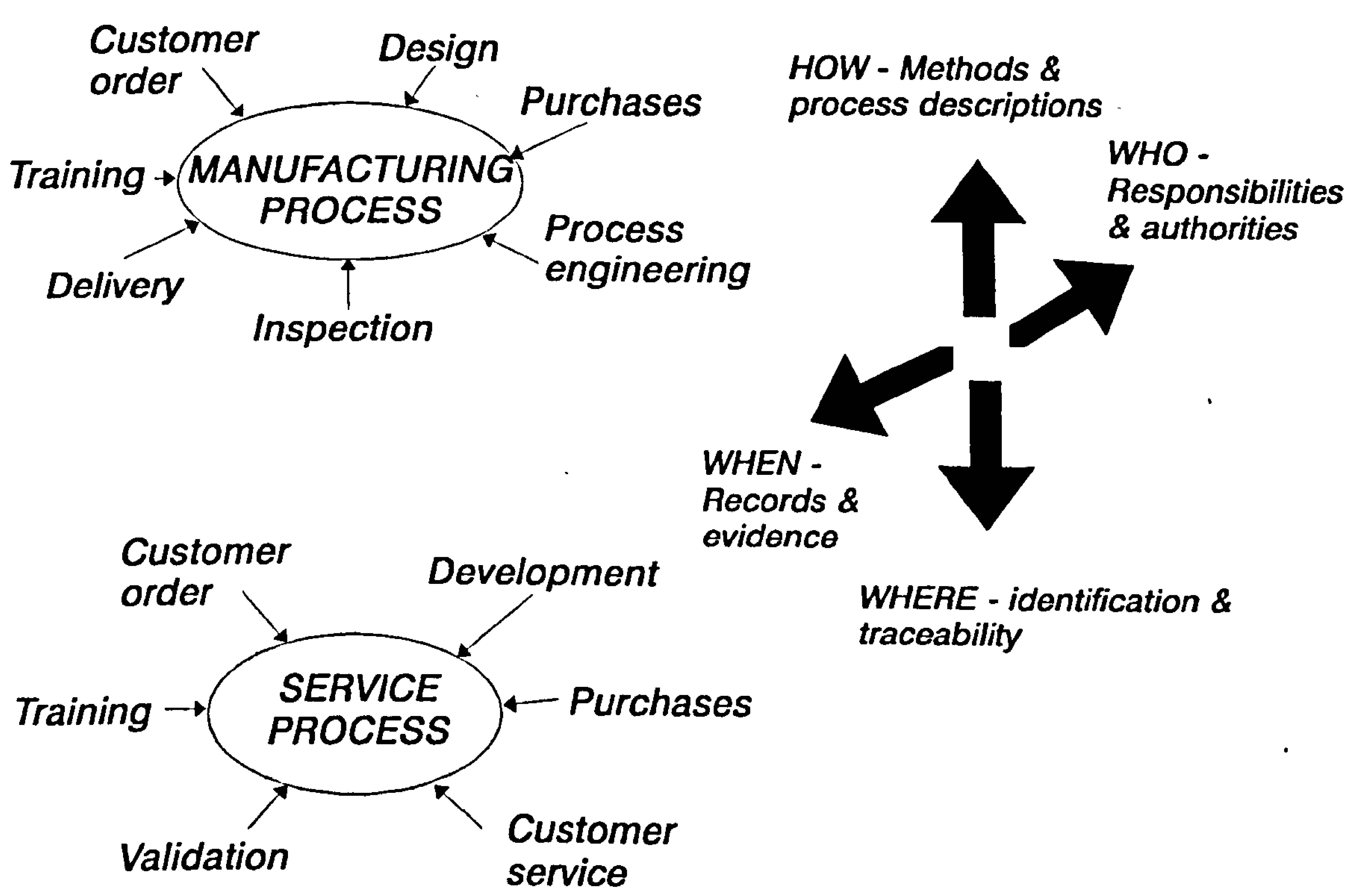
- systems analysis
- systems design

- systems implementation
- systems maintenance

The progression in the U.K. since 1979 in developing a universal model for Quality systems culminated in 1994 with the publication of the internationally harmonised standard BS EN ISO 9000 [10,1994].

The standard provides a checklist of systems analysis requirement in terms of the basic elements of a Quality system as illustrated in Figure 4.2.2.a).

Figure 4.2.2a Typical elements and dimensions of a Quality System

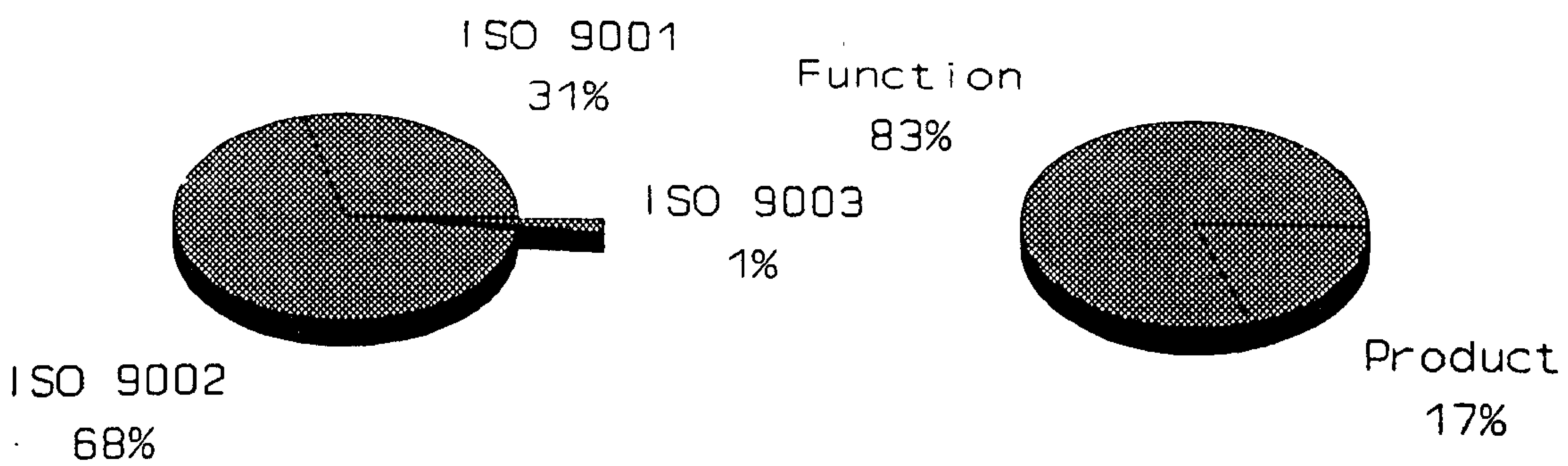


The difference in scope between the three parts of the standard BS EN ISO 9001 and 9002 and 9003 reflects the manner in which the organisation to be assessed (the "supplier") establishes and demonstrates conformance to customer requirements. For the first part of the standard, ISO 9001, the requirements are primarily stated in performance terms and therefore this form of Quality system is applicable where the organisation's capabilities in design, development, production, installation and servicing need to be assessed.

For ISO 9002 the requirements are previously established in terms of a design or specification and therefore this form of Quality system is applicable where assurance is required of the organisations' capabilities in production, installation and servicing. Finally ISO 9003 is applicable where the requirements can be established solely from testing and therefore is used to evaluate Quality systems in terms of final inspection and test capabilities only.

In a study in 1992 by Kehoe [58,1993] the implementation of formalised Quality systems in Europe was predominantly ISO 9001 and ISO 9002 as illustrated in Figure 4.2.2.b).

Figure 4.2.2b Showing the application of ISO 9000



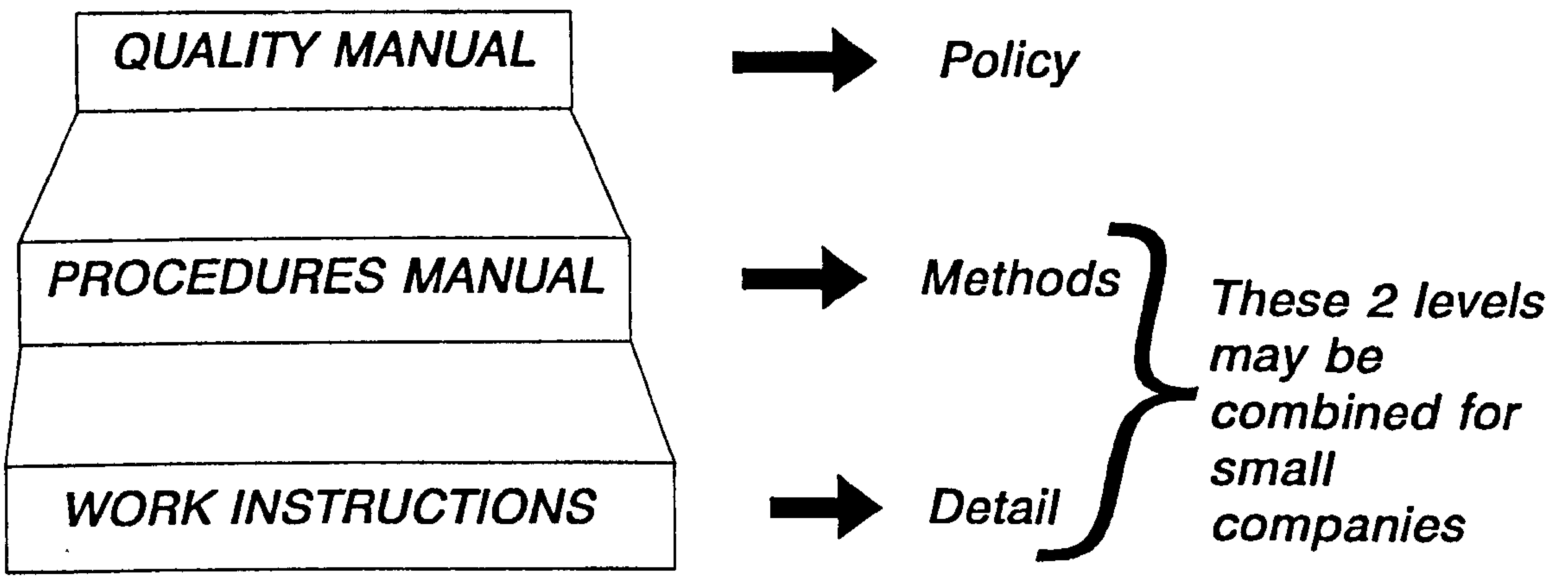
Percentage of companies implementing each of the parts of ISO 9000

Proportion of companies implementing function based procedures vs product based quality plans

The limited application of ISO 9003 reflects the inadequacies of this part of the standard in providing a systems approach to Quality management, focusing as it does primarily on the Quality Control activities of inspection and testing.

The ISO 9000 framework provides an important guide to the design of formal Quality systems and promotes the documentation of the Quality Plan at three levels as shown in Figure 4.2.2.c).

Figure 4.2.2 c Basic Quality System Structure



In developing a formalised Quality system an organisation is required to explicitly describe the policy, the standards, the processes and the methods which are employed internally to manage Quality. Defining the Quality system within the organisation represents a significant contribution to the initial Quality development and involves (with the exception of finance control) all the primary management processes and therefore the majority of managers. Whilst other frameworks do exist for the design of Quality systems (for example the Ford Motor Company Q101 Framework [38,1987]) the international standard ISO 9000 series predominates as the most widely used techniques for systems development.

In terms of implementing Quality systems the main organisational changes relate to the areas of control and review as illustrated in figure 4.2.2.d).

Figure 4.2.2d Quality System implementation requirements

CONTROL	*REVIEW*
- Responsibilities (4.1) *- Quality planning (4.23)* *- Contract specifications (4.3)* *- Design control (4.4)* *- Vendor control (4.6)* *- Identification & traceability (4.8)* *- Process control (4.9)* *- Validation (4.10)* *- Equipment calibration (4.11)* *- Status (4.12)* *- Non-conformance control (4.13)* *- Materials control (4.15)* *- Records control (4.16)* *- Training control (4.18)* *- Statistical conrol (4.20)*	*- Management review (4.1.3)* *- Contract review (4.3.2)* *- Design review (4.4.6)* *- Document review (4.5.3)* *- Review of non-conforming product (4.13.2)* *- Corrective & preventive action (4.14)* *- Internal audit (4.17)*

In establishing the controls necessary within a formalised Quality System objective evidence is required to demonstrate the effective functioning of the system. Implementing these controls therefore requires the organisation to record conformance to specifications and increases the emphasis upon responsibilities, standards and acceptance criteria. The second main implication of implementing a formalised Quality System involves the review of the objective evidence of control. The effect of implementing these reviews is to create a more proactive rather than reactive management style and to recognise Quality management as a systemic issue within the organisation.

The basic tools employed during the implementation of Quality Systems include acceptance sampling techniques for the verification of incoming and outgoing materials, calibration techniques for the validation of inspection and test equipment, statistical process control techniques for monitoring the production processes and vendor assessment techniques for the evaluation of subcontractors.

Finally, the tools and techniques associated with the maintenance of the Quality System primarily involve auditing. The main stages in auditing a Quality System are illustrated in Figure 4.2.2.e).

Figure 4.2.2e The auditing of Quality Systems

STAGES	*PROPORTION*	*TECHNIQUES*
Preparation	*40%*	*Schedules* *Checklists*
Execution	*40%*	*Entry meetings* *Activity sampling*
Reporting	*10%*	*Non-conformance reports* *summary matrices*
Follow-up	*10%*	*Validation* *Close-out*

The audit requirements of ISO 9000 represent a critical element in the development of a systems orientation towards managing Quality. Fox [40,1995] describes the auditing process as "closing the loop" in terms of Quality System development. Without the audit discipline many organisations establish 'open loop' systems where the methods and specifications are defined but the implementation is never verified. Formal auditing requires managers to be able to positively demonstrate that the Quality system is functioning in accordance with planned arrangements and that any corrective actions are effectively implemented. The effect of this audit process is to develop the management responsibility or ownership for the operation of the Quality System and also promotes a more systematic and accountable management style. Research [19,1994] demonstrates that for many large (more than 500 employees) organisations, the major benefits associated with ISO 9000 implementation are derived from the disciplines and accountability promoted through auditing rather than the guidance ISO 9000 provides in the design of the Quality System which is the primary benefit obtained by small (less than 250 employees) companies implementing the standard.

4.2.3. Culture Change During the Systems Orientation Stage

By identifying the establishment of a 'systems' approach to the management of Quality as the first stage of Quality development implies recognisable change within an organisation. In addition to the application of the tools and techniques described in 4.2.2. above, organisations also undergo identifiable culture change which is reflected both in the shared values and also the Quality management style These changes in Quality culture involve:

- increased employee involvement in and responsibility for the assurance of Quality.
- the perception that achieving Quality involves attaining pre-defined standards and that these achievements are externally monitored and demonstrated through objective evidence.
- that the Quality management process primarily involves the control and review of all the elemental business sub-systems.

The predominant cultural features are therefore responsibility and control although the focus for corrective action is on the system or sub-systems rather than the individual or the activity.

Whilst the culture change which occurs during the initial, systems orientation stage of Quality development may appear to be far removed from the required Total Quality culture, nonetheless these early changes are extremely important. The idea that Quality Systems development is an externally driven phenomenon in terms of the plan for development (ISO 9000) and the assessment of development (accreditation agencies such as the British Standards Institution or Lloyds Register of Quality Assurance) is both an enabler for culture change and an inhibitor of further change. Quality Systems standards have the status of 'law' to many organisations and as such will be generally more readily accepted and persevered with than an equivalent code of practice for Quality development.

Developing a systems orientation therefore creates a Quality awareness culture where the management of conformance to specification is given a high priority and the prevailing management style is one of system control and review. In terms of organisation design the management structure adopted during the systems orientation stage of development is consistent with the 'mechanistic' type of organisation identified by Burns and Stalker [16,1994] as one of the two principal types of organisational structure described in the Structural Contingency Theory model. The mechanistic structure is characterised as being formal, proceduralised and pre-defined and is contrasted with the second type of structure identified by contingency theory which is 'organic' and characterises by informal, team-based and less defined organisational structures. Furthermore the structural contingency theory model indicates that the mechanistic structure is appropriate to the systems orientation stage of development due to the well structured and planned approach to managing Quality. The more organic organisational structure is more evident and appropriate at the third stage of Quality development as described below in section 4.4.

The changing organisational culture and structure which occurs during the Quality development process described in this research is also consistent with the Institutional Theory of organisation design proposed by Meyer and Rowan [76,1977] and by Scott [96,1987]. Institutional Theory suggests that organisational structure can be adopted to promote the legitimacy of a requirement of an important external constituent (for example customers), rather than to manage an intrinsic business process. The organisational structures adopted during the second stage of Quality development (described below in Section 4.3.) are consistent with the Institutional Theory viewpoint.

4.2.4. Measures of Development During the Systems Orientation Stage

The primary indicative measures of Quality development during the systems orientation stage are those associated with system performance. Typically these measures would include:

- system accreditation or approval (for example registration to ISO 9000)
- system performance indicators (for example defect rates, customer complaints or, audit non-compliances)
- cost of Quality (for example measured in terms of the prevention, appraisal and failure categories outlined in BS 6143 Part 2 [13,1990]).

These performance measures associated with developing a systems orientation are essential motivators of the development process and are used as both measures of progress and as mechanism for maintaining management enthusiasm.

In addition to these 'results' orientated measures of development the 'activities' associated with developing a systems orientation can also be measured as described above in 4.2.2. and as classified below in Chapter 5. These activities include:

- the formal definition of specifications, procedures, responsibilities and plans.
- the design and implementation of Quality systems in accordance with the requirements of national/international standards
- the audit and review activities associated with system maintenance.

The measures of the cultural change associated with developing a systems approach to managing Quality are primarily an increased awareness of the importance of

Quality to the organisation and the companywide acceptance of roles and responsibilities.

The manner and extent to which these measures change during the Quality development process is detailed below in Chapter 5.

4.3. Stage 2 - Improvement Orientation

4.3.1. Characteristics of Developing an Improvement Approach

The second stage of Quality development identified in the research is described as the **'improvement'** stage. This stage represents the continuous improvement of the processes, methods and results established during the initial (systems) stage of development and requires the involvement of all employees in the pursuit of 'improvement through teamwork' as described by Kehoe [57,1996].

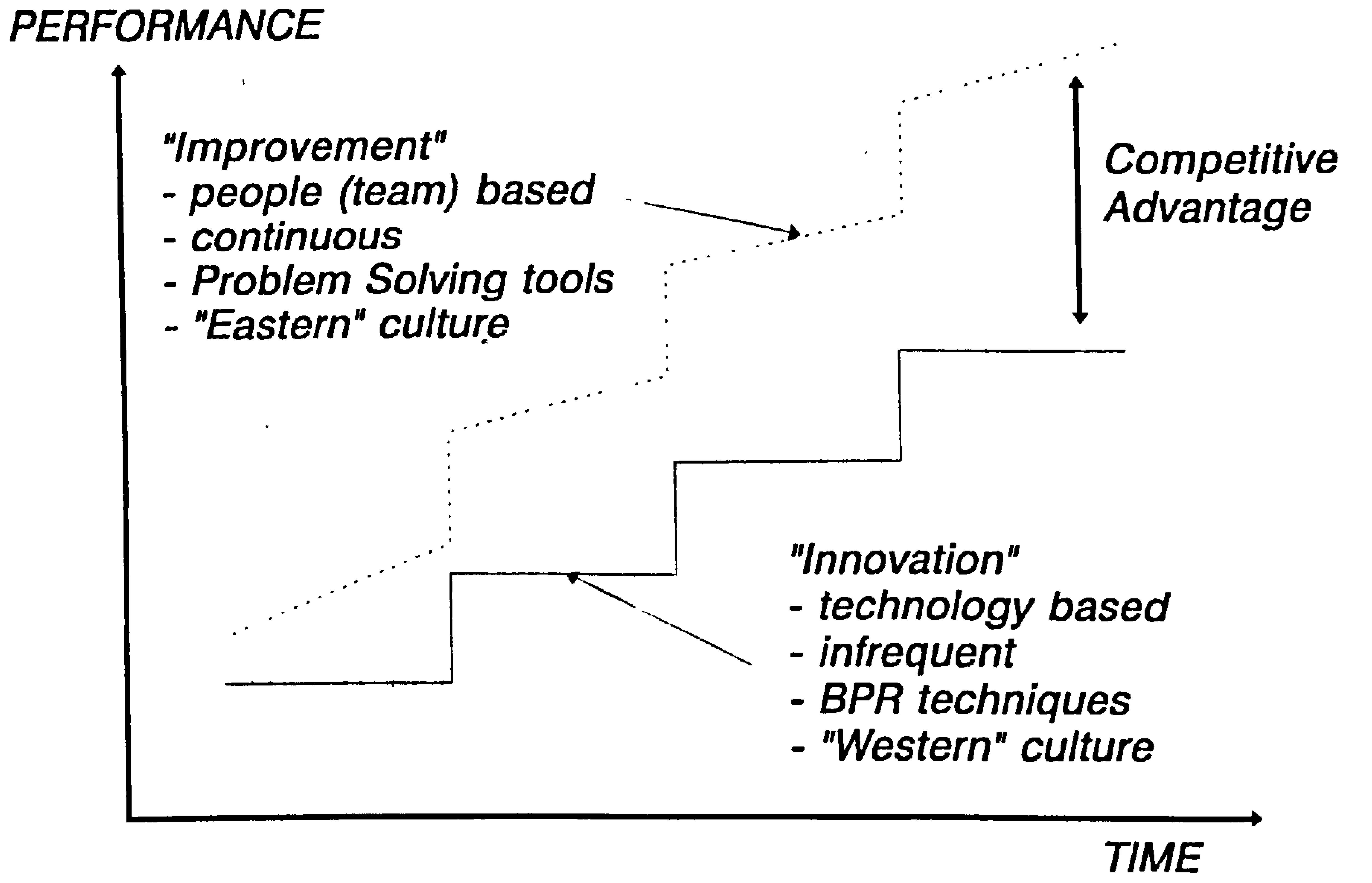
The main objectives of Stage 2, developing an **improvement** orientation, are:

- to establish widespread organisational commitment to improving the processes which support Quality management.
- to promote a 'passion' for improvement through the coordination of the efforts and creativity of individuals
- to employ incremental continuous improvement as the mechanism for achieving competitive advantage through Quality management.

The primary focus for this stage of development is **process** orientated and organisational efforts are directed at process analysis, performance measurement and improvement. The primary drivers for the development of an improvement orientation are internal and this is reflected in an emphasis upon departmental processes and involving groups of employees in measurable improvement projects.

This stage of development is characterised by the Japanese expression 'Kaizen' as described by Masaaki [75,1986] in which developments occur as a result of many small, frequent and gradual improvements over a relatively long period of time as illustrated in Figure 4.3.1.

Figure 4.3.1 The effects of the improvement orientation stage of development



The level of ownership of the Quality development process increases during this second stage as more employees become directly involved in improvement activities and the main organisational change agents are Steering Committees or Quality Councils.

Organisations which develop an improvement orientation typically enjoy the benefits of:

- internal reduction in process costs, waste or lead times
- tangible business benefits from the Quality management efforts
- the creation of a multi-disciplinary organisation where individuals work within a framework of team-based structured problem solving

However, the limitations of this second stage of Quality development are:

- the incremental improvements in processes eventually exhibit diminishing returns if the fundamental process designs are not reviewed
- the improvement in internal processes may not actually address the external performance of the organisation as perceived by the customer
- the activities of Quality improvement are still primarily separate from the main functional processes within the organisation

The importance of this second stage of development is twofold. Firstly the incremental product and process improvements provide a clear linkage between Quality development and business performance through the reduction in the cost of Quality. Secondly, the involvement of employees at all levels within the organisation in the development process reinforces the importance of the role of the individual.

4.3.2. The Tools and Techniques of Developing an Improvement Orientation

The main tools and techniques employed during the improvement stage of development include:

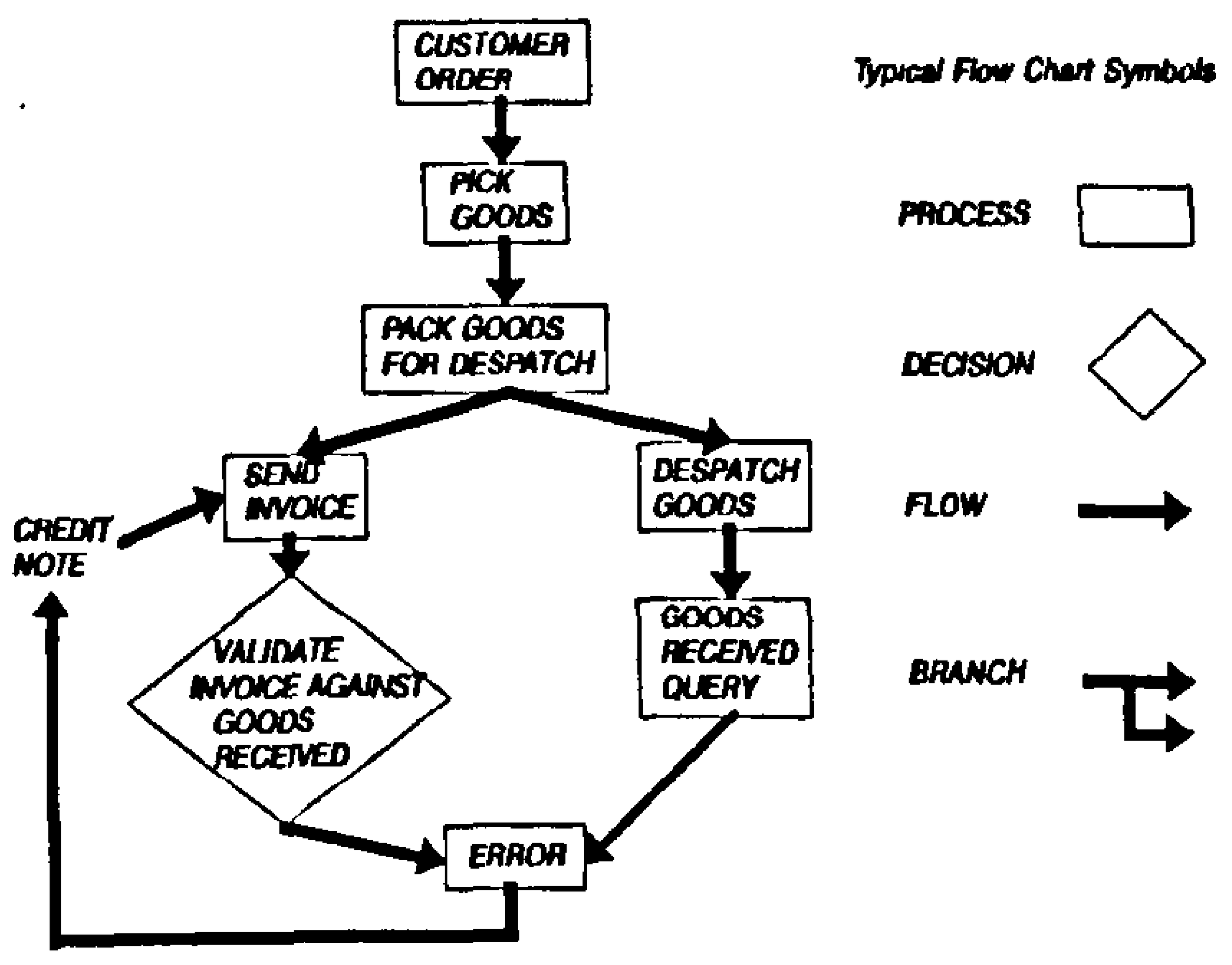
- problem solving tools
- improvement methodologies
- process control tools

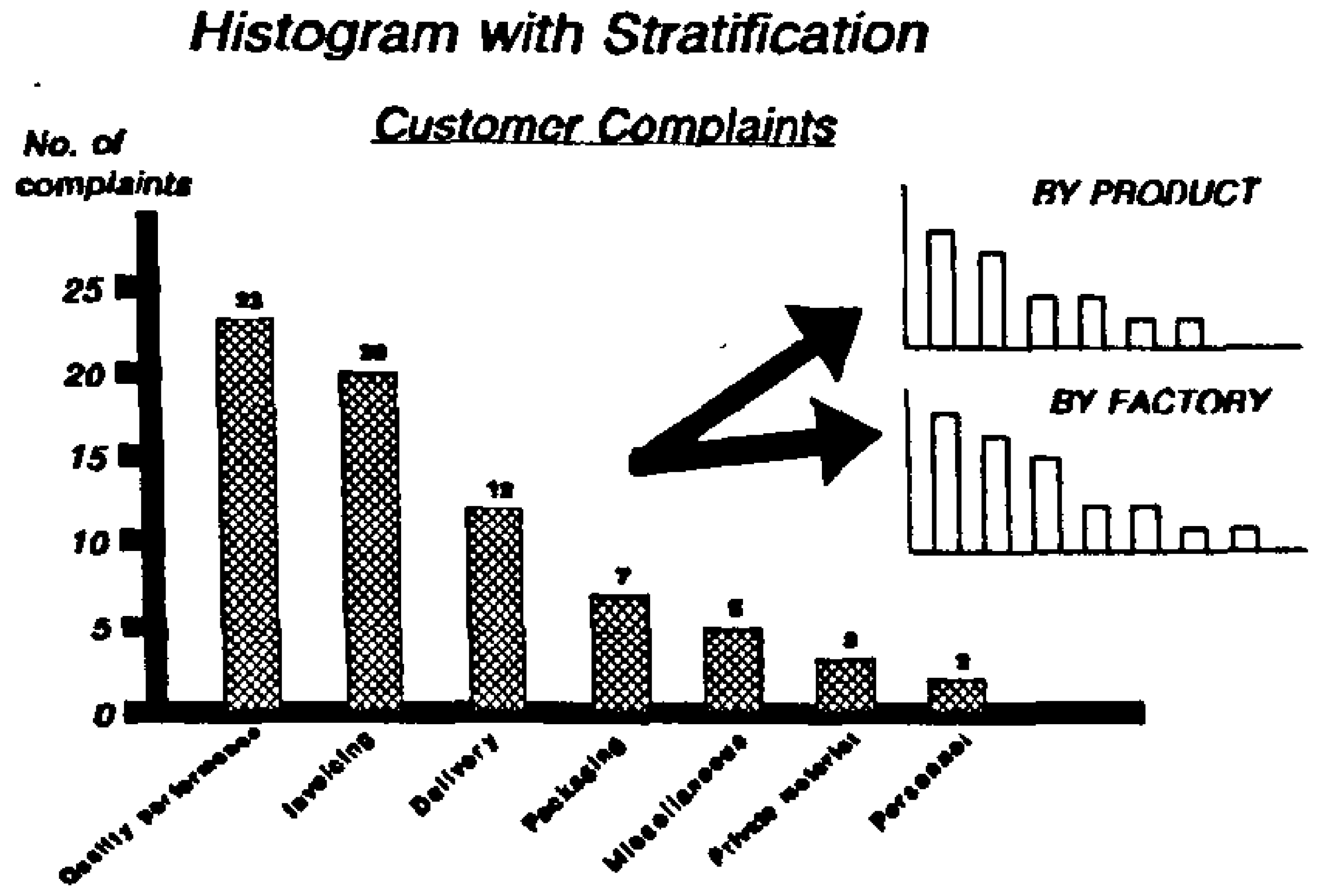
The basic 'tool kit' for improvement was identified by Ishikawa [51,1982] as the seven basic problem solving tools illustrated in Figure 4.3.2.a)

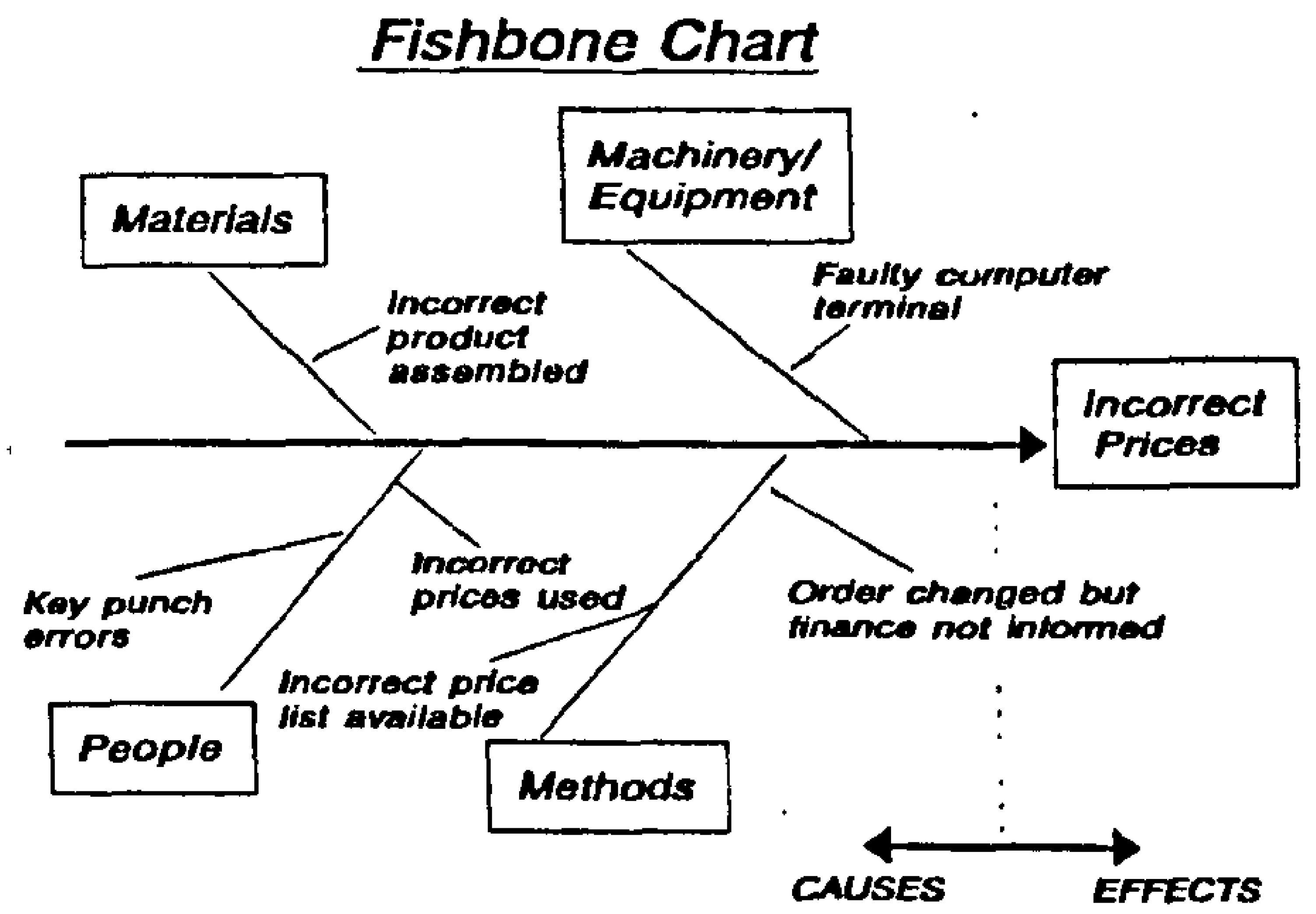
These generalised improvement tools can be applied to a wide range of process situations and can be readily used by employees at all levels within the organisation, particularly to facilitate team-based problem solving.

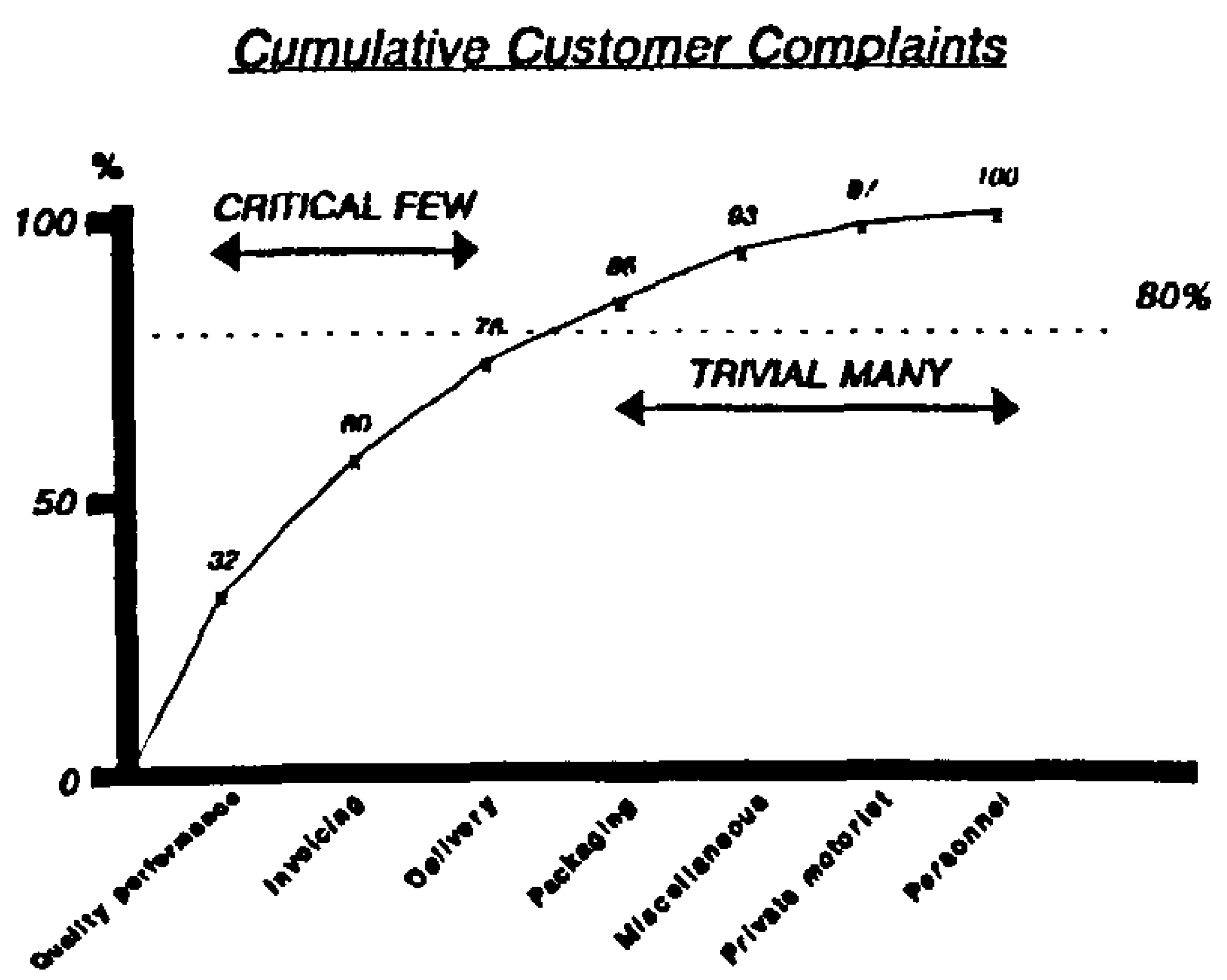
The application of these problem solving tools is most effectively undertaken within some form of step-by-step framework or methodology. The approach to Quality improvement proposed by Juran [55,1967] in which problem solving should be viewed as a sequential process involving a 'diagnostic' journey followed by a 'remedial' journey as illustrated in Figure 4.3.2..b).

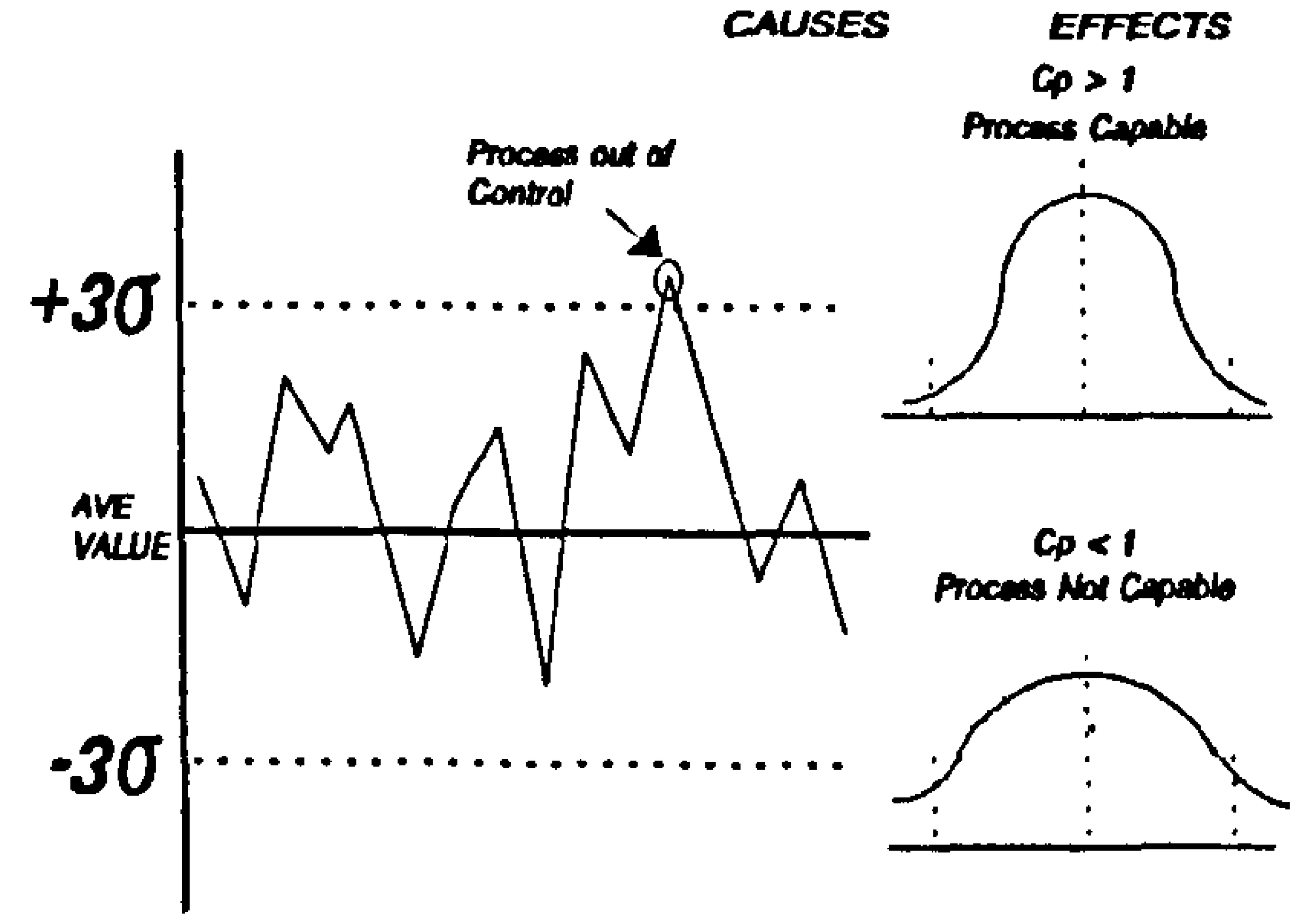
Figure 4.3.2a The 7 basic tools of Quality improvement

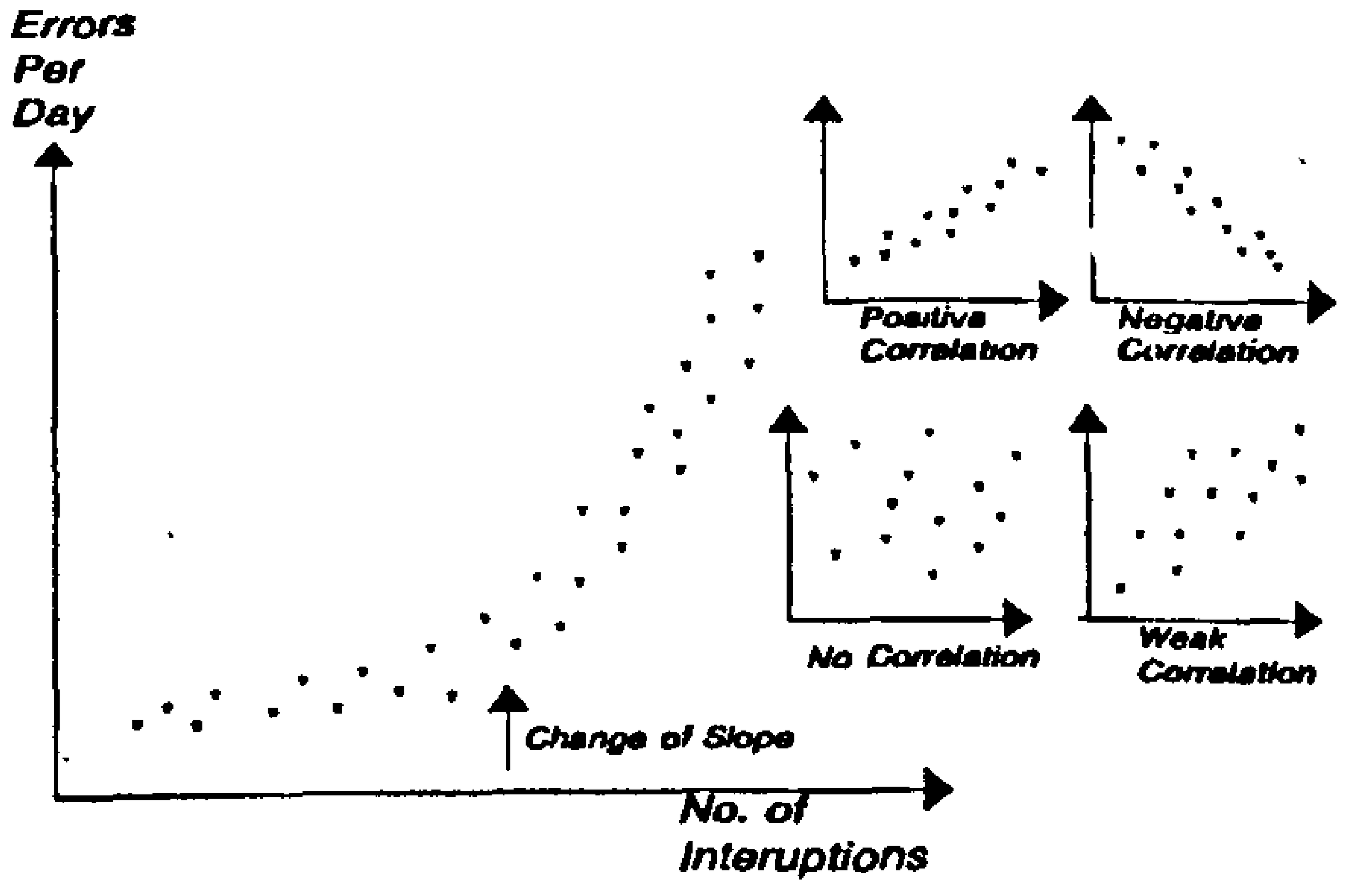










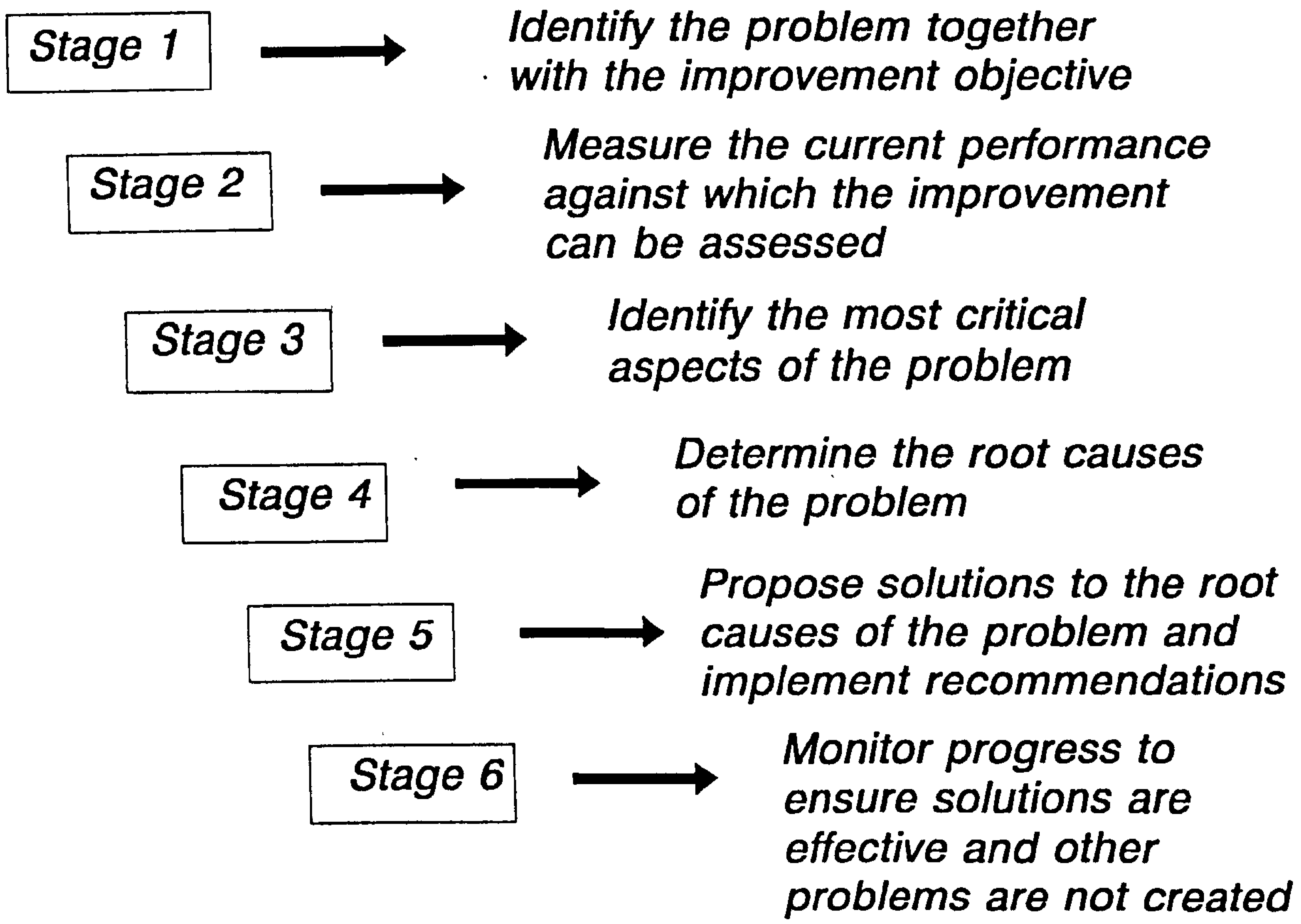


Check Sheet / Tally Chart

Customer Complaints By Category

Delivery	卌 卌 II	12
Packaging	卌 II	7
Quality/Performance	卌 卌 卌 卌 III	23
Personnel	II	2
Invoicing	卌 卌 卌 卌	20
Private Motorist	III	3
Miscellaneous	卌	5

Figure 4.3.2b Basic improvement methodologies



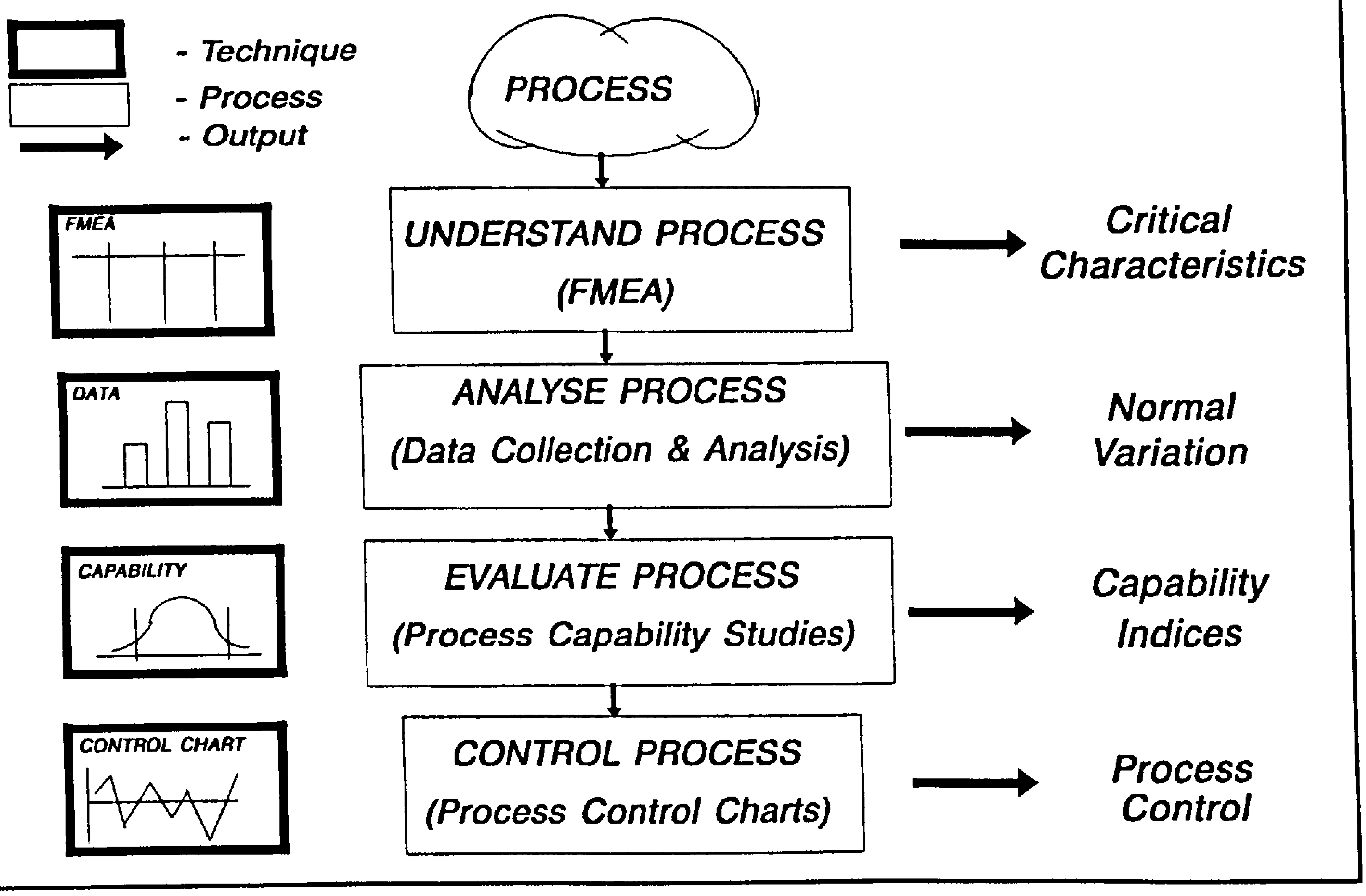
The application of problem solving tools within an improvement methodology is illustrated in the industrial case studies described below in Chapter 8. The main focus of the application of these techniques during the second stage of Quality development is the analysis and improvement of processes and methods as distinct from the definition of the processes (stage 1) or the planning of the process (stage 3).

In addition to a structured, methodological framework within which to apply the problem solving tools, the other primary requirements for developing an improvement orientation is teamwork. Teambuilding and team operation become important constituents of an organisation's approach to managing Quality during the improvement stage of development. Teambuilding and assessment techniques such as the model proposed by Belbin [5,1987] can be used to introduce more formalised teamworking particularly for the operation of Quality improvement projects. By identifying team roles, team leadership and facilitation skills, organisations can effectively introduce team-based improvement projects across a range of processes and promote improved performance in a number of prioritised Quality problem areas. The increased effectiveness of problem solving when undertaken by a team is essential in developing an improvement culture within organisations.

Finally the focus upon internal processes, which is predominant during the second stage of development, lends itself to the application of the range of statistical process control tools. These tools are primarily used to bring improvement through the reduction in variability and hence an increase in the capability of the processes. The techniques of Statistical Process Control are applicable to all three stages of Quality development identified in this research. These techniques range from Quality planning activities such as Failure Mode and Effect Analysis and Control Plans which are associated with a prevention orientated level of development to the use of control charts and monitoring activities which are associated with a systems approach as illustrated in Figure 4.3.2.c)

Primarily, however, the techniques of Statistical Process Control, as identified by Oakland [82,1986], are applied for process improvement. In particular the measurement of process capability, C_p is widely used as a basic indicator of process performance and is typically specified as an improvement objective.

Figure 4.3.2c The tools and techniques of statistical process control



Leading Quality management practitioners such as Ford and Motorola identify both absolute levels and improvement targets for process capability as a requirement from their supplier base. The other key attribute of Statistical Process Control which make these techniques improvement orientated is the general manner in which they are applied. Statistical Process Control is intended to be used as an operator's tool to improve the control of existing processes or operations and therefore builds upon the process definitions and specifications established during Stage 1 of development.

4.3.3. Culture Change During the Improvement Orientation Stage

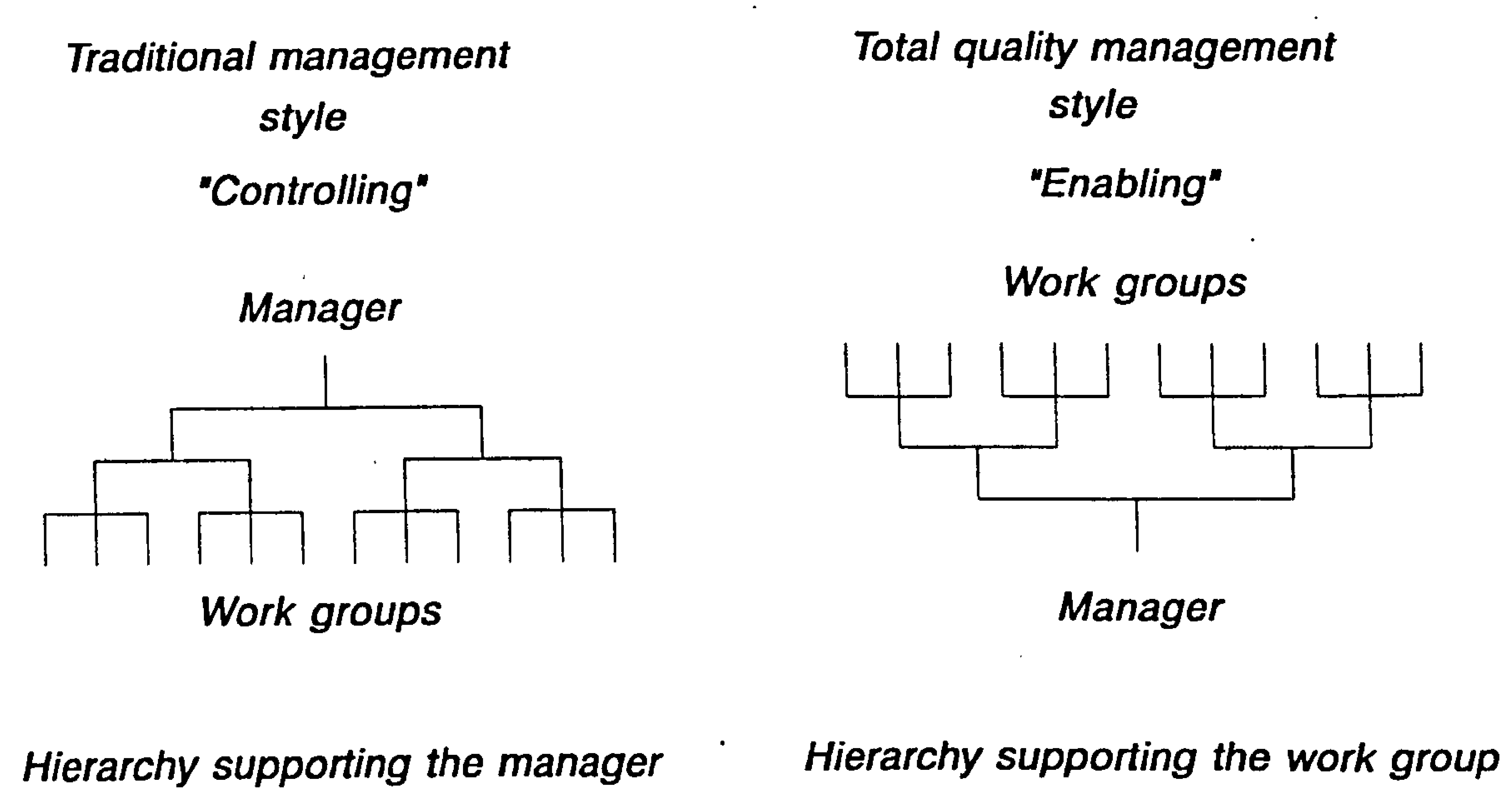
As with the 'systems' stage of development the 'improvement' stage also has identifiable culture change as both an enabler and by-product of the organisational progress and application of the tools and techniques described above in Section 4.3.2. The main changes in organisational culture during the improvement orientation are:

- increased teamworking and awareness of operating in teams
- the companywide understanding that Quality development is a process of continuous improvement
- that Quality management requires a passion for incremental improvements throughout the organisation and to all business processes and methods.

The predominant cultural features are the recognition of the contribution to be made by all employees and an appreciation of the benefits teamworking brings to Quality improvement.

Creating the team-based culture is a difficult transition for many organisations and the creativity that teamworking attempts to unleash is not emphasised during the initial control based culture evident in Stage 1 of development. Indeed the research results given below in Chapters 6 and 7 indicate that the majority of organisations who develop Quality systems are unable to progress to the team-based orientation stage. In essence this is seen as a conflict between the 'controlling' management style predominant during the first stage of development and the 'enabling' management style exhibited during stage two as illustrated in Figure 4.3.3.

Figure 4.3.3 "Enabling" vs "Controlling" management style



The challenge of creating this culture change is manifest in the approaches adopted to team operation and the relative priorities given to alternative types of improvement teams. Two basic team operation mechanisms have been identified, namely:

- **Type A**, top-down, deployed improvement teams directed at cross-functional improvement projects and operating within a fixed set of objectives and timeframe. Such teams are described by Chang, Labovitz and Rosansky [17,1993] as 'Tiger Teams' and represent the predominant approach to team operation in the U.S. In the U.K. Mann and Kehoe [72,1994] also identified these delegated teams as being seen as the most effective form of improvement team.

- **Type B**, bottom-up, self directed improvement teams operating on an ongoing, voluntary basis with improvement objectives and priorities being identified within the team. This form of improvement team is alternatively called Quality Circles, Quality Improvement Teams or Self-Managed Teams and was identified by Juran [55,1967] as representing predominantly the Japanese approach to teamworking.

The approach to teamworking adopted by organisations reflects the developmental model of Quality maturity proposed in this research. As organisations move from a systems-based culture of control and review to a prevention based culture of planning and empowerment, then the predominant form of teamworking, moves from the controlled, delegated 'Type A' team to the voluntary, self-directed 'Type B' team.

The second main problem area in creating the improvement culture relates to the reward and recognition for teams and for individuals contributing to the improvement process. Moving from a perspective where responsibilities are clearly defined and additional contributions are rewarded pro-rata (for example through the operation of a suggestion scheme system) to a mindset where the introduction of improvements is seen as integral to the responsibilities of all employees is essential to Stage 2 development. The phrase 'everyone has two jobs, job number one is the work they undertake and job number two is improving job number one', epitomises this change in organisational culture to adopt a passion for improvement.

4.3.4. Measures of Development During the Improvement Orientation Stage

The primary measures associated with the improvement stage of Quality development are related to team operation and typically would include:

- process improvements including reduced variability and increased capability.

- the participation in improvement teams and the increasing balance of team roles within an organisation.

- the training and application in problem solving tools and team leadership and facilitation skills.

- the cost of Quality

An important feature of this second stage of development is the emphasis upon performance measurement as a mechanism for tracking improvement. Recognising the contribution of teams and individuals to the improvement of processes is an important 'renewal' activity in sustaining the commitment to Quality development. As with the initial stage of development, the improvement orientation can also be parametrically measured in terms of the Quality management activities employed and the culture changes which occur. These measures and the way in which they change during the second stage of development is illustrated below in Chapter 6.

4.4. Stage 3 - Prevention Orientation

4.4.1. Characteristics of Developing a Prevention Approach

The third stage of Quality development is identified in this research as the **'prevention'** stage. This stage of development focuses upon the elimination of Quality problems through improved process or product design and is characterised by an emphasis upon Quality planning rather than improvement as seen during Stage 2. During the prevention orientation of an organisation, Quality development becomes the predominant management issue and process redesign is undertaken to improve the provision of customer service.

The main objectives of Stage 3, developing a prevention orientation are:

- to establish advanced Quality planning as the approach to managing Quality through a predictive rather than reactive organisational style.

- to promote a 'passion' for customer service and developing customer loyalty through partnership.

- to employ process reengineering and Quality planning techniques as the mechanisms for achieving advanced business performance.

The primary focus for this stage of development is customer orientated and organisational efforts are concerned with aligning the products, services and processes with the needs of the customer. The primary drivers for this stage of development are external customers, often due to the need to compete in aggressive international markets or customers who dominate the market place. The importance of the customer during this stage of development is reflected in the emphasis upon restructuring processes to meet customer needs and the incorporation of customer requirements into product or service designs.

The integration and coordination of activities is also a feature of developing a prevention orientation. The techniques employed during this stage of development rely upon a high level of organisational coordination and the ownership of the Quality development process is very high and is typically described as 'Total Quality'.

Organisations which achieve a prevention orientation typically enjoy the benefits of:

- improved level of customer service resulting in increased customer loyalty.

- 'world class' performance in terms of key business measures such as process costs, lead times, defect rates and yield.

- breakthrough in terms of the 'critical mass' of people within the organisation involved and committed to Quality development.

- external, market recognition as being a Total Quality provider of goods and services.

The main challenges however, to achieving and sustaining this level of advanced Quality development are:

- the need to build upon the achievements of the first two stages of development and to make the 'planning' management mindset compatible with the 'control' and the 'improvement' mindsets.

- the organisational effort and commitment necessary to sustain the culture and activities of a prevention orientation in the light of external disturbances such as market conditions, macro economic factors or changes in ownership or senior leadership.

The achievement of this final state of development is essential to organisations aiming to secure the full benefits of Quality management and to compete in critical international markets. If the full benefits of Total Quality Management as described by Cullen [22,1987] and Oakland [83,1989] are to be realised, then organisations need to achieve the fullest level of development.

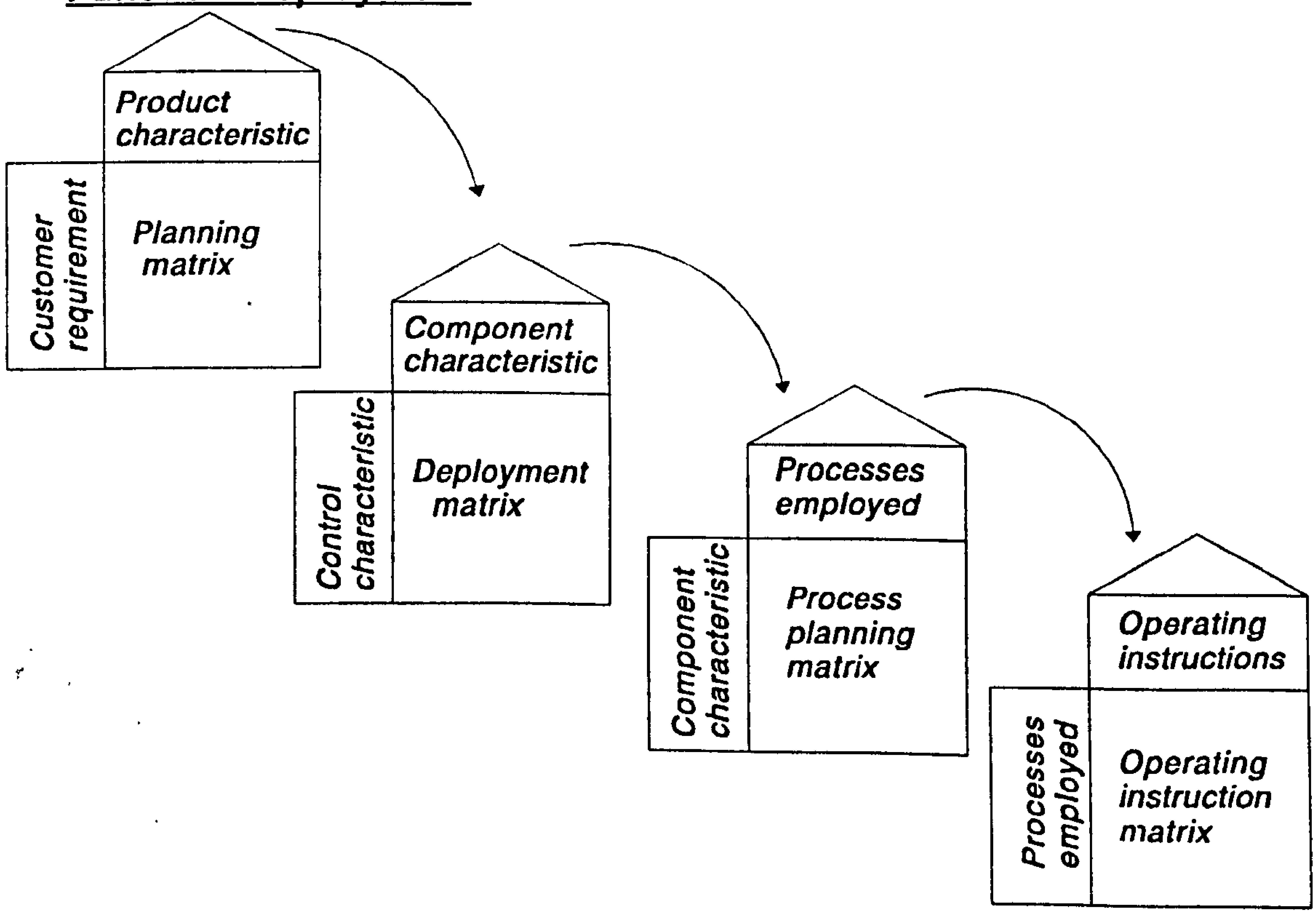
4.4.2. The Tools and Techniques of Developing a Prevention Orientation

The main tools and techniques employed during the prevention orientation stage of development include:

- advanced Quality planning techniques
- the seven management tools
- business process reengineering
- process optimisation tools

The essence of a prevention based approach to the management of Quality is the emphasis upon planning and prediction. The main toolset for advanced Quality planning was identified by Sullivan [100,1986] as the methodology for Quality Function Deployment (QFD). The main elements of the QFD 'House of Quality' are illustrated in Figure 4.4.2.a).

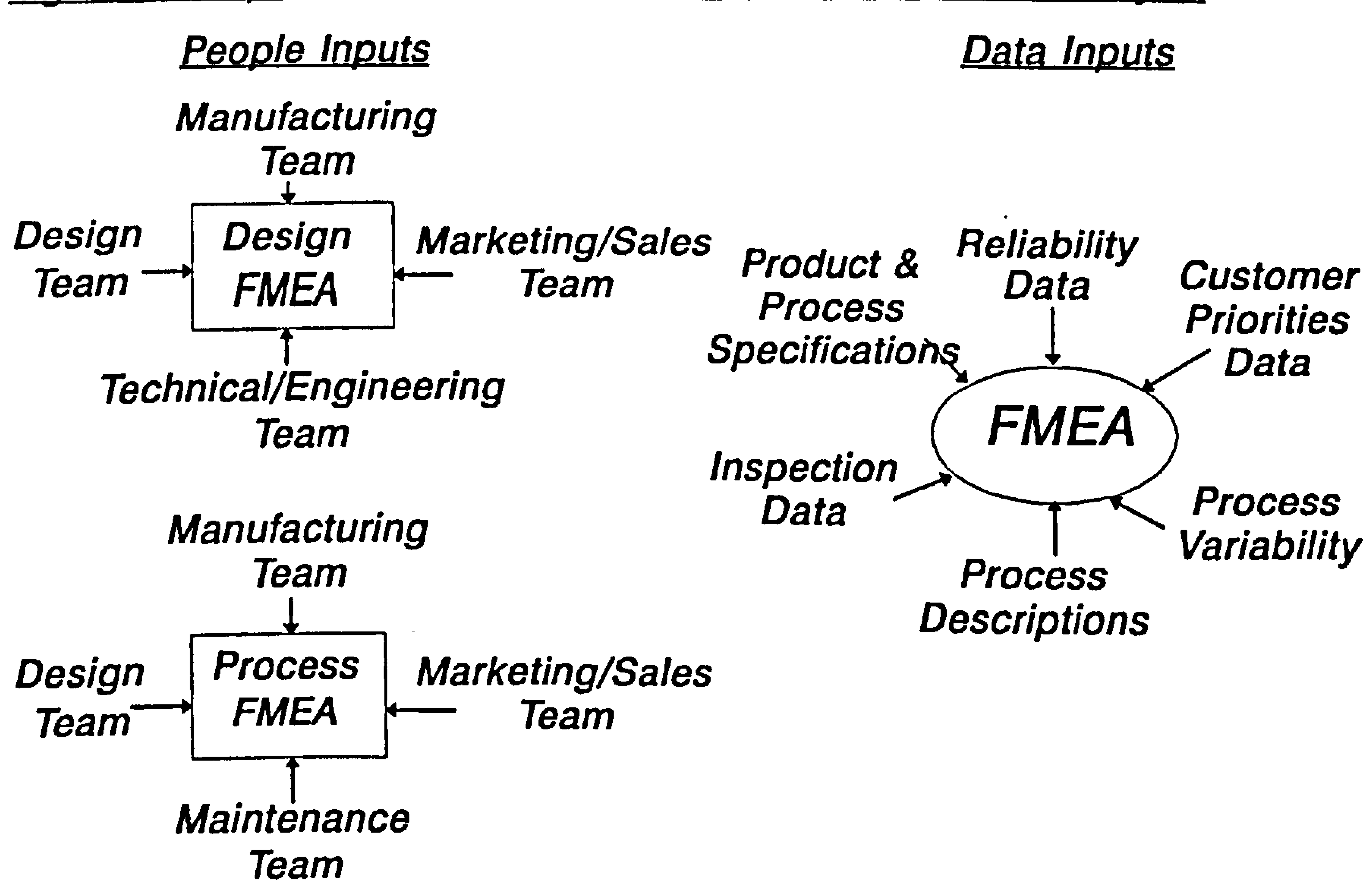
Figure 4.4.2a The four matrices documented in Quality Function Deployment



The importance of the QFD matrices is that they provide an integrated approach to linking the requirements of the customer to the technical features of the product and the control plans of the manufacturing processes. The integrated approach provided by QFD also applies to the requirements, features and control plans at increasing levels of detail through the decompositional process of QFD. The application of QFD also requires a considerable level of organisational integratedness requiring marketing, design, technical, production and quality inputs and a strong customer focus and customer understanding.

The second prevention orientated Quality planning technique is Failure Model Effects and Analysis (FMEA) which can be applied to both product design and processing. The main elements in creating an FMEA are illustrated in Figure 4.4.2.b).

Figure 4.4.2b) The elements of Failure Mode and Effects Analysis



The emphasis of FMEA is again predictive in attempting to identify potential failures of the design or the process and through a team based evaluation of the causes, effects and controls, aims to prevent failures for the customer. The determination of the indices for severity, occurrence and detection which generate the risk priority number also requires a coordinated organisational approach and a clear understanding of the customers' requirements and applications. The main areas of application of FMEA to Quality development are described by the Ford Motor Company [37,1989] as being precursor to the preparation of control plans and control charts and by Kehoe, Escolme and Mann [60,1994] as a preventative technique for improved product and process safety.

The seven 'new' or 'management' Quality tools have been described by Muzuno [78,1988] as a toolset for teams of managers to understand process relationships in order to prevent Quality problems. The seven management tools are:

- affinity diagrams
- inter-relationship digraphs
- tree diagrams
- matrix diagrams
- matrix data analysis
- process decision program charts
- arrow diagrams

These tools are illustrated in Figure 4.4.2.c).

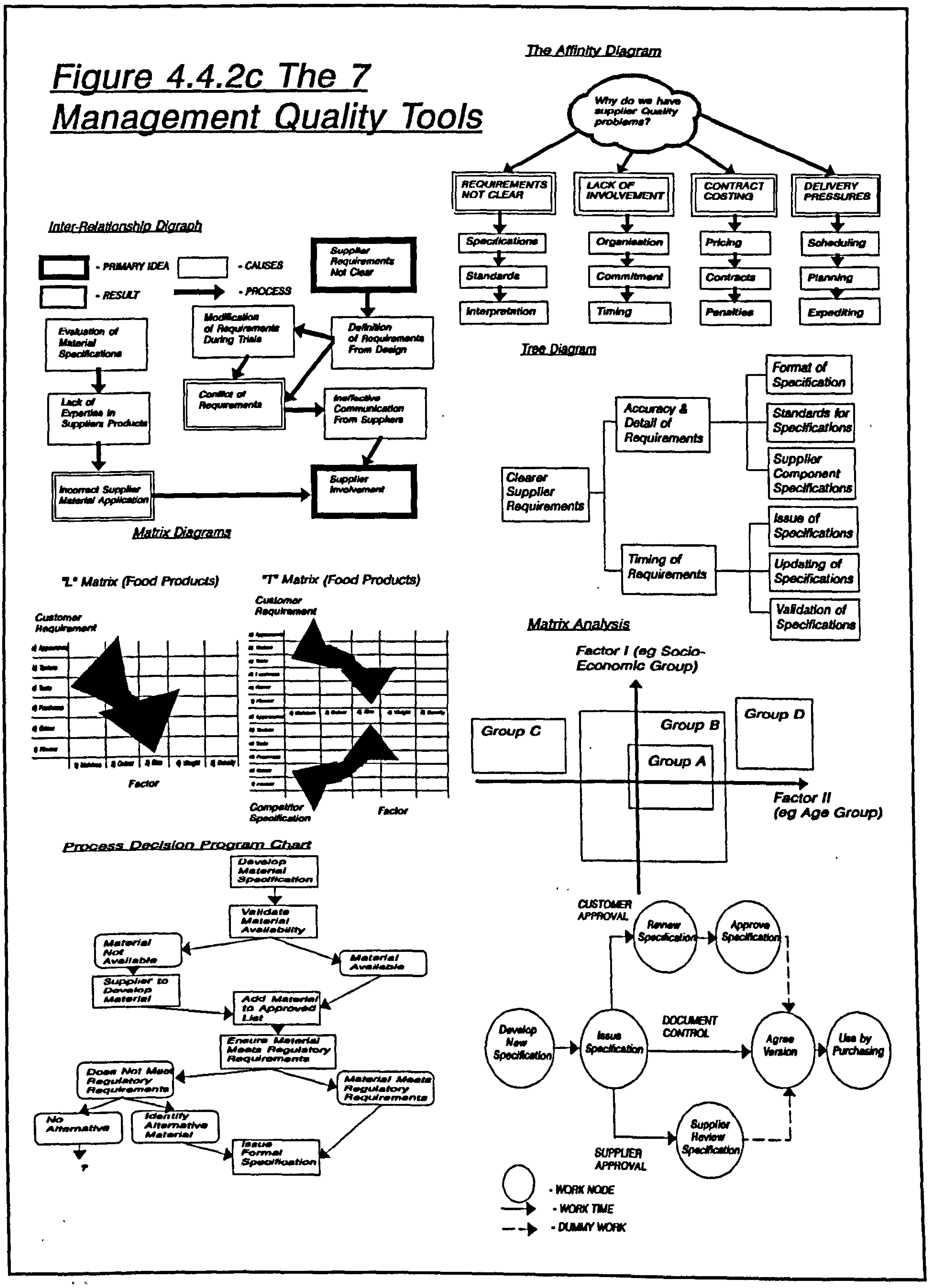


Figure 4.4.2c The 7 Management Quality Tools

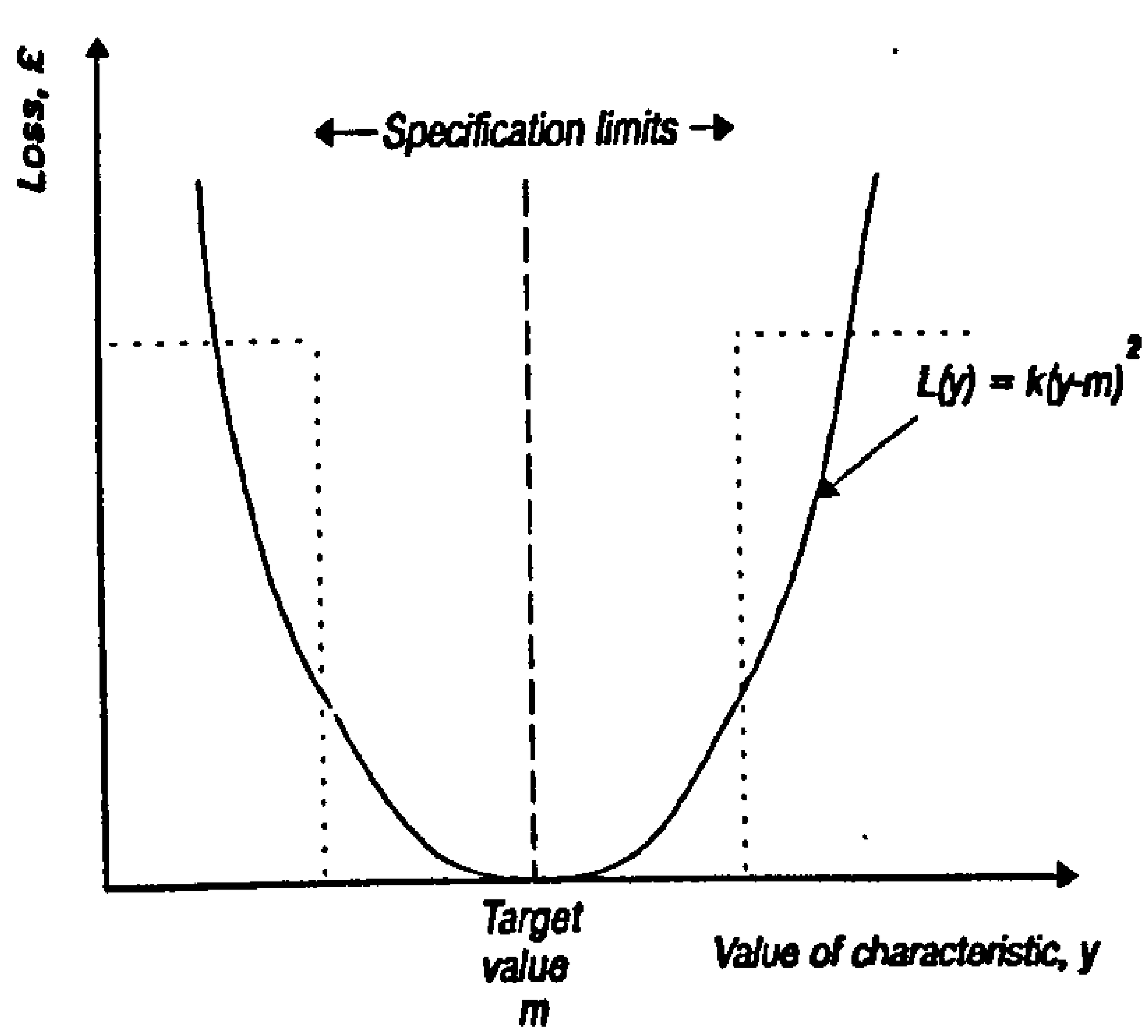
The main contribution to Quality development of the application of the seven management tools lies in the improved organisational understanding of the factors and relationships which create Quality problems. Through an improved 'mapping' and definition of Quality problems, managers can develop products, services and processes in which Quality defects are prevented. The level of Quality development in terms of organisational integration, teamworking and planning needs to be advanced in order to effectively utilise these tools.

Business process re-engineering (BPR) was described by Hammer and Champy [43,1993] as "the fundamental re-thinking and radical redesign of business processes to achieve dramatic improvement in critical contemporary measures of performance such as cost, Quality or service". This process involves re-structuring organisations on a process rather than functional basis, normally in order to deliver enhanced customer service. Again the essence of BPR is the increased integratedness of the organisation with an objective of improved customer orientation. This approach is in contrast to the Kaizen philosophy predominant during the improvement orientation stage of development. Rather than incrementally improving business performance, BPR seeks to radically re-structure organisational processes to produce step-changes in performance. The apparent 'conflict' between the Kaizen and BPR methodologies are resolved in the Quality development model proposed in this research in that they are appropriate to different stages of development and therefore are complimentary rather than alternative approaches. The implementation of BPR is typically associated with organisations striving for world-class performance and a highly integrated and self-critical management style.

Finally, the techniques for process optimisation can also be characteristically be contrasted with the tools of process improvement and control employed during the second stage of development. In particular, the techniques developed by Taguchi [31] for both describing the Quality Loss Function and for the Design of Experiments represent a prevention rather than improvement or systems orientation. These process optimisation techniques are illustrated in Figure 4.4.2.d).

Figure 4.4.2d The Taguchi Loss Function and Experimental Design

The Quality loss function



The orthogonal array for 7 factors

Experiment number	Factor A	B	C	D	E	F	G	Experimental result
1	1	1	1	1	1	1	1	y1
2	1	1	1	2	2	2	2	y2
3	1	2	2	1	1	2	2	y3
4	1	2	2	2	2	1	1	y4
5	2	1	2	1	2	1	2	y5
6	2	1	2	2	1	2	1	y6
7	2	2	1	1	2	2	1	y7
8	2	2	1	2	1	1	2	y8

$L_8(2^7)$ Orthogonal array
7 Factors
2 Levels each
8 Experiments

The concept of Quality 'Loss' being represented as a quadratic function rather than the simple PAF cost model (stage 1) or the process cost model (stage 2) places a much greater emphasis upon robust processes in which deviations are minimised or eliminated. The Taguchi Loss function encourages a prevention orientated approach to process design and in particular the use of Experimental Design techniques for establishing optimum process settings. Taguchi proposed the use of orthogonal arrays to reduce the complexity of process experimentation and the evaluation of the signal-to-noise ratio as the criteria for process optimisation.

The application of Taguchi techniques encourages the design of more robust processes in which Quality problems are prevented rather than monitored (as with the on-line techniques such as SPC) and promotes Quality planning as the mechanism for development. Taguchi has suggested that off-line, Quality Engineering tools have overtaken on-line, Quality control tools as being the major contributor to Quality development within leading Japanese companies during the 1990's.

4.4.3. Culture Change During the Prevention Orientation Stage

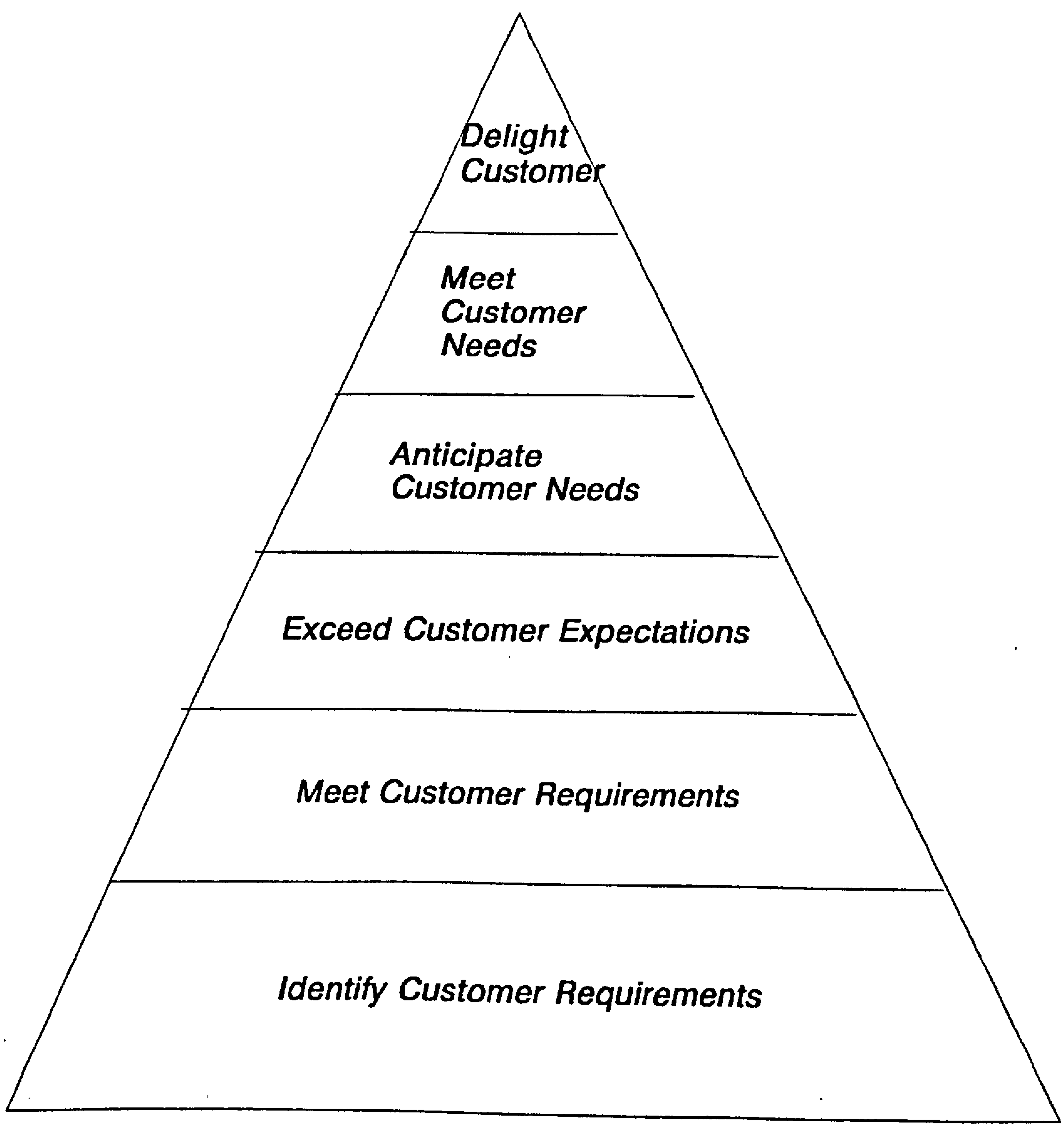
The organisational culture established during the 'prevention' stage of development is typically described as the Total Quality culture and is characterised by:

- a passion for customer service
- a fundamental belief that business development is inexorably linked to Quality development
- a commitment to prevention rather than cure through the emphasis upon design and planning activities.
- empowerment of self-development orientated individuals with a clear view of business objectives and priorities and a shared and consistent culture.

The organisational re-orientation towards the customer was described by Lyall

[67,1993] as a progression from satisfying basic customer requirement (equivalent to the 'systems' stage of development) through the anticipation of customer needs and exceeding customer expectations (equivalent to the 'improvement' stage of development) to the achievement of customer delight and loyalty as illustrated in figure 4.4.3.

Figure 4.4.3 The stages towards developing customer delight



Establishing customer loyalty requires re-focussing the organisation as illustrated in Figure 4.4.3 and emphasising the Quality of the relationship with the customer. This requires a customer orientated Quality culture to be embedded throughout the organisation at all levels.

The organisational belief in the business benefits of Quality management are essential to sustaining Total Quality and have been identified by Robson [93,1989] as an essential mindset for sustaining senior management commitment to Quality development. Whilst the need for 'senior management commitment' is seen as a truism for any organisational improvement initiative, the responsibility of senior managers during the final stage of Quality development is paramount. The significance of senior management responsibility was identified by Westbrook [107,1995] in a study of Total Quality organisations in Japan. Westbrook identified the emphasis upon integrating and planning activities in advanced Quality orientated companies as requiring the breadth of influence which can only be provided by senior level managers. The need for more integrated processes to develop a prevention orientation distinguishes this final stage of Quality development from the previous stage where the emphasis was upon the improvement of individual elements of the business.

In terms of the Structural Contingency Theory Model the organisational structure prevalent during the prevention stage of development is organic. This implies an inherently team-based organisation with informal structures and less emphasis upon functional boundaries. Indeed maturing to this advanced state of Quality development has been described by many writers including Cullen, Chopin, Robson and Crosby as being primarily an organisational issue.

4.4.4. Measures of Development During the Prevention Orientation Stage

The primary measures indicating the prevention orientation stage of Quality development relate to customer service features of integrated performance including:

- customer service levels particularly in terms of customer loyalty
- product and service reliability measures
- the elimination of routing defectiveness throughout the business process
- the cost of Quality in terms of loss to society

These measures associated with a prevention orientated approach to managing Quality are commonly benchmarked by mature organisations who are externally focused and seeking international levels of 'best' business performance.

Prevention orientated organisations have a 'learning' approach and therefore the list of Quality Management and techniques which are applied is being constantly extended and developed as the organisation is forward looking in order to preempt and hence prevent problems. The culture change in prevention orientated organisations can be assessed in terms of the coherency of business objectives, the passion for the customer and the absence of functional 'empires'.

SUMMARY

- *A framework for Quality development is proposed comprising three separate related stages which can be characterised in terms of the activities undertaken, the Quality culture which predominates and the results which are achieved.*

- *The first stage of development is described as establishing a systems orientation which primarily involves the formalising of the Quality requirements establishing standards and methods and is typified by the implementation of systems such as ISO 9000 and a controlling management of style.*

- *The second stage of development is described as establishing an improvement orientation in which team-based, problem-solving techniques are applied to continuously improve processes and create measurable improvements in business performance through a more enabling management style.*

- *The final stage of development is described as a prevention orientation in which techniques for enhancing customer service and advance Quality planning predominate and long term competitive advantage through Total Quality is achieved.*

CHAPTER 5

PARAMETERS FOR THE CLASSIFICATION OF QUALITY DEVELOPMENT

In Chapter 4, the descriptive stages of Quality development were identified as being systems, improvement and prevention orientations. The purpose of this chapter of the thesis is to identify the parameters which can be used to illustrate the developmental nature of Quality management. The quantitive approach adopted in this research (and described below in Chapter 6) is to pull together published industrial Quality development survey data into a coherent academic framework. The parameters selected to describe Quality development therefore reflect the importance assigned from the literature reviewed in Chapters 2 and 3 and also the parameters measured in a range of available industrial surveys.

The parameterisation of Quality development is a complex task both in terms of the classification of the parameters and also in terms of proposing a viable developmental scale. The problems therefore are:

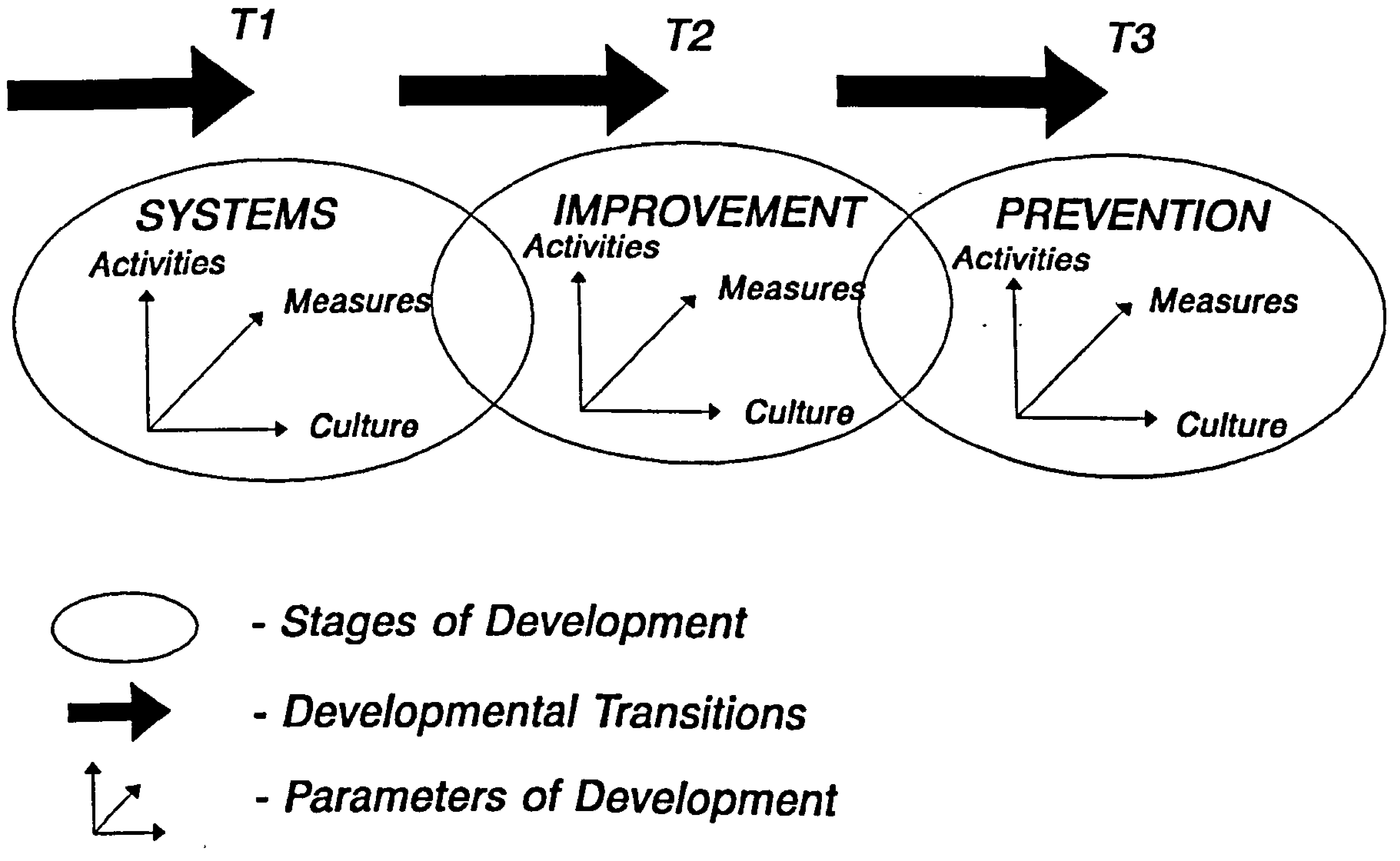
- what are the 'dimensions' for which valid parameters can be proposed?

- what are the appropriate scales for each of these dimensions?

The complexity comes from having to parametise both the qualitative and quantitive aspects of Quality management. The research challenge therefore has been to identify parameters which can model both the 'hard' (techniques) issues of Quality development and the 'soft' (people) issues.

The parametric models proposed in this research and described below utilise three dimensional versions of the classification 'grids' proposed by Puttick [90,1993] together with the techniques of matrix analysis. The usefulness of the classification grid is that each of the parameters can be considered to have two basic states (high/low, complex/simple) and this approach simplifies the parameterisation process considerably. The complexity of the Quality development process described above is handled through the application of a series of three dimensional parameterised models onto which can be illustrated the proposed characteristic stages of Quality development as shown in Figure 5.1.

Figure 5.1 The Relationships between the Stages, Transitions and Parameters of Quality Development



5.1. The Tools and Techniques Parameters

Reflecting upon the dimensions of Quality management described above in Chapter 3, the first of the parametric models of development proposed in this research relates to the application of the tools and techniques of Quality management and is described as the 'Activity Model' of development.

5.1.1. The Tools and Techniques Axes of Quality Development

In identifying valid development parameters or axes to describe the application of Quality management tools and techniques consideration needs to be given to:

- the extent to which a particular parameter reflects development as described in Chapter 4 and;
- the extent to which the parameter can be reliably measured through surveys of industrial practice.

The three axes of the tools and techniques classification grids proposed in this research are:

- the nature of the techniques applied in terms of their complexity of application (the **'complexity'** axis)
- the level of organisational involvement required in the application of the tool or technique (the **'involvement'** axis)
- the number of different tools and techniques which are applied (the **'quantity'** axis)

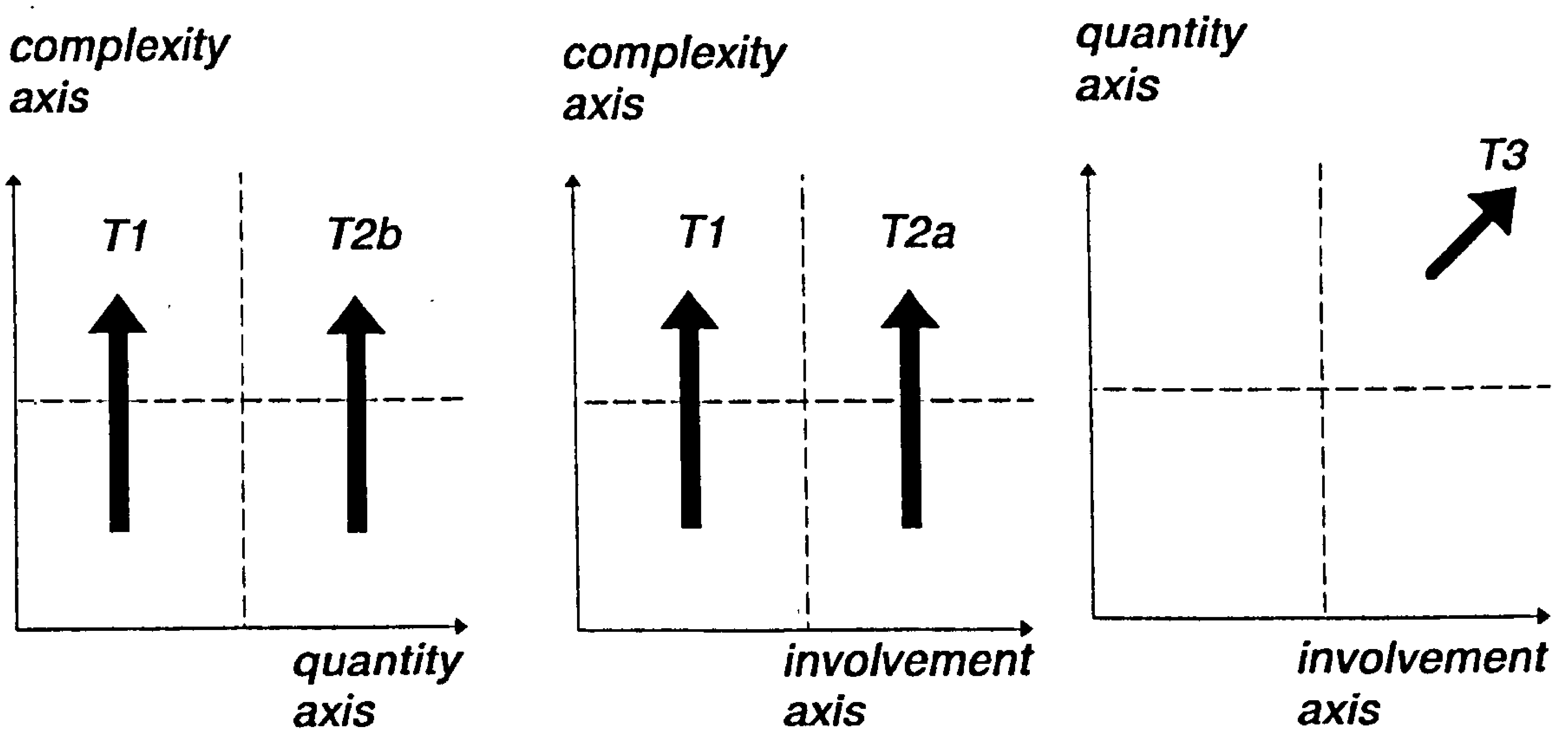
Each of these three axis represents an element of organisational maturity in terms of the management of Quality. Each to some extent is a simplistic parameter and is a function of other organisational parameters such as the educational level of the staff involved, the length of time the Quality development process has been in place and also the external market pressures placed upon the organisation. Considered together however, they do represent a coherent parametric model of Quality development through the application of tools and techniques.

The first of these axes relates to the complexity of the techniques and distinguishes between activities which are relatively simple to apply in terms of the number of steps or stages to the technique and those activities which require multi-stage methodologies and complex support information.

The second of the activity model axes relates to the level of involvement required within the organisation to apply the tools and techniques. This axis therefore distinguishes between those activities which require cross-functional and team-based organisational support and those activities which can be implemented through the actions of single functions or individuals.

When these first two axes are combined to form a Puttick-type classification grid, the tools and techniques of Quality management which support the implementation of a systems orientation and the subsequent development of an improvement orientation with an emphasis upon teambuilding as typified by service industries are illustrated and shown in Figure 5.1.1. with the transitions T1, T2a, T2b, and T3 being defined below in Figure 5.1.2

Figure5.1.1 The 3 dimensional classification grids which comprise the Activity Model



The third of the activity model axes relates to the number of the tools and techniques applied and when combined with the complexity model represents the Quality development of an organisation moving from a systems orientation to an improvement orientation primarily through the application of individual techniques, typified for example by the motor industry and again illustrated in Figure 5.1.1.

The final combination of axes relates the number of tools and techniques applied to the level of organisational involvement required. This third classification grid illustrates the need for integration of both the organisational coordination (teamworking) and the widespread application of Quality management tools and techniques which represents the development towards advanced Quality planning as illustrated in Figure 5.1.1.

The importance of this new, three dimensional classification model of the Quality management tools and techniques proposed in this research is that it provides a simple, coherent framework for understanding both the relationships between the activities but also the developmental transitions which can take place. The model has 8 'domains' each of which describes a combination of complexity, involvement and number of applied tools and techniques as detailed below in section 5.1.2.

The complexity of applying Quality management tools and techniques is well represented using this three dimensional grid which also illustrates the various optional, transitional routes to Quality development. It is often the complexity of these relationships together with the uncertainty and variety of developmental paths which creates the organisational Quality 'paralysis' described in Chapter 1.

Whilst this parametric modelling of the tools and techniques of Quality management may not be exhaustive, it does provide a significant framework for the classification of activities and for the identification of developmental transitions consistent with the model of Quality development proposed in Chapter 4.

5.1.2. The Activity Model of Quality Development

Combining the three classification grids described above in Section 5.1.1. forms a three dimensional matrix with 8 identifiable classification domains. Each of these domains represent the high or low combination of each of the three axes of complexity (A), involvement (B) and number of techniques applied (C). The identification of each of these domains, together with illustrative tools and techniques and developmental descriptors is shown in Figure 5.1.2.

Figure 5.1.2 The Activity Model classification domains

Illustrative Technique	Complexity Parameter	Involvement Parameter	Quantity Parameter	Developmental Transition
Acceptance Sampling	A1	B1	C1	T1 (SYSTEMS)
ISO 9000	A2	B1	C1	
Problem Solving Tools	A1	B2	C1	T2a (IMPROVEMENT TEAM LED)
Problem Solving Methodologies	A2	B2	C1	
Statistical Process Control	A1	B1	C2	T2b (IMPROVEMENT TECHNIQUES LED)
Capability-Control Plan-SPC	A2	B1	C2	
7 Management Tools	A1	B2	C2	T3 (PREVENTION)
Quality Function Deployment	A2	B2	C2	

The first two domains [A1 B1 C1] and [A2 B1 C1] are categorised as the T1 transition and represents the development towards a systems orientation. The application of tools and techniques represented by the T1 transition is characterised by implementations led primarily by the Quality Assurance function such as ISO 9000.

The second two domains [A1 B2 C1] and [A2 B2 C1] are categorised as the T2a transition in which the development of an improvement orientation takes place through the implementation of team-based problem solving and improvement methodologies. The application of tools and techniques represented by the T2a transition is characterised by the implementation of the seven Q.C. tools and the use by problem solving teams of individual techniques such as Ishikawa diagrams or Pareto analysis.

The third two domains of the Activity Model [A1 B1 C2] and [A2 B1 C2] are categorised as the T2b transition in which the development of an improvement orientation is primarily led through the application of process improvement tools and techniques such as capability studies and statistical process control.

The developments represented by the T2a and T2b transitions are combined in the final two domains [A1 B2 C2] and [A2 B2 C2] in which the integration of techniques and involvement are categorised as the T3 transition towards a prevention orientation. Typical therefore of the Quality management tools and techniques applied during the T3 transition are the 7 Management Tools such as Affinity Diagrams or Inter-relationship Diagraphs and the multi-staged prevention methodologies such as Quality Function Deployment or Failure Mode and Effects Analysis.

The research significance of the Activity Model lies in the manner in which the parameters described in the three dimensional grid relate to the model of Quality development proposed in Chapter 4 as illustrated in the industrial survey data presented in Chapter 6.

5.2. The Cultural Parameters

The second of the parametric models proposed in this research relates to the 'people' dimension of Quality management and is used to classify the cultural changes which occur during organisational development. A three dimensional classification matrix is again used to facilitate the analysis of the industrial data and this is described as the 'Culture Model' of Quality development.

5.2.1. The Cultural Axes of Quality Development

In establishing valid development parameters or axes to describe the cultural aspects of Quality Management, consideration should again be given to:

- the cultural changes which take place as organisations develop firstly a systems then improvement and finally prevention orientation as described in Chapter 4.

- the extent to which aspects of culture change can be reliably extracted using industrial survey questionnaires and case studies.

The three Quality culture change axes used to classify the Culture Model of development are:

- the predominant management style which can be classified as either 'controlling' or 'empowering' (the **'management approach'** axis).

- the extent to which teamwork operates within the organisation, making the distinction therefore between an individualistic and a team-based culture (the **'teamworking'** axis).

- the emphasis upon customer focus which can be classified as low (for organisations who are aiming to meet basic customer requirements) or high (for organisations with a passion for delighting customers) (**'customer focus'** axis).

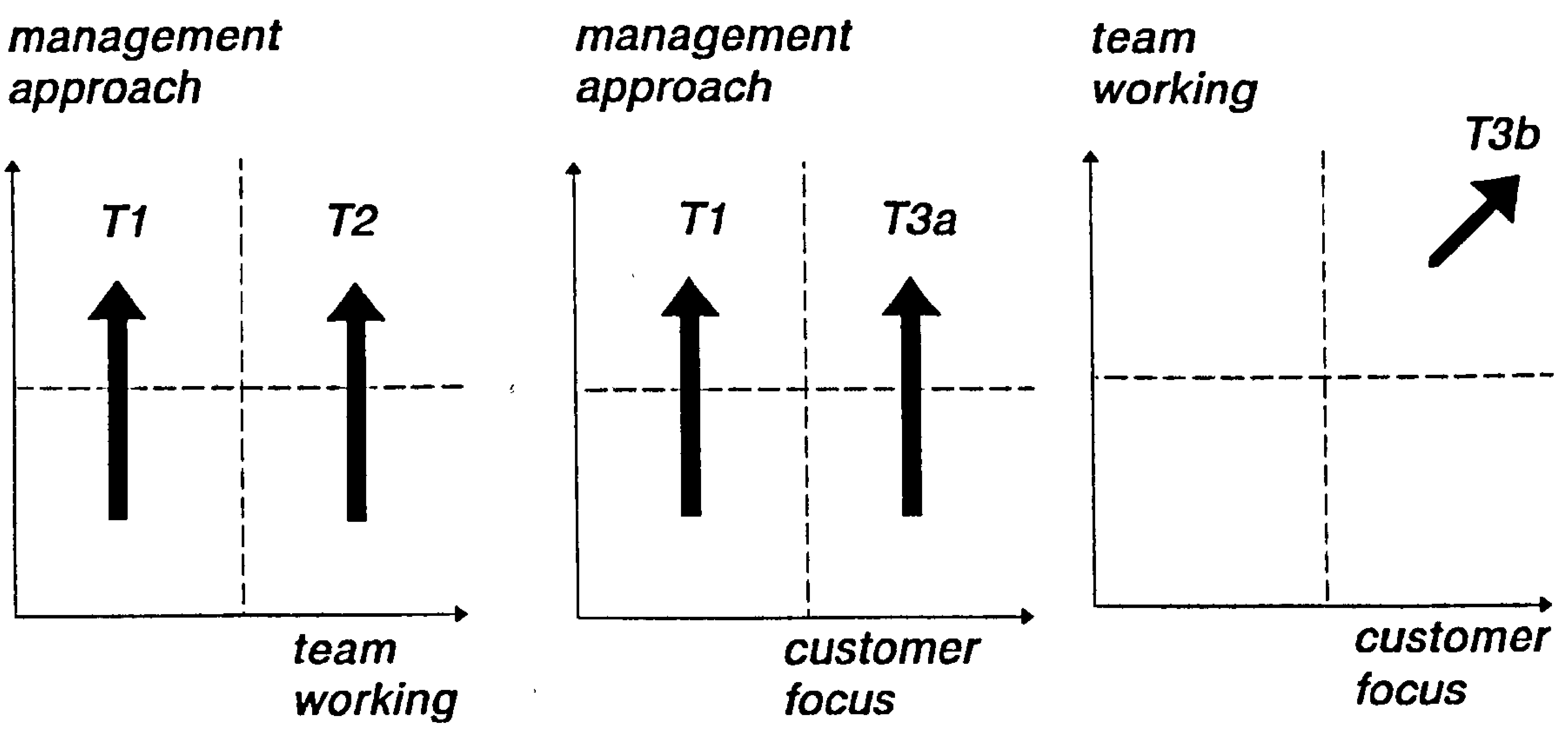
Again each of these axes represents one element of the culture change which occurs as organisations develop in terms of the Management of Quality. The axes are inter-related as illustrated by the transitions described below in section 5.2.2. and are also functions of other cultural features such as senior management Quality leadership, employee training and customer diversity. They are, however, the primary features of the change in Quality culture identified in the literature and research reviewed in Chapters 2 and 3.

The first of the axes classifies the management approach as either a controlling (deployed) style or an enabling (empowered) style. This concept of management style was identified by leading Quality Management practitioners such as Deming [27,1986] and Crosby [21,1979] as a critical enabler to Quality development. In reality however, the concept of a unitary management style existing within an organisation is clearly simplistic as to some extent this will vary from function to function and even from individual manager to individual manager. It is, however, possible to classify predominant management approaches, particularly in the development of Quality systems and in the operation of improvement teams.

The second of the Culture Model axes relates to the application of teamworking within the organisation and the extent to which functional boundaries exist. The classification here distinguishes between developments which are primarily achieved through individual or functional involvement and those which are achieved through teamwork. In the later stages of Quality development, this classification can also distinguish between organisations in which teamworking takes place in addition to the functional structures and those in which team operation is integral to the structure of the organisation.

Combining these first two axes into a classification grid provides two important insights into the cultural changes during Quality development. Firstly the transition which occurs during the development of Quality systems is illustrated as individual organisational functions are empowered with greater responsibility for the management of Quality. Secondly, the distinction between the deployed Quality improvement team (top-down) and the self directed, voluntary (bottom-up) Quality improvement team described in Chapter 4, section 4.3.3. The difference between a controlled approach to the organisation of improvement teams and an empowered approach is clearly made in the classification grid and this is illustrated in Figure 5.2.1.

Figure 5.2.1 The 3 dimensional classification grids which comprise the Culture Model



The third of the Culture Model axes classifies the degree of customer orientation and distinguishes between different levels of customer focus. The 'low' level of customer orientation corresponds to an organisational approach in which the customer is primarily the responsibility of the Sales/Marketing function and the customer orientation is essentially manifested throughout the organisation as conformance to requirements. The 'high' level of customer orientation corresponds to an organisational 'passion' for the customer in which the relationship with customers (both internal and external) is an integral management priority. When this classification of customer focus is combined with the management approach dimension the grid illustrates both the organisational maturing associated with the recognition of the importance of internal customers and interfaces and also the organisational re-orientation associated with re-engineering business processes to create greater customer focus. These relationships are again illustrated in Figure 5.2.1.

The final combination of axes relates the customer orientation to the classification of teamworking. This again illustrates important features of Quality development culture change and in particular the coordination of customer driven, teambased prevention activities such as product and process design methodologies. The transition towards bringing the customer to the centre of a coordinated organisation is characteristic of the final (prevention) stage of Quality development described above in Chapter 4.

As with the Activity Model, this three dimensional classification matrix provides an important new framework for understanding the complex culture changes required for Quality development. The 8 domains represented in the Culture Model are more representative of the transitions which occur during the later stages of Quality development and again this is consistent with the model of Quality development proposed in Chapter 4 which indicates a greater emphasis upon the mechanistic tools and techniques in the early stages of development whereas culture change is the predominant issue during the final stage of development.

It is the inherent complexity portrayed in the Culture Model which makes the process of creating a 'Total Quality' culture so demanding and hence so illusive. The problems of culture change described by Robson [93,1989] as the "hard reality" of Total Quality are evident from transitions represented in the Culture Model. So, for example, if the management challenge was a straightforward (two dimensional) task of say creating a team-based, customer focused organisation, then this could be achieved through management edict - that is using a controlled management approach. Creating the same team-based, customer orientated culture using an empowered, enabling management style is a much more significant organisational challenge yet it is much more likely to create a robust and lasting culture change.

5.2.2. The Culture Model of Quality Development

Combining the three classification grids described above in section 5.2.1. forms a second three dimensional matrix in which the 8 domains represent the cultural transitions of Quality development. Again, as with the Activity Model, the combination of each of the three axes of management approach (A), teamworking (B) and customer orientation (C) forms 8 distinct domains of culture change. These domains together with descriptors of the cultural characteristics portrayed and the associated developmental transitions are shown in Figure 5.2.2.

Figure 5.2.2 The Culture Model classification domains

Characteristic Culture	*Management Approach*	*Team-Working*	*Customer Orientation*	*Developmental Transition*
Functional Involvement in Quality Assurance	*A1*	*B1*	*C1*	*T1 (SYSTEMS)*
	A2	*B1*	*C1*	
Internal Improvement Teamworking	*A1*	*B2*	*C1*	*T2 (IMPROVEMENT-TEAM LED)*
	A2	*B2*	*C1*	
Internal and External Customer Focus	*A1*	*B1*	*C2*	*T3a (PREVENTION-FUNCTIONAL)*
	A2	*B1*	*C2*	
Re-engineered Customer Focused Business Processes	*A1*	*B2*	*C2*	*T3b (PREVENTION-INTEGRAL)*
	A2	*B2*	*C2*	

The first two domains [A1 B1 C1] and [A2 B1 C1] are categorised as the T1 transition and represents the cultural developments associated with accepting the responsibilities of procedural Quality systems. Individuals and functions are empowered with Quality management responsibilities under a Quality system and this organisation-wide involvement and contribution represents the major culture change associated with developing a systems orientation.

The second two domains [A1 B2 C1] and [A2 B2 C1] are categorised as the T2 improvement transition and represent the progression towards an internally focused, team-based improvement culture. The distinction between the deployed Quality improvement team which is directed and controlled by managers and the voluntary improvement team which is empowered to identify and prioritise improvements is clearly made in the Culture Model. The T2 transition modelled in this research also illustrates that these two approaches to improvement team operation are not mutually exclusive or opposing but instead are part of the cultural transition associated with Quality development.

The third two domains [A1 B1 C2] and [A2 B1 C2] are categorised as the T3a transition and represents one of the two cultural transitions which prevail during the prevention stage of Quality development. The primary cultural change during the T3a transition relates to the increasing customer focus which can be either internally directed through the application of methodologies such as IBM's Departmental Purpose Analysis described by McCabe [69,1989] or externally directed through an organisational focus upon customer service. The customer 'driven' organisation portrayed during the T3a transition does not however undergo process restructuring but rather manages customer service through traditional, functional structures. The empowerment of employees to enhance the relationships with customers and to improve communication both internally and externally is the second important development during the T3a transition.

The final two domains [A1 B2 C2] and [A2 B2 C2] are categorised as the T3b transition and this also represents a mature Quality culture development associated with a prevention orientation. The integration of team operation into the organisational culture is prevalent during the T3b transition. The coordination of activities such as product and process design into a multi-functional, integrated effort is the primary culture change during the T3b transition. This represents the enabling culture to support the advanced Quality planning methodologies such as Quality Function Deployment and Failure Mode and Effects Analysis. The second major culture change during the T3b transition is associated with the empowerment of the customer focused process teams. This represents the culture change fundamental to the re-engineering of business processes proposed by Hammer and Champy [43,1993] in which organisations achieve significant improvements in business performance through the arrangement of the organisation into process teams rather than functional specialities. This empowered, team-based, customer orientated, integrated organisation represents the commonly perceived Total Quality culture identified in the literature review in Chapters 2 and 3.

As with the Activity Model proposed above in Section 5.1., the Culture Model represents an important new classification mechanism for understanding the cultural parameters of Quality development. The transitions represented in the Culture Model illustrate the increased emphasis upon organisational and cultural issues during the later stages of development. The domains of the Culture Model also depict the complexity of developing a Total Quality culture through the need to simultaneously progress parameters requiring different, although not exclusive, organisational change.

5.3. The Measurement Parameters

The third and final of the parametric models proposed in this research describes the metrics dimension of Quality management. The measurement of Quality development has attracted increasing research interest as described in Chapters 2 and 3 and again this research proposes a three axis classification matrix which describes the 'Measurement Model' of Quality development.

5.3.1. The Measurement Axes of Quality Development

The parameters to describe the metrics of Quality management, to some extent have been established above in sections 5.1 and 5.2 in the parameterisation of the Quality development activities and culture change. Clearly each of three models proposed in this research are related as one describes what is done to bring about Quality development (the activities), the second describes the changes which occur (the culture) and the third describes the effects of the development (the measures). Whilst each of the first two models, describing the activities and the culture, have parameters associated with their development, the Measurement Model provides a classification for the measures of Quality development. The requirements therefore of the axes of the Measurement Model are:

- they should encompass the range of academic and industrial Quality assessment measures and methodologies.

- they should be capable of being validated from industrial survey data and assessment scoring schemes.

The three axes used to classify the Measurement Model of Quality development are:

- the measures of the efforts which are devoted to the management of Quality (the **'Quality efforts'** axis)

- the measures which reflect the results of the way in which Quality is managed in the organisation (the **'Quality results'** axis)

- the measures which reflect the business benefits of the Quality development process (the **'Quality benefits'** axis)

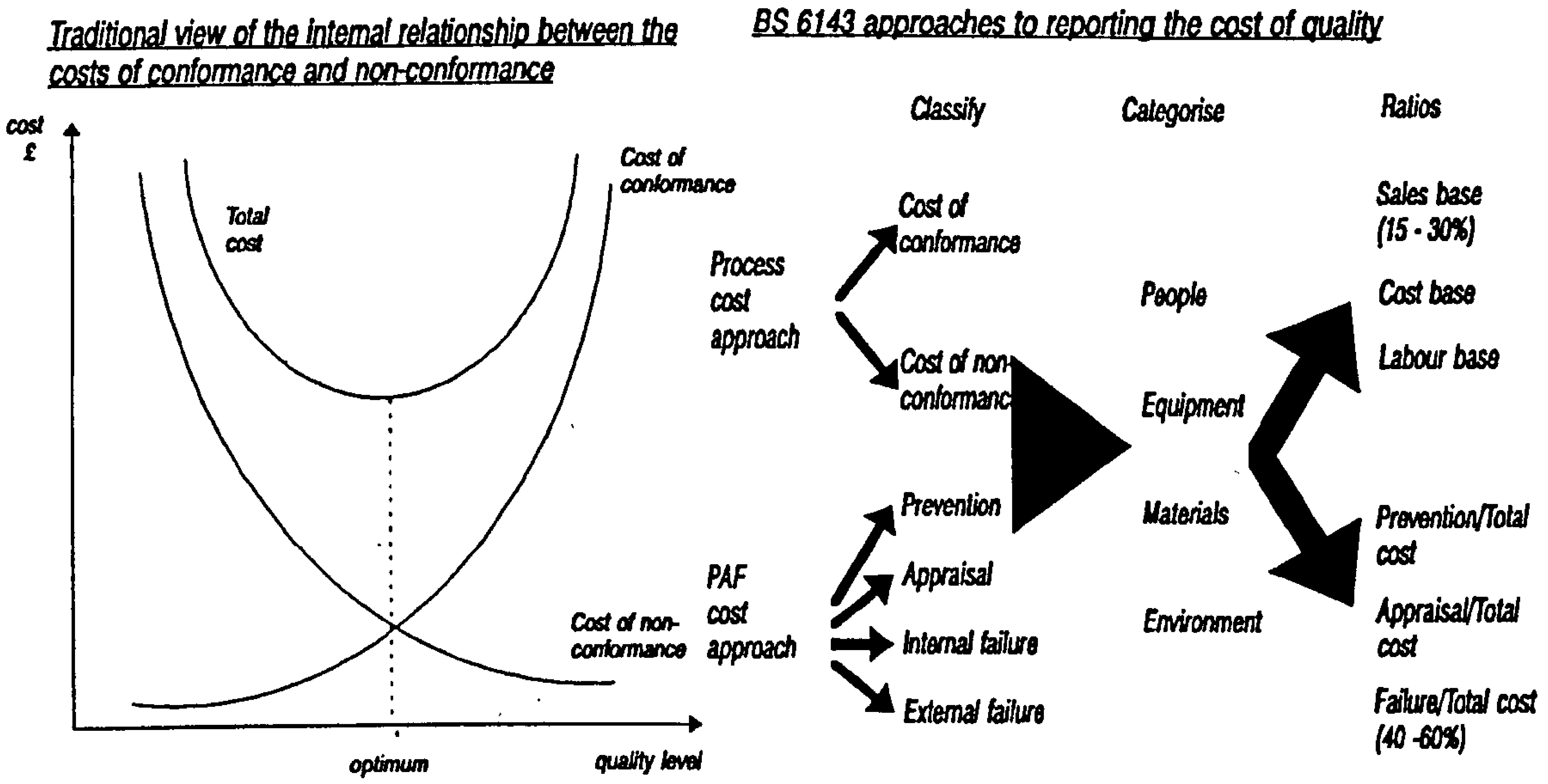
Each of these axis are inter-related as described in the transitions outlined below in section 5.3.2. Also the axes are functions of the activities and culture changes which take place as part of the Quality management process.

The first of the axes classifies the Quality efforts made by the organisation and these are described as either low, reflecting limited commitment or activity, or high corresponding to increased organisational resource devoted to Quality development. This metric is therefore a reflection of the leadership, commitment and awareness of Quality management together with the initiatives which are pursued to bring about Quality development.

The second of the axes classifies the Quality results accrued by the organisation in terms of changes in Quality related performance. The results classification of low corresponds to limited change in performance or recognition of the Quality efforts, whereas the high classification corresponds to a significant change in organisational performance or recognition. A critical organisational implication of the Quality development process is the relationship between effort and results both in terms of the 'return on investment' viewpoint and also the time difference between the commitment of resources and the achievement of results.

The third of the axes classifies the business benefits related to Quality development and primarily reflects the change in internal business benefits, in terms of the Cost of Quality (as described in Chapter 4) and the external benefits in terms of market share. Again the classification describes the Quality benefits as either low, corresponding to a limited reduction in the internal Costs of Quality or high which corresponds to a significant reduction in costs and increased market benefits. The modelling of the Cost of Quality has evolved considerably in recent years as the thinking of Quality professionals has moved away from the Juran approach which proposed an 'optimum' cost model to the prevention/appraisal/failure (PAF) cost model and the process cost model described for example in the British Standard BS 6143 [12,1992 and 13,1990] and illustrated in Figure 5.3.1.a).

Figure 5.3.1a Comparison of the Cost of Quality Models



Both the PAF and the Process Cost models encompass metrics for the impact of Quality Management upon the customer, primarily in the form of corrective actions. Neither of these cost models, however, accurately reflect the more positive external features of Quality development (such as increased customer loyalty).

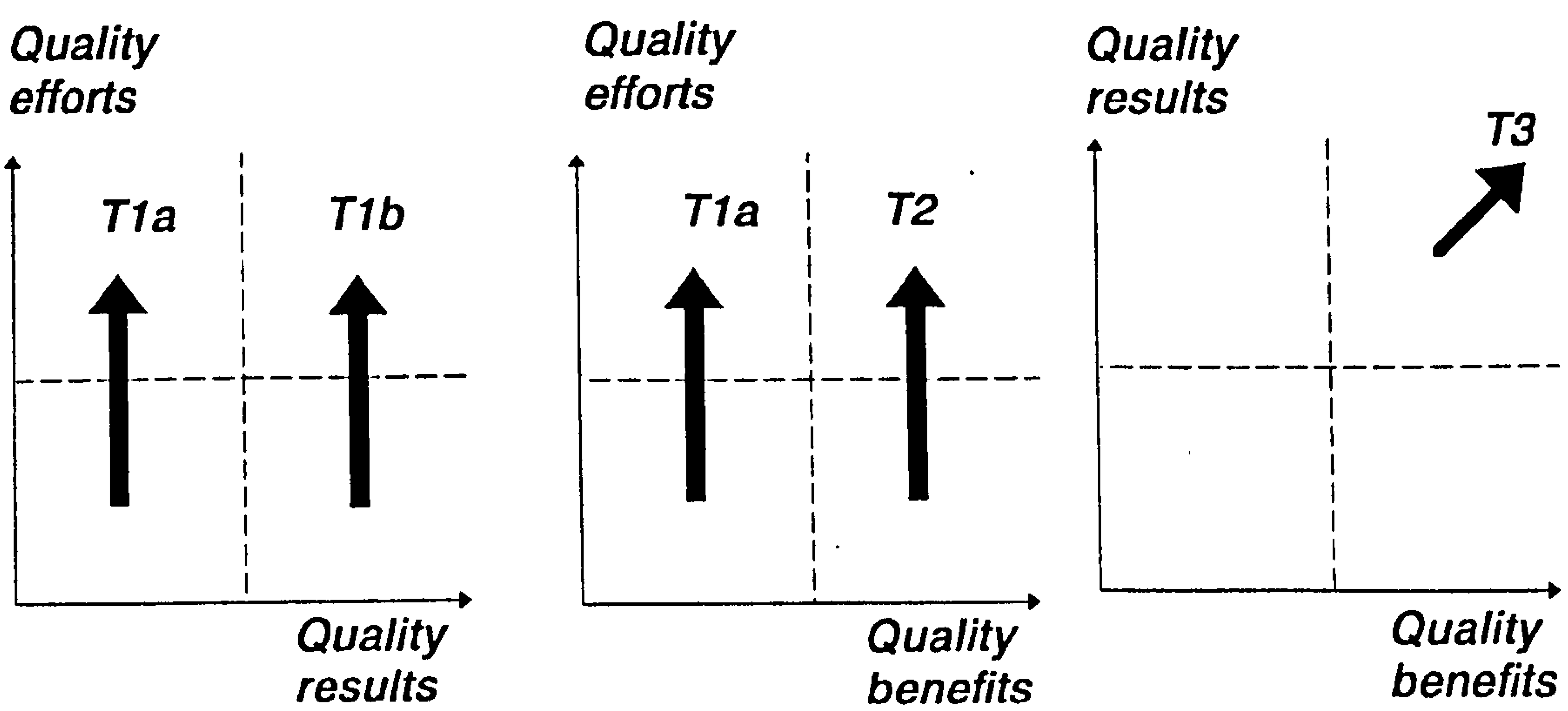
The combination of the first of the two measurement classification axes illustrates the relationships between Quality management efforts and Quality performance results which occur during Quality development. This classification grid illustrates the phenomenon that the efforts in Quality Management need to be both invested prior to the achieving of the results, but also that this effort needs to be sustained over a period of time to achieve the measurable change in performance to occur. This organisational 'inertia' illustrated through the classification grid has contributed to the disillusionment as to whether the Quality revolution was delivering results as experienced during the 1990's and described in Chapter 1.

Combining the axis classifying the Quality efforts with the axis measuring business benefits illustrates a second important development corollary which is that the initial investments in efforts at Quality development can actually increase the internal cost of Quality. The investment for example in establishing a Quality system can significantly increase the internal costs of managing Quality as this represents an expenditure on Quality management infrastructure. Similarly investment in training during the improvement stage of development requires an allocation of resources which are not immediately recovered.

Similarly the combination of the axes of results and benefits illustrates the commonly observed Quality management experience of improving Quality performance right up to the point that the organisation goes out of business! The translation of operational Quality performance improvements into business performance improvements is a fundamental feature of the benefits of achieving a mature, prevention orientated organisation. The reduction in the overall cost of Quality is geared towards an investment in prevention, described by Crosby [21,1979] as the "Gold in the Mine".

The three classification grids which make up the Measurement Model are shown in Figure 5.3.1.b). The 8 domains represented in the Measurement Model illustrate the long-term nature of the improvements in performance derived from Quality development. The need to perceive Quality development as a long-term strategic advantage rather than a short-term operational 'fix' is critical to sustained development and is clearly illustrated in the Measurement Model proposed in this research.

Figure 5.3.1b The 3 dimensional classification grids which comprise the Measurement Model



5.3.2. The Measurement Model of Quality Development

The combination of the three measurement classification grids forms the third of the parametric models of Quality development and the 8 domains represent the measurement transitions which occur. As with the Activity Model and the Culture Model, the 8 domains present in the Measurement Model reflect the transitions and relationships between the axes of Quality effort (A), Quality results (B) and Quality benefits (C) as shown in Figure 5.3.2.

The first two domains [A1 B1 C1] and [A2 B1 C1] are classified as the T1a) transition and represent the measurable efforts invested in commencing the application of Quality management.

Figure 5.3.2 The Measurement Model classification domains

Measurement Focus	Quality Efforts	Quality Results	Quality Benefits	Developmental Transition
Systems Preparation and Awareness	A1	B1	C1	T1a (SYSTEMS DEFINITION)
	A2	B1	C1	
Systems Implementation and Review	A1	B2	C1	T1b (SYSTEMS-ACCREDITATION)
	A2	B2	C1	
Internal Processes Focused	A1	B1	C2	T2 (IMPROVED-PROCESSES)
	A2	B1	C2	
External Customer Focused	A1	B2	C2	T3 (PREVENTION)
	A2	B2	C2	

The effort is primarily invested in the design of the specifications and controls necessary to establish auditable systems. The investment during this T1a) transition in terms of management effort, employee training, equipment and external consultancy is usually significant without necessarily bringing about measurable improvements in terms of defect levels, cycle times or complaints. The T1a) transition corresponds to the planning design and implementation of a Quality system and typically from the study undertaken by Kehoe [58,1993] takes organisations between 12 and 18 months.

The second two domains [A1 B2 C1] and [A2 B2 C1] are classified as the T1b) Transition and represent the recognition and accreditation of the systems development undertaken during the T1a) transition. The results achieved during the T1b) transition are typically second or third party accreditation of the Quality management efforts and improvements in terms of the internal assessments of control such as Quality audits or the management review process. The lack of significant business benefits generated during the T1b) transition was identified by Connell [19,1994] as a primary reason for over 60% of organisations not progressing beyond the systems stage of development.

The third two domains [A1 B1 C2] and [A2 B1 C2] are categorised as the T2 transition and represents the improvements in internal business performance due to the process improvements occurring during the improvement orientation. The results achieved during the T2 transition in terms of the external customer are however, limited. The focus of the effort metrics during the T2 transition relate to internal process improvements and team operation which reduces the failure costs although this is often achieved at the expense of appraisal costs due to the implementation of techniques such as Statistical Process Control.

The final two domains [A1 B2 C2] and [A2 B2 C2] are classified as the T3 transition and represents the integral achievement of effort, results and benefits associated with a Total Quality organisation. The internal performance in terms of process capability and the external benefits in terms of customer retention and increased revenues are evident during the T3 transition. The 'picture' of Total Quality operation which is often depicted as advanced quality efforts resulting in world class performance which translates into enhanced business performance is illustrated in this final parametric transition.

The overall importance of the Measurement Model classification matrix is the distinction provided between measures which represent effort, results and benefits. These distinctions and the relationships represented in the Model's transitions provide an important insight into the metrics of Quality development.

SUMMARY

- *This chapter of the research proposes three parametric models to be used in the identification of the stages of Quality development.*

- *Each of the parametric models is structured as a three dimensional classification grid where each of the parameters can be quantified at one of two levels established from industrial survey research. The three parametric models proposed in this research are the Activity Model, the Culture Model and the Measurement Model.*

- *The Activity Model comprises axes of complexity, involvement and quantity and describes the developmental transition occurring in the application of the tools and techniques of Quality Management.*

- *The Culture Model comprises axes of management approach, teamworking and customer focus and describes the complex cultural change required for the development of a Total Quality organisation.*

- *The Measurement Model comprises axes of efforts, results and benefits and describes the relationships between the metrics used to assess Quality development.*

CHAPTER 6

INDUSTRIAL SURVEY DATA ON QUALITY DEVELOPMENT PARAMETERS

6.1 Industrial Survey Data

In Chapters 4 and 5, the framework for Quality development was proposed together with three parametric models for describing the progression in the Quality management process. The purpose of this chapter is to present industrial survey data which supports the developmental framework and parametric modelling proposed in this research. The survey data is analysed in Chapter 7 and the research further substantiated through the industrial case studies presented in Chapter 8.

This chapter utilises two primary sources of industrial survey data both conducted at the University of Liverpool. The first survey is described in both Mann and Kehoe [72,1994] and Mann and Kehoe [73,1995] and involved a major study of Quality management practices within the U.K. as described below in section 6.1.2. The second survey was a comprehensive study across seven sectors of U.K. manufacturing industry and is described in Zain and Kehoe [109,1996] and below in section 6.1.3. This chapter selectively utilises key elements of both these research surveys to qualify the parametric modelling of Quality development proposed in this research.

6.1.1. Research Data Requirements

The data presented in this research was generated as part of an ongoing programme evaluating industrial practice in the management of Quality. Overall this data has provided important insights into the process of implementing Total Quality

Management within the U.K., as described by Mann [71,1992] and the measurement of the relative Quality position of U.K. manufacturing industries as described by Zain [108,1993].

In terms of the research presented in this thesis, the key requirements of the industrial data are:

- to illustrate the three stages of development identified in Chapter 4 through the clustering of Quality parameters;
- to quantify the correlation between Quality development and the parameters proposed in the Activity Model, Culture Model and Measurement Model described in Chapter 5.

The first of these research requirements is to provide data which illustrates identifiable clusters or groups of organisations around parameters which characterise the **systems, improvement** or **prevention** stages of development as proposed in Chapter 4. The data collection approach used to illustrate the triple-stage framework of development was to select a stratified random population across a range of manufacturing sectors and to identify significant proportions of the population occurring at nominated points in the framework.

For the second of the research requirements, data was collected corresponding to each of the axes in each of the three parametric models. In order to illustrate correlation between Quality development and the parameters in the Activity Model, the Culture Model and the Measurement Model a bi-modal survey was undertaken in which data for each of the parameters was collected for identifiably 'developed' and 'undeveloped' organisations.

The format adopted for both of the surveys was a multi-stage industrial questionnaire each of which was extensively reviewed and piloted prior to release. The surveys were longitudinal in that both were undertaken across a range of organisations in which the questions were pre-set and responses were equally weighted in terms of the research significance. This form of longitudinal industrial survey is contrasted with the detailed case study investigation described in Chapter 8 in which individual organisations were asked case-specific questions and company factors were individually evaluated.

Both questionnaires were designed as postal surveys and took account of the problems of this research method identified by Joliffe [54,1986] by targeting the person required to complete the data and by simplifying both the structure and the response format of the questionnaire. In both cases the response rate was above the typical research level of around 15-20% identified by Black [9,1994] although data collected via unsolicited industrial survey is inevitably skewed by the respondents motivation to reply to such a request. The factors identified by Moser and Kalton [79,1971] which affect the respondents attitude to a questionnaire survey were inevitably present in this research and most critically such information was more likely to be provided by individuals and organisations "interested" in the issue of Quality management. This 'a-typical' make-up of the survey respondents was overcome in this research in two ways. Firstly the data was collected primarily for comparative purposes rather than to establish 'absolute' levels of development. The disproportionate response rate from individuals and organisations who are explicitly interested in Quality management issues is therefore a factor only in the scaling of the parameters rather than the correlation or clustering of factors.

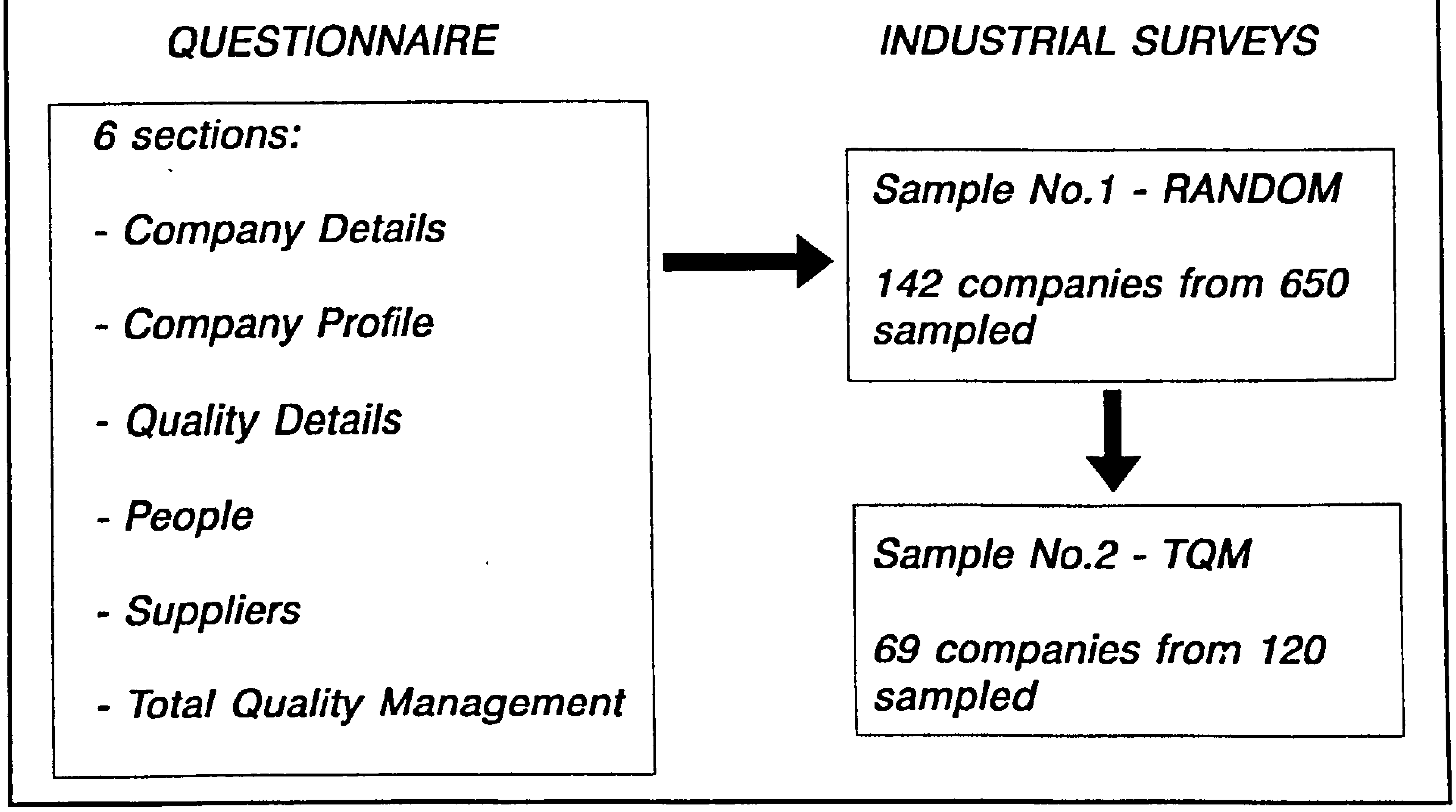
Secondly two separate surveys have been employed in this research together with case study data and these are used independently in the validation of the integrated framework and modelling parameters. Overall the effect of this potential respondent bias is primarily to identify greater numbers of organisations at greater levels of development. The main hypothesis in this research however, is that Quality development can be appropriately classified in terms of systems, improvement or prevention orientations, rather than attempting to identify what proportion of organisations fall into each category which would be more influenced by such bias.

6.1.2. Industrial Survey 1 - Development Correlation Data

The first of the industrial surveys is described in references [72,1994] and [73,1995] and was part of a comprehensive research study into Quality Management practices in the U.K. The complete questionnaire was structured into 6 sections as illustrated in figure 6.1.2.

The questionnaire was designed to provide a range of insights into the application of Quality management techniques and was used by Mann [71,1992] to identify relationships between organisational characteristics, approaches to Total Quality implementation and the effects upon business performance indicators.

Figure 6.1.2 Industrial survey 1 - structure and sample selection



The questionnaire was extensively reviewed within the University and piloted prior to the full survey to ensure the presentation, clarity and completion time were optimised. Two separate target populations were identified, one selected at random from the Kompass Directory [63,1988] comprising 650 manufacturing companies and the second selected from Total Quality literature as 120 companies who were identified as 'developed' in terms of the management of Quality. For the purposes of this research, the reasons for selecting two distinct sample populations were:

- to provide comparative sub-groups, one of which represented the 'general' manufacturing population and the other represented a skewed (developed) population.
- to provide a basis for the correlation between Quality development and the individual parametric axes in the Activity, Culture and Measurement Models.

The companies in survey 1 therefore were grouped according to whether they were identifiably 'developed' or not. The companies surveyed in survey 2, described below in section 6.1.3, were selected on the basis of size (in terms of employees and turnover) in an attempt to produce a population more uniformly developed with respect to other organisational characteristics such as management structure, market share and ownership. The population examined in the random sample of survey 1 was more likely to produce a greater spectrum of Quality development and would therefore be more appropriate for the correlation analysis described below in Chapter 7.

Although both the sample populations for survey 1 received the same questionnaire and in each case the survey was directed to the Quality manager or director, there were significant differences in the response rate. For the random survey of 650 companies, 142 responded (22%) including 19 of whom also identified themselves as pursuing Total Quality. For the Total Quality survey of 120 companies, 69 responded (58%) which is well in excess of normal industrial survey response rate of around 15-20% identified by Black [9,1994]. The main reasons postulated for the differences in response rates were:

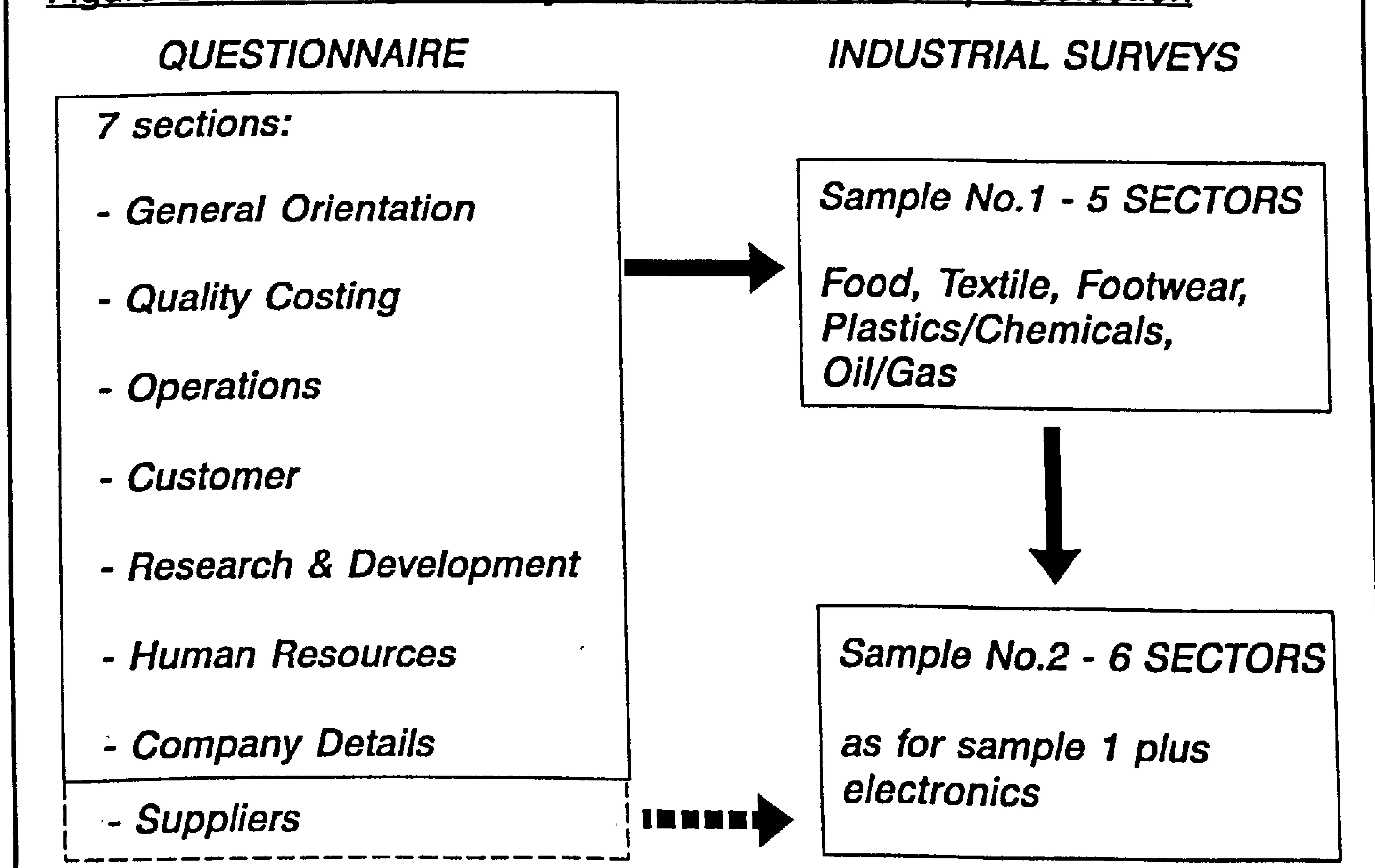
- increased interest, by definition, from the Total Quality orientated companies
- increased reliability of the Total Quality database due to its more up-to-date nature, whereas the Kompass database contained organisations perceived not to be relevant to the study (non-manufacturing or too small in size) which inhibited responses.

The bias present in the responding sample due to the enthusiasm of the respondents for the subject matter is a problem inherent in this format of survey-based industrial research. In the analysis of the data presented in Chapter 7, however, the effect of respondent bias is reduced through the use of comparative component analysis rather than attempting to identify absolute levels of Quality development.

6.1.3. Industrial Survey 2 - Development Grouping Data

The second of the industrial surveys utilised in this research is described in Zain and Kehoe [109,1996] and formed part of a benchmarking research programme examining the relative Quality position across a range of industrial sectors. The complete questionnaire was again structured into 6 areas with a seventh area to determine company details as shown in Figure 6.1.3.

Figure 6.1.3 Industrial survey 2 - structure and sample selection



The measurement orientated questionnaire was designed to assess different facets of Quality management and was used by Zain [108,1993] to develop a mechanism for measuring the Quality 'position' of a manufacturing company relative to industrial sector-based norms. The survey was conducted in two stages with two separate sample populations. The first sample population was selected from five industrial sectors (to provide sample uniformity) with each company being identified at random from the appropriate trade directories. The sample size chosen was 100 companies from each sector. For the second sample population the five original sectors were again chosen together with the electronics manufacturing sector and the companies were chosen on the basis of employing more than 500 people and having a turnover in excess of £100m. For the second sample population the companies were selected from a database provided by the (then) Huddersfield Polytechnic based upon employers of graduate students.

The overall response rate from sample 1 was 13.5% calculated according to the Council of American Survey Research Organisation (See Appendix 5.2 of Zain [108,1993]), which was made up from individual sector response rates for chemical, oil, textile, food and footwear of 40%, 21.8%, 14.5%, 14.5% and 9.1% respectively. As the focus of the research was the measurement of Quality development and the population for sample 1 was selected at random, the relatively poor response rate was due to respondents identifying the questionnaire as inappropriate in relation to the level of Quality awareness. This point was further illustrated by the increase in overall response rate in sample 2 to 26.5% which comprised generally larger companies having been selected on the basis of employing more than 500 people and having a turnover in excess of £100m (although in practice 34% of respondents from sample 2 employed less than 500 people due to inaccuracies in the database). The distribution of responses for the original sectors of chemical, textile, food, oil and footwear was 29.1%, 16.3%, 15.1%, 5.8% and 0% respectively. In addition sample also included the electronics sector (16.3% of respondents) and companies who were re-categorised into either engineering (10.5%) or miscellaneous (6.9%).

Overall this second survey produced a coherent, cross sector population of companies appropriate for the cluster analysis of Quality development proposed below in Chapter 7.

6.2. Activity Parameters Data

6.2.1. Factors in the Activity Modelling of Quality Development

In Chapter 4, one of the key features identified for each stage of Quality development was the application of certain characteristic tools and techniques. This framework was defined in greater detail in the Activity Model described in Chapter 5 in which the applications of the tools and techniques (the 'activities' of Quality Management) were parameterised in terms of:

- the **complexity** of the techniques or activities
- the required level of **involvement** to sustain the application of the activities
- the **quantity** of Quality management activities applied

The aim of the data collection and analysis part of this research is to therefore demonstrate firstly the correlation between the three axes of the Activity Model and Quality development and secondly to demonstrate that the grouping of organisations in identifiable domains correspond to the stages of development identified as systems, improvement and prevention. Elements of the industrial research data described as survey 1 in Section 6.1.2. above are used to illustrate the correlation between the increasing complexity, involvement and quantity of activities and the level of development in terms of the management of Quality. Survey 1 therefore is used to demonstrate that each of the three parameters in the Activity Model shows a positive correlation with the extent of Quality maturity as described by the distinction between organisations selected as Total Quality and organisations selected at random.

Individual elements of the research data described in survey 2 in section 6.1.3. are then used to illustrate the identifiable grouping of companies at specified points in the Activity Model to form domains which correspond to the stages of Quality development proposed in Chapter 4. Survey 2 data is therefore used to illustrate the characteristic groupings of companies and to demonstrate that development through Quality management occurs within a staged framework in which the activities employed form an important feature.

6.2.2. Development Correlation Data for the Activity Parameters

The data on the application of Quality Activities was collected in survey 1 through question number 29 which asked:

'Which of the following quality improvement activities does your company use?'

Problem solving

Statistical sampling

Quality awareness programme

Delegated teams

Voluntary teams

Internal audits

Supplier improvement activities

Statistical process control

Quality costs

BS 5750

Taguchi Activities

Total Quality Management

The elements identified to represent the complexity parameter were the comparative application of BS5750 (systems), statistical process control (improvement) and Taguchi methods (prevention). The quantity parameter was measured in terms of both the proportion of companies employing more than 5 of the listed techniques and the average number of techniques employed. Finally the involvement parameter was assessed through the relative application of awareness programmes (systems), delegated teams (improvement) and voluntary teams (prevention).

The data collected through survey 1 is shown in table 6.2.2. in which the comparative data for the Total Quality sample (69 companies) and the random sample (142 companies) is quoted for each of the dimensions in the Activity Model.

Table 6.2.2. Survey 1 Data for the Activity Model

	Random Sample (142)	**Total Quality Sample (69)**
	Complexity Axis	
ISO 9000	16.9%	46.4%
S.P.C.	14.8%	59.4%
Taguchi	2.8%	34.8%
	Quantity Axis	
> 5 Techniques	22.5%	71%
Average number of techniques	49.2%	65%
	Involvement	
Awareness Programmes	19.7%	71%
Delegated Teams	14.1%	66.7%
Voluntary Teams	6.3%	31.9%

The figures quoted in table 6.2.2. are the number of companies in each sample undertaking the activities specified. The correlation between the level of development (identified as the difference between the 'random' companies and the 'Total Quality' companies) and the extent of application in each of the three axes of the Activity Model is described below in Chapter 7.

6.2.3. Development Grouping Data for the Activity Parameters

The element of survey 2 used to collect data on the application of Quality activities was question number 19 which asked:

'Does the shopfloor use these techniques regularly in running daily operations?'

Statistical process control

Statistical sampling

process capability studies

process failure mode and effects analysis

poka yoke

quality improvement teams

quality circles

quality awareness programs

internal audits

From this survey the activities used to represent the complexity parameter were the comparative application of internal audits (system maintenance activity), statistical process control (process improvement activity) and failure mode and effects analysis (prevention orientated activity). The quantity parameter was measured in terms of the distribution of the number of companies employing increasing numbers of techniques. Finally the involvement parameter was again measured through the relative approach of quality awareness programmes (systems), quality improvement teams (improvement) and quality circles (prevention).

The cross sector data from survey 2 is shown in table 6.2.3. in which the number of companies from both sample 1 (5 sectors) and sample 2 (8 sectors) applying activities in each of the three axes of the Activity Model is quoted.

Table 6.2.3. Survey 2 Data for the Activity Model

	Percentage of Companies
Complexity Axis	
Internal Audits	83.7%
Statistical Process Control	53.5%
Failure Mode Effects Analysis	14%
Quantity Axis	
2 Techniques	18.6%
3 Techniques	14%
4 Techniques	12.8%
5 Techniques	16.3%
6 Techniques	11.6%
7 Techniques	8.1%
8 Techniques	2.3%
Involvement Axis	
Quality Awareness Programmes	55.8%
Quality Improvement Teams	57%
Quality Circles	37.2%

The data presented in table 6.3.2. specifically relates to the application of activities at the shopfloor level. The questionnaire was worded in this way to ensure the widespread application of activities rather than to identify selective usage of techniques, for example within a Quality department. As the data from survey 2 is used primarily to identify the clustering of companies into one or other of the stages of Quality development it was important to establish the widespread use of activities as a means for establishing a viable 'threshold' of application. The clustering analysis based upon the three dimensions of the Activity Model is shown below in Chapter 7.

6.3 Culture Parameters Data

6.3.1. Factors in the Culture Modelling of Quality development

The second of the features identified in Chapter 4 as characterising the stages of Quality development was the culture change which takes place within the organisation. The detailed framework described in Chapter 5 as the Culture Model identified the parameters of Quality culture change as:

- the change in **management approach** to managing Quality within the organisation
- the change in emphasis upon **teamworking** within the organisation
- the increased **customer focus** within the organisation for both the internal and external customers

The identification and collection of data on the culture of an organisation is extremely difficult to achieve through the use of simple research tools such as industrial questionnaire surveys. Jolliffe [54,1986] and Moser and Kalton [79,1971] both identified the problems with attempting to construct individual questions to be answered by an individual or groups of individuals which could adequately frame abstract concepts such as organisational culture.

The industrial survey data used in this research therefore is utilised to indicate general measurable cultural features which are characteristic of the parameters proposed in the Culture Model. The analysis of the data provided below in Chapter 7 does not attempt to define the composite Quality culture for any given organisation but attempts to identify indicators and groupings of cultural features which it is proposed characterise systems, improvement or prevention orientations.

The data from survey 1 is again used to demonstrate general (positive) correlation between the parameters proposed in the Culture Model of Quality development and the data from survey 2 is used to identify the clustering of cultural features which correspond to the systems, improvement and prevention stages of development.

6.3.2. Development Correlation Data for the Culture Parameters

The data used for the assessment of the cultural parameters was collected in survey 1 using a number of different questions from the questionnaire.

The first dimension of the Culture Model, management approach was assessed from considering the extent of formal Quality training for Managers (Question 35 - corresponding to a systems orientation), the involvement of other functions, for example suppliers, in improvement programmes (Question 4.1.1. - corresponding to an improvement orientation) and the effectiveness of communications within the organisation (Question 21 - corresponding to a prevention orientation).

The teamworking dimension of the Culture Model was assessed by considering the extent of formal training for staff and operators (Question 35 - corresponding to a systems orientation), the application of delegated Quality improvement teams (Question 29 - corresponding to an improvement orientation) and the application of voluntary Quality teams (Question 29 - corresponding to a prevention orientation).

Finally the customer focus parameter of the Culture model was assessed by considering the level of customer contact/visits (systems orientation) the extent to which customer's perceptions of the products or services are surveyed (improvement orientation) and the degree of advanced planning undertaken with customers (prevention orientation). Each of these elements relating to customer focus were assessed from Question 34 of the questionnaire.

Table 6.3.2. Survey 1 Data for the Culture Model

	Random Sample (142)	**Total Quality Sample (69)**
Management Approach Axis		
Formal Quality Training for Managers	57%	95.2%
Involvement in Improvement Programmes	48.1%	82.9%
Effectiveness of Communication	29.4%	73.8%
Teamworking Axis		
Formal Quality Training for Staff & Operators	53.2%	92.9%
Application of Delegated Teams	14.1%	66.7%
Application of Voluntary Teams	6.3%	31.9%
Customer Focus Axis		
Customer Contact/visits	79.9%	90.7%
Customer Surveys	44.6%	72.1%
Customer involvement/planning	43.9%	76.7%

The data quoted in table 6.3.2. is again for the relative number of companies in each sample demonstrating the individual parameter. The correlation analysis of the comparison between the random sample of companies and the Total Quality sample is presented below in Chapter 7.

6.3.3. Development Grouping Data for the Culture Parameters

The data used to assess the clustering of companies according to the cultural parameters was derived from a number of different elements of the survey 2 questionnaire.

The elements used to characterise the management approach were the involvement of the senior executive in the Quality development process (Question 7 - corresponding to the systems orientation) and the extent of management training in Quality appreciation (Question 40 - corresponding to the improvement orientation) and the level of organisational interaction during key business processes (Question 6, corresponding to the prevention orientation). These elements were consistent with the corresponding data from survey 1 but were more likely to generate identifiable groupings rather than developmental transitions.

The assessment of the application of teamworking was provided in survey 2 by considering the extent to which Quality management was a functional separate entity within the organisation (Question 2 - corresponding to the systems orientation), the organisational involvement in process improvement programmes (Question 22 - corresponding to an improvement orientation) and the involvement in a range of integrated approaches to product design and development (Question 35 - corresponding to a prevention orientation).

The final elements of survey 2 considered to assess the customer focus dimension were the level of customer contact/visits (Question 27 - corresponding to a systems orientation) the extent to which corrective actions and improvements were made in response to customer complaints (Question 25 - corresponding to an improvement orientation) and the widespread level of staff involved in customer focused activities (Question 16 - corresponding to a prevention orientation).

The cross-sector data from survey 2 for each of these elements of the Culture Model is shown in table 6.3.3 and again companies from both of the samples of survey 2 are quoted.

Table 6.3.3. Survey 2 Data for the Culture Model

	Percentage of Companies
Management Approach Axis	
Involvement of CEO in Quality development	90.7%
Management training in Quality appreciation	65.1%
Interaction during key business processes	44.2%
Teamworking Axis	
Separate Quality function	72.1%
Involvement in process improvement programmes	53.5%
Integrated approaches to design/development	29.1%
Customer Focus Axis	
Customer contracts/visits	87.2%
Customer corrective action programmes	57%
Widespread customer focus amongst staff	15.1%

The data presented in Table 6.3.3. relates to a significant organisational commitment to each of the elements quoted and this was again assessed against a nominal 'threshold' of involvement. The grouping of companies based upon these culture parameters is analysed below in Chapter 7.

6.4. Measurement Parameters Data

6.4.1. Factors in the Measurement Modelling of Quality Development

The final of the parameters identified in Chapter 4 as characterising the stages of Quality development were the metrics of Quality management. The Measurement Model proposed in Chapter 5 identified the key parameters as:

- the Quality **efforts** undertaken by a company in the pursuit of Quality development.
- the Quality **results** in terms of the measures of achievement associated with Quality development
- the Quality **benefits** which accrue from the Quality development process

The metrics data of Quality development is rather easier to collect using an industrial survey than information regarding culture but nevertheless it is important to identify readily available parameters. Both Mann [71,1992] and Zain [108,1993] made distinctions in their work between efforts and results and both pieces of research utilised well established measures of Quality development such as systems accreditation and Quality costs.

The survey data analysed below in Chapter 7 is, however, only a sub-set of the performance measures used by industrial companies. The more complete models of performance measures proposed by Frizelle [41,1989], Barber and Hollier [4,1986] or Crawford et al [20,1988] are more appropriate to the complete modelling of the business development of an organisation. The measurement parameters selected in this research have been chosen to relate specifically to the concept of the way in which Quality is managed within the organisation.

Survey 1 data is used to demonstrate the general correlation between each of the parameters in the measurement model and the aggregate level of Quality development and survey 2 data is used to identify the clustering of metrics which correspond to the three stages of Quality development proposed.

6.4.2. Development Correlation Data for the Measurement Parameters

The data selected from survey 1 to assess the correlation between the Measurement Model parameters and Quality development are again derived from various sections of the questionnaire.

The Quality efforts are measured in terms of the extent to which a Quality policy has been developed by the Organisation (Question 22 - corresponding to a systems orientated effort), the combined efforts on training within the company (Question 35 - corresponding to an improvement orientated effort) and the efforts made to create an integrated Quality Supply chain (Question 41.1-5 - corresponding to a prevention orientated effort).

The Quality results parameters were assessed in terms of the certification of the company to ISO 9000/AQAP (Question 27 - corresponding to a systems orientated result), the comparative performance of processes and products (Question 34.7 -

corresponding to an improvement orientated result), and the results in terms of the company's reputation for Quality as being the market leader (Question 26 - corresponding to a prevention orientated result).

Finally the Quality benefits dimension of the Measurement Model was assessed using the level of application of Quality costing (Question 33 - corresponding to a systems orientated benefit), the application of competitive benchmarking (Question 34.6 - corresponding to an improvement orientated benefit) and finally the increase of market share due to Quality development (Question 44 - corresponding to a prevention orientated benefit).

The data collected from survey 1 for each of the dimensions of the Measurement Model is shown in table 6.4.2.

Table 6.4.2. Survey 1 Data for the Measurement Model

	Random Sample (142)	Total Quality Sample (69)
Quality Efforts Axis		
Development of a formal Quality policy	85.2%	100%
Combined efforts on Quality training	55%	93.7%
Integrated supply chain developments	38.4%	88.4%
Quality Results Axis		
Certification to ISO 9000/AQAP	50.4%	67.4%
Comparative product & process studies	18%	32.6%
Reputation as market leader for Quality	28.7%	72.5%
Quality Benefits Axis		
Application of Quality costing	22.5%	69.8%
Application of competitive benchmarking	56.8%	74.4%
Increased market share due to Quality	28.7%	69.6%

The correlation analysis for the measurement data quoted in table 6.4.2. is presented below in Chapter 7.

6.4.3. Development Grouping Data for the Measurement Parameters

The data used to demonstrate the clustering of companies according to the measurement parameters was again provided by a range of elements within the survey 2 questionnaire.

The grouping data for the Quality efforts dimension was assessed in terms of the development, in writing, of a Quality Policy (Question 1 - corresponding to a systems orientated effort), the overall level of resources provided for Quality training and awareness (Question 41 - corresponding to an improvement orientated effort) and the efforts to create a more integrated approach to product and process design (Question 35 - corresponding to a prevention orientated effort).

The Quality results dimension of the Measurement Model was assessed for the grouping of data by means of the extent of certification to the ISO 9000 standard (Question 4 -corresponding to a systems orientated result), the level of process capability (Question 17 - corresponding to improvement orientated result) and by the external reputation for product design reliability (Question 34 - corresponding to a prevention orientated result). These measures were selected from the range of measures determined in the survey 2 questionnaire which were well validated both in terms of reliability and accuracy in the ARUBS testing of the survey 2 questionnaire undertaken by Zain.

Finally the Quality benefits dimension was assessed in terms of the application and collection of Quality Costs (Question 11 - corresponding to a systems orientated benefit), the deployment and reporting of the business benefits of Quality development (Question 13 - corresponding to an improvement orientated benefit) and the increased market share due to Quality development (Question 52 - corresponding to a prevention orientated benefit).

The cross sector data from survey 2 for each of the dimensions of the Measurement Model is shown in table 6.4.3. with companies from both of the survey samples being quoted.

Figure 6.4.3. Survey 2 Data for the Measurement Model

	Percentage of Companies
Quality Efforts Axis	
Development of a written Quality policy	86%
Commitment of resources to Quality training	52.3%
Integrated approach to product & process design	29.1%
Quality Results Axis	
Certification to ISO 9000	62.8%
Process capability demonstrated	43%
Reputation for design reliability	29.1%
Quality Benefits Axis	
Collection of Quality costs	69.8%
Reporting and deployment of business benefits	46.5%
Improved market share due to Quality	27.9%

The cluster analysis for the data quoted in table 6.4.3. is presented below in Chapter 7.

The data elements from both survey 1 and survey 2 used in this research have been selected on two primary criteria. Firstly they should reflect the respective parameters from the theoretical framework of Quality development proposed in this research and should be consistent with the description of the framework presented in Chapters 4 and 5. Secondly the data should be reliable in terms of the correct interpretation of what is required of the respondents by the question and accurate in the sense that the respondent could answer the question to a high degree of certainty. Both of these criteria have been applied in the selection of the industrial data presented in this chapter.

Chapter 6 Summary

- *This chapter of the thesis describes the industrial survey data used to assist in the validation of the model of Quality development and the parametric features proposed in this research.*

- *Two primary sources of data are used, the first from the survey by Mann, is used to demonstrate the correlation between each of the parametric models of Quality development and the aggregate difference in development between a random sample of companies and a Total Quality sample of companies. The second source of data, from the survey by Zain, is used to demonstrate the clustering of the level of Quality development corresponding to the systems, improvement and prevention stages of development.*

- *Data is selected from both surveys for the Activity Model, the Culture Model and the Measurement Model and this is analysed below in Chapter 7.*

- *The industrial data presented is intended to illustrate the concepts of the Quality development framework proposed in this research rather than as a mechanism for classifying the absolute level of development of any individual respondent.*

CHAPTER 7

ANALYSIS OF THE INDUSTRIAL SURVEY DATA

7.1. Analysis of the Survey Data

Chapter 6 presented data from two independent, industrial surveys in each of the three domains of activities, culture and measurement. The purpose of this chapter is to present the analysis of the survey data. The analysis of the data is conducted using two separate approaches. The first approach is correlation analysis which is undertaken to demonstrate the validity of the axes of development in each of the three models of quality development. The main objective of the correlation analysis is to illustrate that an increase in the individual factor (for example the number of quality management techniques employed) correlates to an independent, aggregate measure of quality development.

The second approach to the analysis is undertaken to demonstrate significant groupings or 'clusters' in the industrial data corresponding to each of the three stages of quality development proposed in this research, namely systems, improvement and prevention. This cluster analysis does not assume that each of the stages of quality development are equally populated with industrial companies (indeed Chapter 4 proposes that only a proportion of companies at each stage will progress to the next) but instead seeks to identify characteristic groupings from the data.

7.1.1. Analysis and Requirements Strategy

The role of the data analysis in this research programme is to illustrate the developmental framework produced as a result of the literature and action based research activities. This data-for-illustration approach is in contrast with a data-for-formulation approach whereby less focused industrial surveys are analysed and the results produced are searched for 'patterns' of phenomenon and then a hypothesis postulated to describe the patterns observed. In this research the hypothesis is made from an understanding of the subject area and the data used to illustrate both the framework (stages) and the models of development. The primary requirements of the data analysis process are therefore:

- to identify statistically significant correlation between each of the factors of the quality development models and a generalised measure of development.

- to identify characteristic 'footprints' or groupings of parameters which correspond to the stages of development proposed.

In terms of the analysis strategy adopted for this research, this is again divided into two approaches.

- the correlation analysis strategy involves the comparison of the correlation coefficients for each of the factors in each of the dimensions between the data generated for Total Quality and non-Total Quality organisations.

- the cluster analysis strategy involves undertaking a sign test on a scatter diagram representing data across a range of industrial sectors.

Both of the analysis strategies are consistent with the analysis requirement to provide comparative interpretation of the data rather than absolute measures of correlation or clustering. By demonstrating from 'real' industrial data that a greater correlation exists between Quality 'developed' organisations and the parameters proposed in the developmental models validates the research framework which is primarily intended to provide understanding and a relational map of the quality management techniques and methodologies rather than a simple classification tool. Similarly the groupings identified from the cluster analysis are primarily to substantiate the proposal of staged development rather than as a technique for measuring or pinpointing the current level of quality development.

7.1.2. Method for Correlation Analysis

A number of statistical techniques are available to indicate the relative dependency of two variables and of the methods for quantifying this relationship the correlation coefficient is the most basic measure and this has been adopted in this research as the primary measure of correlation.

In order to analyse the correlation between the factors representing the dimensions in each of the three models of Quality development use has been made of the basic matrix analysis techniques associated with Principal Component Analysis (PCA). The first application of PCA was made by Pearson [86,1901] to obtain the principle regression line between two variables and thereby to indicate the relationship between the variables. The formal method of principal components developed by Hotelling [46,1932] and described by Jackson [52,1991] can be used to determine the sample covariance matrix for sets of data of the type generated in the industrial surveys described above in Chapter 6. From the variance and covariance coefficients of the research data the correlation coefficient can be determined. The correlation coefficient is adopted in this research primarily because it provides a simple indicative measure of the relationship between the parameters proposed in each of the models and Quality development. Insufficient data points were available to undertake, for example, cross tabulation analysis but as the data is to be used to demonstrate the models proposed other more detailed parameter by parameter comparisons were not relevant.

In using correlation coefficients to analyse survey research data in this way, it is important to clearly establish the basis of the correlation which is to be tested. For the data described above as survey 1, two sets of data have been generated in each of the dimensions (axes) for the three models of quality development proposed. Each data element relates to a parameter which is used to model Quality development (for example the 'complexity' parameter in the Activity Model) and has been measured against an aggregate measure of Quality development, namely whether the respondent organisation is considered a Total Quality company or not. The correlation to be tested therefore in this research is the relationship between the value of the parameter (expressed in general as a proportion of the total number of companies exhibiting the specific parametric feature) and the generalised measure of Quality development (in terms of being a Total Quality company or not).

The method for correlation analysis therefore requires the parameters in each of the developmental models to be compared between the Total Quality (TQ) and non-Total

Quality (NTQ) companies. A positive correlation coefficient would indicate that the axes of the models represent a valid representation of Quality development. The relative magnitude of the correlation coefficient would indicate the extent of the relationship between the particular parametric model and the concept of Quality development with the range of -1 to +1 representing 'perfect' negative and positive correlations respectively. The essence of the analysis is to demonstrate generalised correlation between the parametric models of Quality development and the aggregated concept of mature Quality orientated organisations. The number of parametric data elements considered and indeed the number of industrial companies surveyed are insufficient to allow the method to be used as a definitive measure of Quality development for pinpointing any individual organisation but as described above in Chapter 6 that has not been the objective of the correlation analysis in the context of this research. Instead the analysis is performed to provide validation from the industrial survey data that the theoretical models proposed in the research are consistent with industrial practice.

The correlation analysis is performed for the Activity Model, the Culture Model and the Measurement Model in sections 7.2, 7.3 and 7.4 respectively below. For each of the models the parameters identified in Chapter 6 are considered in each of the dimensions A, B and C as described in Chapter 5. The general form of the data for each model is shown in figure 7.1.2.

The most basic comparative analysis performed on the data is to examine the relative mean values for each of the parameters using the vector of means for each dimension of the model as given by equation 7.1.2.a) to 7.1.2.c).

Figure 7.1.2 General form of the analysis data

Parameter	Element	NTQ Companies	TQ Companies
ACTIVITY MODEL			
Complexity	A1	A1,NTQ	A1,TQ
Quantity	A2	A2,NTQ	A2,TQ
Involvement	A3	A3,NTQ	A3,TQ
CULTURE MODEL			
Management Approach	B1	B1,NTQ	B1,TQ
Teamworking	B2	B2,NTQ	B2,TQ
Customer focus	B3	B3,NTQ	B3,TQ
MEASUREMENT MODEL			
Efforts	C1	C1,NTQ	C1,TQ
Results	C2	C2,NTQ	C2,TQ
Benefits	C3	C3,NTQ	C3,TQ

$$\textit{Vector of Means, Parameter } A = \overline{X_A} = \begin{bmatrix} \overline{X_{A,NTQ}} \\ \overline{X_{A,TQ}} \end{bmatrix} \quad .... \ 7.1.2a$$

$$\textit{Parameter } B = \overline{X_B} = \begin{bmatrix} \overline{X_{B,NTQ}} \\ \overline{X_{B,TQ}} \end{bmatrix} \quad .... \ 7.1.2b$$

$$\textit{Parameter } C = \overline{X_C} = \begin{bmatrix} \overline{X_{C<NTQ}} \\ \overline{X_{C,TQ}} \end{bmatrix} \quad .... \ 7.1.2c$$

In order to determine the correlation coefficients for each of the models, the data for each of the dimensions is combined in order to provide a more viable data set. The sample covariance matrix for each set of data for each model is therefore given in equation 7.1.2.d).

$$\textit{Sample Covariance Matrice } s = \begin{bmatrix} s^2_{NTQ} & s_{NTQ,TQ} \\ s_{NTQ,TQ} & s^2_{TQ} \end{bmatrix} \quad ...7.1.2d$$

where s^2_{NTQ} *is the variance of the data set for NTQ companies*

s^2_{TQ} *is the variance of the data set for TQ companies*

$s_{NTQ,TQ}$ *is the covariance of the complete data set*

and is given by equation 7.1.2.e).

$$s_{NTQ,TQ} = \frac{n\Sigma x_{NTQ,k}\, x_{TQ,k} - \Sigma x_{NTQ,k}\, \Sigma x_{TQ,k}}{[n(n-1)]} \quad .... \ 7.1.2e$$

where n is the total number of data elements combining factors in each of the three dimensions of the model.

The correlation coefficient for the correlation between the parameters for the NTQ companies and the parameters for the TQ companies can then be expressed as given in equation 7.1.2.f).

$$\textit{Correlation Coefficient } r = \frac{s_{NTQ,TQ}}{s_{NTQ}\, s_{TQ}} \quad .... \ 7.1.2f$$

The values for the vectors of means, the covariance matrix and correlation coefficient are established for each of the three models of Quality development. The differences between the parametric mean values represents the significance of each of the dimensions within the model and the overall correlation coefficient gives a measure of the extent to which the model reflects the Quality development of an organisation.

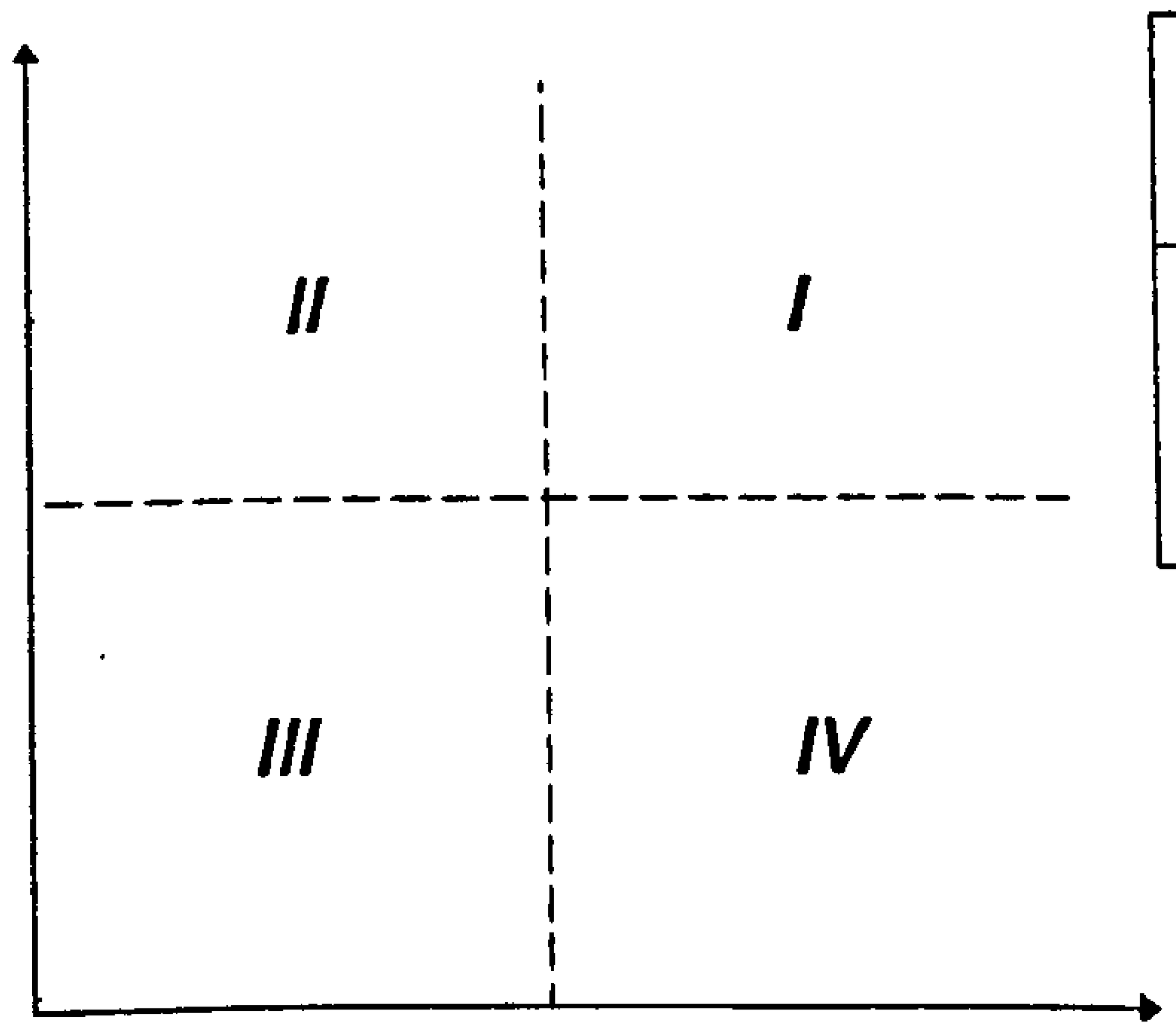
7.1.3. Method for Cluster Analysis

The techniques for identifying clustering within data are primarily based upon tests for non-normal distribution of the sample data. The primary objective for the method for cluster analysis adopted in this research has been to indicate significant values of parameters proposed in each of the three models of Quality development. The clusters of data identified should be capable of interpretation in terms of the stages of Quality development proposed namely the transitions from systems to improvement and from improvement to prevention orientation. As with the correlation analysis method described above, the aim of the analysis is to provide general substantiation from the industrial survey data of the framework proposed rather than to attempt to classify individual companies as specifically systems, improvement or prevention orientated.

A simple form of clustering analysis was adopted by Zain [108,1993] in the evaluation of the ARUBS programme by examining the ratio of the mean value to the standard deviation for each of the scoring modes considered. This ratio was described as the "clustering characteristic" by Zain and was a method for cross sector analysis and generated a single parameter which could be minimised in order to select the most appropriate scoring mode (the method of scoring which produced the most pronounced grouping). For this research, however, it is the overall grouping of elements of the survey data which is of importance rather than the comparative weighting mechanisms for presentation of the data.

The method adopted in this research is based upon the sign test proposed by Ishikawa [51,1982] as a method for examining data represented on two dimensional matrices such as those used to represent the models of Quality development described above in Chapter 5. The sign test examines data in each of the four quadrants of the matrix using upper and lower confidence limits set at 1% and 5% levels of significance as shown in Figure 7.1.3. The sign test is used to examine scatter diagrams to determine the significance of patterns to the data.

Figure 7.1.3 The Sign Test to examine clustering of the survey 2 data



significance table

	lower limit		upper limit	
n	1%	5%	5%	1%
86	30	33	53	56

The number of data points in each of the quadrants is determined and compared with the 1% and 5% significant values in the table. Values of clustering which fall within the upper and lower significance levels indicate patterns of data which are statistically significant in relation to the normal expected distribution of the data.

The sign test can therefore be used to examine the industrial data described as survey 2 above in Chapter 6 to evaluate the distribution of companies for each of the parameters in each of the three models of Quality development. The combination of parameters which are suggested in this research to indicate transitions to systems, improvement and prevention orientations can be tested using the industrial data of survey 2 to evaluate significant clusters of companies corresponding to the respective stages of Quality development.

Again, the analysis method used in this research to demonstrate the clustering of companies around the stages of Quality development is not intended to be exhaustive but instead indicative of the groupings proposed. The other limitation imposed by attempting to be too rigorous with the analysis of clusters is due to the transitional nature of the developmental framework. A proportion of the companies examined in survey 2 are inevitably undergoing transition from one of the stages of Quality orientation to another and this phenomenon will clearly mitigate against the observation of clusters in the data. This phenomenon is potentially most acutely prevalent during the improvement orientation stage of Quality development in which the overriding philosophy of continuous improvement and the absence of any external assessment mechanism makes organisations at this stage of development less easily grouped through the use of simple industrial questionnaires. The improvement stage of development is more appropriately identified through the industrial case study evidence presented below in Chapter 8.

7.2. Analysis of the Activity Data

The analysis of the industrial survey data associated with the Activity Model has two components as described above in Chapter 6. The survey 1 data is analysed using the correlation method in order to validate the dimensions of the Activity Model and the survey 2 data is analysed for characteristic clusters of companies corresponding to the proposed stages of Quality development reflected in the model.

7.2.1. Correlation Analysis for the Activity Data

The initial analysis of the Activity Model data presented in table 6.2.2. above involved the calculation of the vectors of means for the complexity axis, the quantity axis and the involvement axis as shown in table 7.2.1.a).

Table 7.2.1a Vectors of means for complexity, quantity and involvement axes

Axis	Vector of Means	Ratio of Means, NTQ:TQ
Complexity	$\begin{bmatrix} 11.5 \\ 46.9 \end{bmatrix}$	4.08
Quantity	$\begin{bmatrix} 35.9 \\ 68 \end{bmatrix}$	1.89
Involvement	$\begin{bmatrix} 13.4 \\ 56.5 \end{bmatrix}$	4.22

Table 7.2.1.a. illustrates significant differences in each of the dimensions of the Activity Model between the NTQ companies and the TQ companies. The values quoted for the vectors of means are expressed as percentages of full range and the results indicate that TQ companies are almost twice the level of development for each of the parameters in the Activity Model. The data of table 7.2.1.a. represents the first validation from the industrial data of the Activity Model of Quality development proposed in this research.

The covariance matrix together with the correlation coefficient for the Activity Model data is shown in Table 7.2.1.b)

Table 7.2.1b Covariance Matrix and Correlation Coefficient for the Activity Model data

Covariance Matrix	***Correlation Coefficient***
$\begin{bmatrix} 198.6 & 133.8 \\ 133.8 & 254.2 \end{bmatrix}$	***0.6***

From Table 7.2.1.b), the positive correlation of 0.6 indicates that there is a strong correlation between the parameters proposed in the Activity Model and the industrial data obtained comparing NTQ and TQ companies. This data represents the second validation that the industrial data supports the hypothesis of a positive correlation between the parameters proposed within the Activity Model and Quality development.

7.2.2. Cluster Analysis for the Activity Data

Cluster analysis of the Activity Model data presented above in table 6.2.2. involves the examination of the number of companies in each of the domains of the model by means of the sign test. The overall number of respondent companies from survey 2 was 86 (n) and the proportion in each of the domains is shown in figure 7.2.2.

Figure 7.2.2 Sign Test data for the Activity Model data

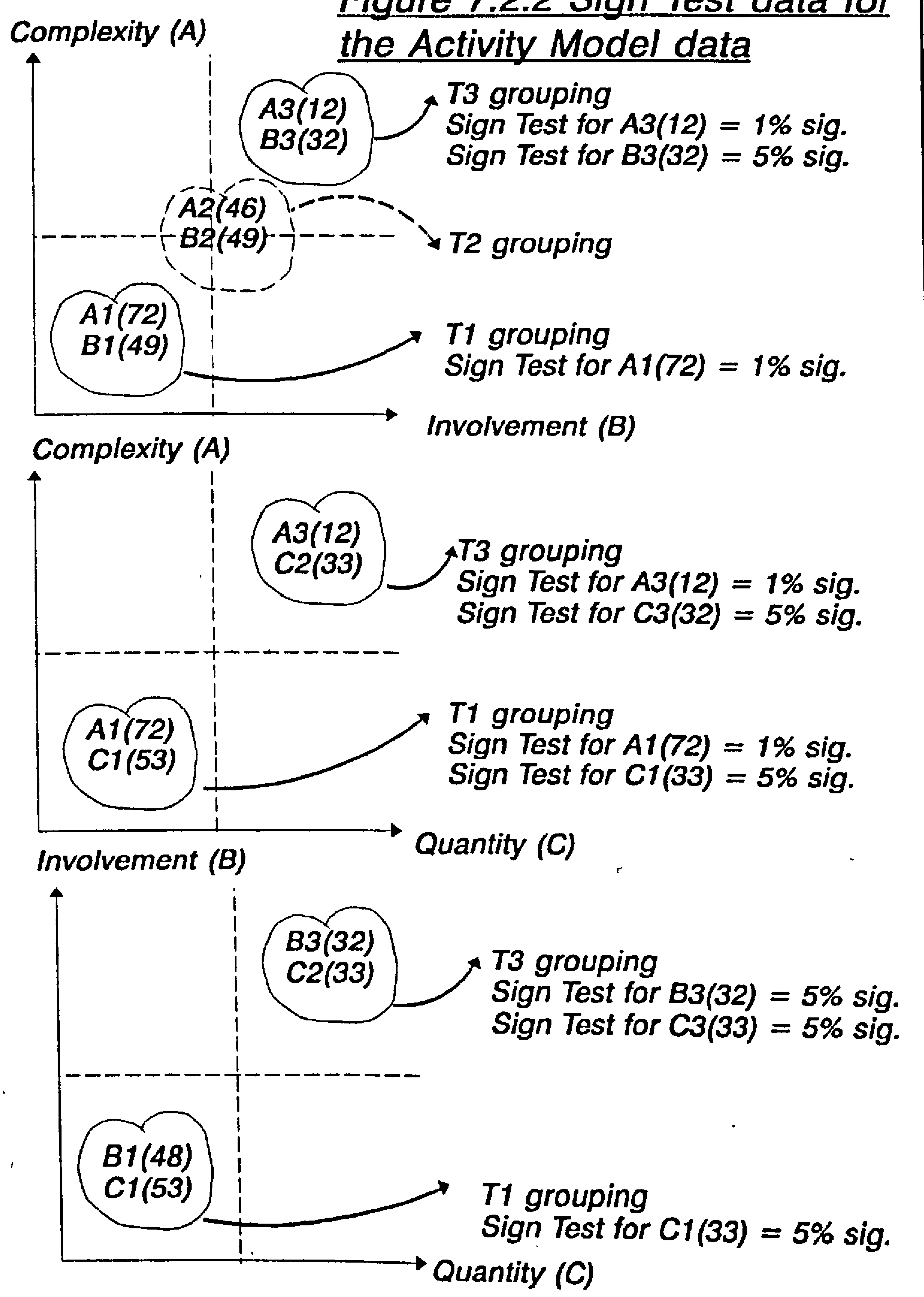


Figure 7.2.2. identifies two significant clusters of companies which correspond to the systems orientation (T1) and the prevention orientation (T3) stages of development as proposed in this research.

The systems orientation grouping is indicated from the Activity Model through the application of less complex techniques (A1, the Quality System Audit techniques) in 72 of the 86 companies (83.7%). This result corresponds to the sign test 1% significance level and is therefore a statistically significant feature of the complexity parameter. The systems orientation is also indicated from the quantity of techniques parameter (C1, the application of 5 or less techniques) which was exhibited in 53 of the 86 companies (61.6%). This result corresponds to a 5% significance level and is again therefore indicative of companies grouped in a systems orientation. The third parameter of the Activity Model used to indicate a systems orientation is the involvement of employees in the application of the techniques (B1, the application of Quality awareness programmes) and this is exhibited by 48 of the 86 companies (55.8%). This result does not exhibit a statistical significance in terms of the sign test and this may be due to this element of the industrial data (awareness programmes) being indicative of the transition from a systems to an improvement orientation, as discussed above in section 7.1.3. The questionnaire does not distinguish between the Quality Systems awareness programmes often employed as part of an ISO 9000 implementation plan and the more general Quality appreciation training often presented at the beginning of a programme of continuous improvement. From the industrial data therefore, the parameter B1 does not conclusively indicate a grouping of companies corresponding to a systems orientation.

The prevention orientation grouping is indicated from the Activity Model by each of the three parameters. The application of more complex techniques (A3, the application of Failure Mode and Effects Analysis) was exhibited in 12 of the 86 companies (14%) and this result corresponds to the 1% significance level indicating again a strong clustering for this parameter. The prevention orientation is also indicated from the involvement parameter (B3, the application of Quality Circles) which was exhibited by 32 of the 86 companies (37.2%) corresponding to a 5% significance level. Finally the T3 (prevention) grouping is also exhibited by the quantity of techniques parameter (C2, the application of more than 5 techniques) which was exhibited in 33 of the 86 companies (38.4%) and again corresponds to a 5% significance level. Taken together the parameters A3, B3 and C2 provide strong evidence from the industrial data of a grouping of companies corresponding to the prevention orientation stage of Quality development.

The clustering of characteristics of the improvement orientation stage of Quality development are less well indicated by the survey 2 data as each of the parameters in the Activity Model exhibit a 'normal' distribution of data. In particular the application of techniques of moderate complexity (A2, the application of Statistical Process Control) which is exhibited by 46 of the 86 companies (53.5%) and the moderate involvement of employees in quality activities (B2, the implementation of Quality improvement teams) which is exhibited by 49 of the 86 companies (57%) both exhibit data more normally distributed. This difficulty in identifying clustering of companies corresponding to the improvement orientation is discussed above in section 7.1.3. and is due in part to the limitations of the industrial questionnaire in identifying the transitional feature of Quality development.

7.3. Analysis of the Culture Data

The analysis of the industrial survey data associated with the culture model also has two components which involve the analysis of tables 6.3.2. and 6.3.3. from Chapter 6 above. The correlation analysis is conducted on the survey 1 data and the cluster analysis performed on the data from survey 2.

7.3.1. Correlation Analysis for the Culture Data

The initial correlation analysis of the Culture Model data from table 6.3.2. involves the calculation of the vector of means for the management approach axis, the teamworking axis and the customer focus axis as shown in table 7.3.1.a).

Table 7.3.1a Vectors of means for management approach, teamworking and customer focus axes

Axis	Vector of Means	Ratio of Means, NTQ:TQ
Management Approach	$\begin{bmatrix} 45.1 \\ 84 \end{bmatrix}$	1.86
Teamworking	$\begin{bmatrix} 24.5 \\ 63.8 \end{bmatrix}$	2.61
Customer Focus	$\begin{bmatrix} 56.1 \\ 79.8 \end{bmatrix}$	1.42

Table 7.3.1.a) again indicates a greater level of development in each of the three axes from the Total Quality companies. The ratio of the means are not as significant as for the activity model and this reflects the ability of an industrial questionnaire based survey to accurately define Quality culture as discussed above in section 6.3.1. Despite these limitations, the data shown in table 7.3.1.a) does provide qualified validation of the parameters used in the Culture Model of Quality development.

The covariance matrix together with the overall correlation coefficient for the Culture Model data is shown in table 7.3.1.b).

Table 7.3.1b Covariance Matrix and Correlation Coefficient for the Culture Model data

Covariance Matrix	Correlation Coefficient
$\begin{bmatrix} 505.7 & 366.1 \\ 366.1 & 371.2 \end{bmatrix}$	0.85

From table 7.3.1.b) the strong positive correlation coefficient 0.85 indicates a significant correlation between the parameters proposed for the Culture Model and the generalised difference in Quality development between the random sample (NTQ) and the Total Quality sample. This coefficient of correlation represents the second major validation of the Culture Model in terms of the parametric modelling of Quality development. The relatively high value for the correlation coefficient also supports the hypothesis that culture change is the most significant feature of the mature state of Quality development associated with Total Quality organisations.

7.3.2. Cluster Analysis for the Culture Data

The survey 2 data for the Culture Model presented above in table 6.3.2. is analysed in terms of the number of companies in each of the domains and the diagram again evaluated using the sign test as shown in figure 7.3.2. The number of respondents (n) was again taken as 86.

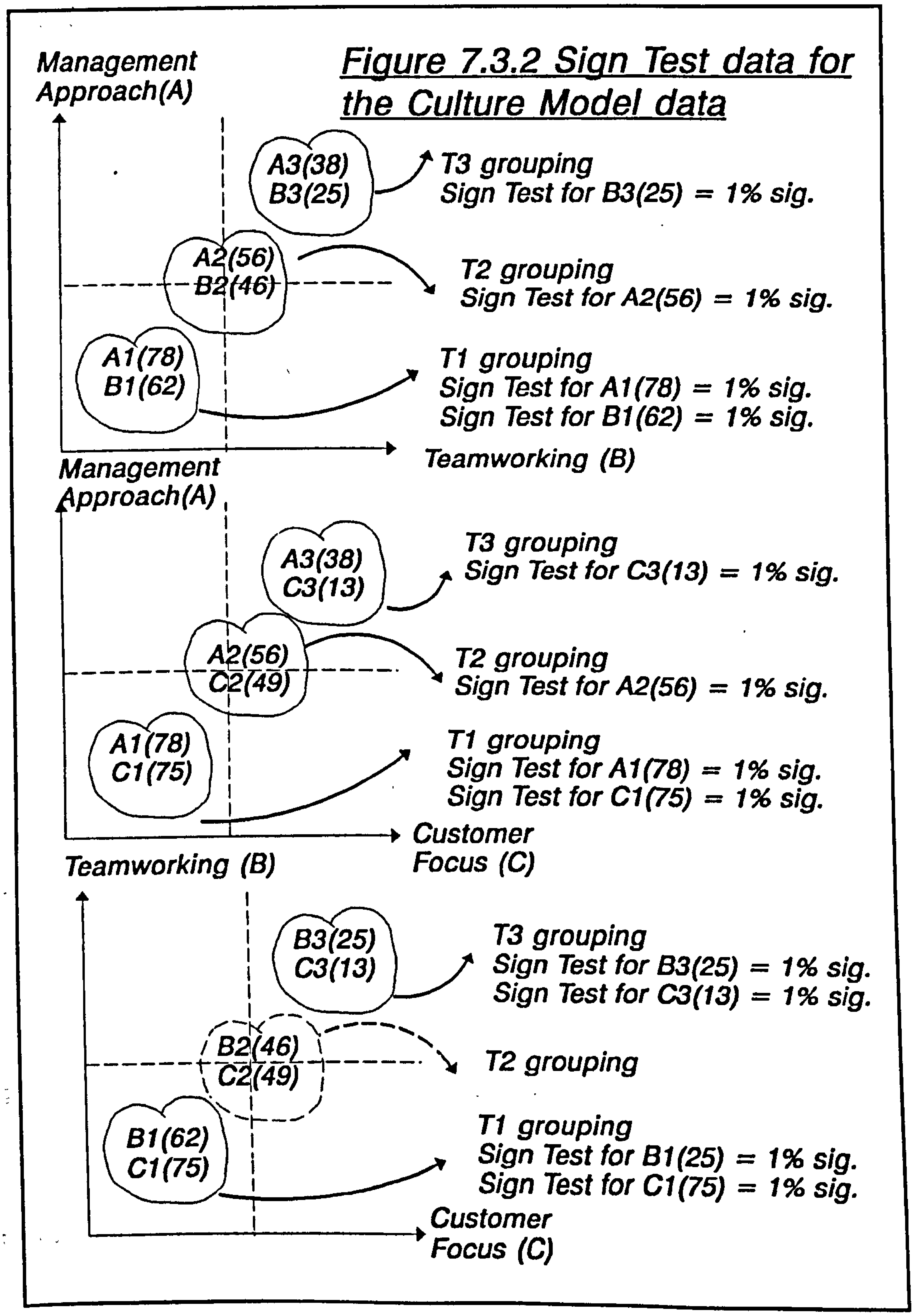


Figure 7.3.2. again shows significant clusters of companies in both the systems orientation (T1) and the prevention orientation but also indicates some degree of clustering corresponding to the improvement orientation (T2).

The systems orientation grouping is indicated from each of the parameters of the Culture Model. The management approach (A1 - the involvement of the Senior Manager in the Quality development process) was exhibited by 78 of the 86 companies (90.7%) which corresponds to the sign test 1% significance level. The teamworking features of the systems orientation (B1 - the functionalised approach to Quality management) was exhibited by 62 of the 86 companies (72.1%) again corresponding to the 1% significance level. Finally the customer focus feature of the systems orientation (C1 - the general contacting and visiting of customers) was exhibited by 75 of the 86 companies (87.2%) corresponding to a 1% significance level. The highly significant level of clustering for each of the Culture Model parameters corresponding to the systems orientation indicates that the prevalent Quality culture within an organisation is an important feature or characteristic of the level of development. This research finding is wholly consistent with the current Quality management literature reviewed in Chapters 2 and 3 which suggests that culture change which may not be readily facilitated using the current set of Quality management tools and techniques as discussed below in Chapter 9.

The improvement orientation grouping is indicated from the Culture Model in terms of the management approach parameter (A2 - the management training in Quality appreciation) which is exhibited by 56 of the 86 companies (65.1%) corresponding to a 1% significance level. The remaining two parameters, teamworking and customer focus are not significantly distributed which again reflects upon the transitional nature of the improvement culture which for many organisations begins enthusiastically with employee training but fails to progress due to the conflicts between teams and functions and between internal and external objectives.

The prevention orientation is indicated from the Culture Model by two of the three parameters. The teamworking corresponding to the prevention orientation (B3, the integrated team approach to design and development) was exhibited by 25 of the 86 companies (29.1%) and this corresponded to a 1% significance level. The customer focus parameter (C3, the widespread customer focus amongst staff) was exhibited by 13 of the 86 companies (15.1%) again this result was at the 1% significance level. The management approach parameter did not show a significant grouping corresponding to a prevention orientation although the result was very close to the 5% significance level.

Overall the survey 2 data shows significant clustering of companies corresponding to the stages of Quality development proposed in this research and supports the validation of the Culture Model.

7.4. Analysis of the Measurement Data

The analysis of the Measurement Model in terms of the data from surveys 1 and 2 considers the data from tables 6.4.2. and 6.4.3. from Chapter 6 above. Again the correlation analysis is conducted on the survey 1 data and cluster analysis is performed on the data from survey 2.

7.4.1. Correlation Analysis for the Measurement Data

As for the two previous parametric models the correlation analysis for the Measurement Model data involves the calculation of the vectors of means for the Quality efforts axis, the Quality results axis and the Quality benefits axis as shown in table 7.4.1.a).

Table 7.4.1a Vectors of means for Quality efforts, Quality results and Quality benefits axes

Axis	Vector of Means	Ratio of Means, NTQ:TQ
Efforts	$\begin{bmatrix} 59.5 \\ 94 \end{bmatrix}$	1.58
Results	$\begin{bmatrix} 32.4 \\ 57.5 \end{bmatrix}$	1.78
Benefits	$\begin{bmatrix} 36 \\ 71.3 \end{bmatrix}$	1.98

The mean values and ratios of means shown in table 7.4.1.a) also indicate a positive difference between the random sample (NTQ) and the Total Quality sample of companies. The highest ratio corresponds to the Quality benefits dimension which supports the view expressed in Chapter 5 that the benefits of Quality management are primarily accrued at the later stage of development. Overall the vectors of means from the industrial data provide an initial validation of the parameters proposed in the Measurement Model of Quality development.

The covariance matrix together with the overall correlation coefficient for the Measurement Model data from survey 1 is shown in table 7.4.1.b)

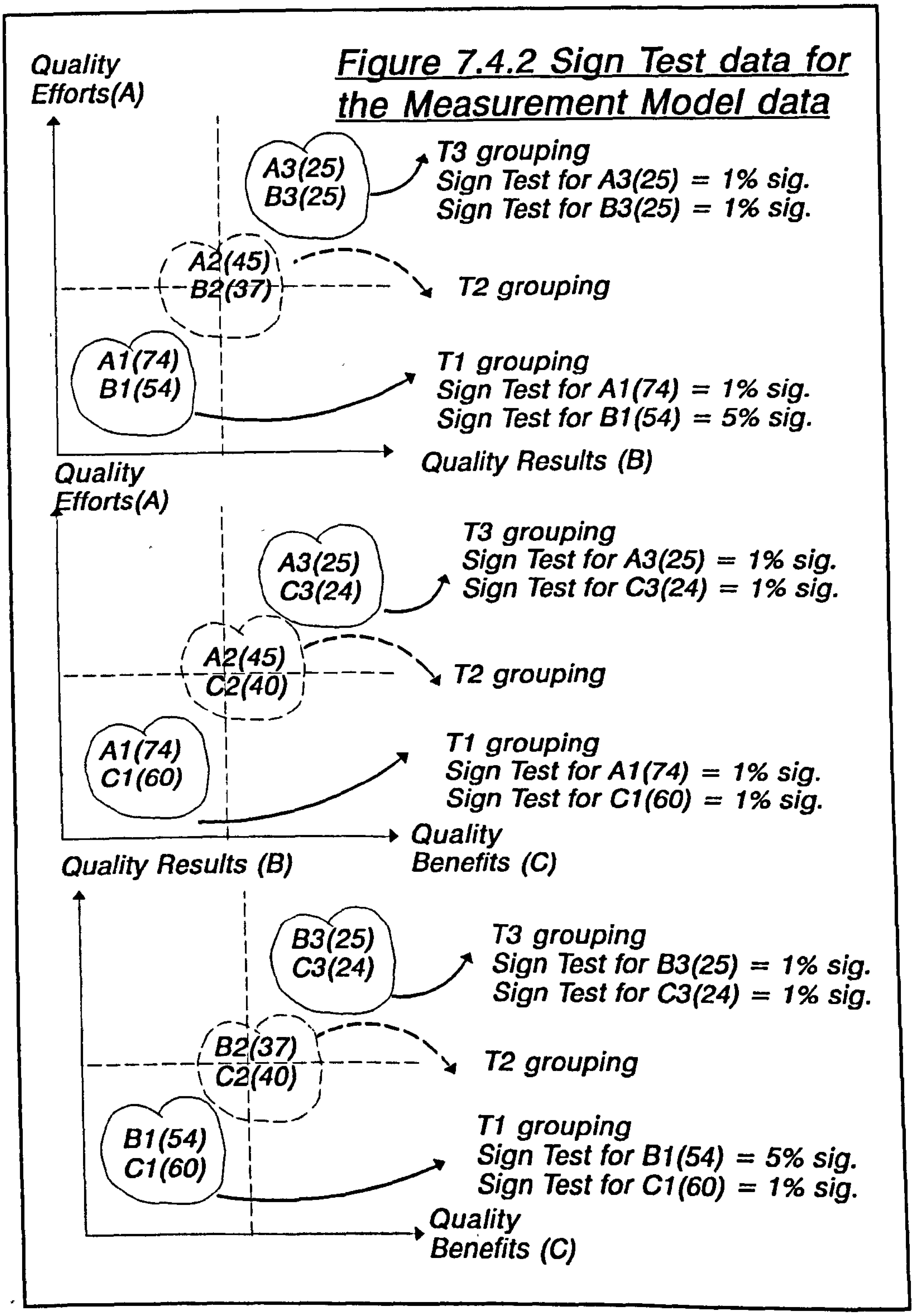
Table 7.4.1b Covariance Matrix and Correlation Coefficient for the Measurement Model data

Covariance Matrix	Correlation Coefficient
$\begin{bmatrix} 455.5 & 303.8 \\ 303.8 & 383.5 \end{bmatrix}$	0.73

Table 7.4.1.b) again illustrates a positive correlation between the parameters of the Measurement Model and the general level of Quality development indicated by companies in survey 1. The correlation coefficient of 0.73 is consistent with the levels of correlation found for both the Activity Model and the Culture Model and supports the view that metrics for Quality development can be determined. The high correlation further validates the concept of modelling Quality development by the combined examination of organisational effort, results and benefits due to Quality management.

7.4.2. Cluster Analysis for the Measurement Data

The survey 2 data for the Measurement Model presented above in table 6.4.2, is again analysed according to the domain grouping as measured by the sign test as shown in figure 7.4.2. The number of respondents (n) was again taken as 86.



As with the Activity Model, the data shown in figure 7.4.2. also shows significant clusters of companies for both the systems orientation (T1) and the prevention orientation (T3) but exhibits less significant grouping for the improvement orientation (T2).

The systems orientation grouping is indicated from each of the measurement parameters. The Quality effort (A1, the formalising of a written Quality policy) is exhibited by 14 of the 86 companies (86%) and corresponds to a sign test significance level of 1%. The Quality results parameter (B1, the certification to ISO 9000) is exhibited by 54 of the 86 companies (62.8%) corresponding to a 5% level of significance. Finally the Quality benefits parameter (C1, the collection of Quality costs) is exhibited by 60 of the 86 companies (69.8%) which also corresponds to the 1% level of significance. The significant level of clustering of companies based on these system's orientated metrics is again consistent with the literature on Quality system's development reviewed in Chapters 2 and 3. Both Stebbings [98,1995] and Fox [40,1995] identify the considerable, quantifiable efforts required to create a systems approach to Quality and highlight the benefits from measuring the cost of Quality within the organisation. The results of adopting a systems orientated approach are also readily quantified through the third party assessment of the systems established.

As with the Activity Model, the parameters associated with the development of an improvement orientation are less well grouped for the Measurement Model. Again this more normal distribution of the data corresponds to the difficulties in identifying the transitional characteristics of Quality development using a questionnaire based approach and also indicates the problems of identifying coherent relationships between efforts results and benefits at this stage of development which lead to the Quality 'paralysis' described above in Chapter 1.

The prevention orientation is indicated from the Measurement model with each of the three parameters exhibiting groupings at the 1% significance level. The Quality efforts in terms of creating a more integrated organisation (A3, an integrated approach to product and process design) were exhibited by 25 of the 86 companies (29.1%) as was the Quality result in terms of the reputation for design reliability (B3). The third parameter corresponding to the benefits of a prevention orientated approach (C3, improved market share due to Quality) was exhibited by 24 of the 86 companies (27.9%). These significant clustering of companies corresponding to mature, prevention orientated companies is again consistent with the world class levels of performance achieved by what Zain described as 'Super Successful' Total Quality organisations.

Overall the clustering of companies into systems, improvement and prevention orientations is again well indicated by the Measurement Model proposed in this research. Of particular importance are the insights this new framework brings to the understanding of the complex relationships existing in industry between what companies do, what they achieve and what benefit is brought by the application of the principles of Quality management.

CHAPTER 7 SUMMARY

- *This chapter analyses the industrial survey data presented in Chapter 6 and attempts to validate both the framework of Quality development and the parametric models proposed in this research.*

- *The data from survey 1 is analysed in terms of the correlation between the parameters in each of the Activity, Culture and Measurement Models and an aggregate measure of quality development. Correlation coefficients of 0.6, 0.85 and 0.73 are observed for the Activity Model, Culture Model and Measurement Model respectively. These significant levels of correlation form the first part of the validation of the applicability of the parametric models.*

- *The data from survey 2 is analysed for groupings of data corresponding to the three stages of Quality development proposed. All three models show significant levels of grouping for both the systems orientation stage and the prevention orientation stage with the most significant groupings being exhibited by the Culture Model. The transitional nature of the improvement stage produced less significant groupings in each of the three models.*

CHAPTER 8

INDUSTRIAL CASE STUDY DATA

8.1. Case Study Background

The second major research mechanism used to validate the models of Quality development proposed in this thesis is through the use of industrial case studies. Case studies, undertaken over a period of years are an extremely important qualitative research tool in the examination of management applications as identified by Mills [77,1995] and by Easterby-Smith et al [32,1991]. The approach adopted in this research to undertaking industrial case studies is the action based research model described by Tranfield et al [104,1994] in which organisations are studied in detail over a period of time. Data produced using this approach is much richer and more reliable than the industrial structured interview approach adopted by Mann [71,1992], Zain [108,1993] and Lyons [68,1996] in other research supervised by the author. The longitudinal studies used in this research are particularly relevant to the validation of Quality development which by its nature, occurs over a period of time. The extended period over which this research has been conducted, however, was not available to the supervised researchers quoted above.

8.1.1. Objectives of the Industrial Case Studies

The primary aim in undertaking the five industrial case studies quoted in this research was to facilitate and observe the Quality development processes taking place in a range of manufacturing organisations. The aim of each of the organisations studied was to produce a quantifiable and sustainable improvement in the management of Quality within their companies although not necessarily to achieve a status of Total Quality.

The primary research objective from studying the five companies was to observe the relationships between the Quality Management tools and techniques used by the companies and the changes in organisational culture and performance which resulted. The explicit role of the author in each of the case studies was primarily as facilitator and teacher in helping the organisations understand and use the techniques of Quality management. The implicit role was to observe the Quality developments which took place and to create and validate the model of Quality development and identify the characteristic parameters which are presented in this thesis. The mechanisms for collaboration between the companies and the university varied as described below but in each case the Quality developments both in terms of the actions and the consequences were observed in detail over a period of time.

8.1.2. The Structure of the Industrial Case Studies

The industrial case study data is presented using a common format for each of the five companies. The format for presenting the data was developed to focus the narrative upon the key elements of Quality development proposed in this research (namely the characterisation of the stages of development) and also to extract the key parameters used for modelling development identified in this research. The structure is adopted to assist in the identification and validation of the stage of Quality development exhibited by each of the five companies studied and to position the companies in each of the three parametric models of development.

The initial section to each of the case studies provides important background information on the organisation, not only in terms of the business profile of the company, but also the historical perspective in terms of the pressures for Quality development both internal and external. Of particular importance in each of the case studies was the changing marketplace either in terms of competitor actions or customer pressures.

The case studies are then divided into two sections, one of which identifies the corresponding stage of development for the company (systems, improvement or prevention) based upon the framework proposed in Chapter 4 and the other section positions the company in terms of the three parametric models, the Activity Model, the Culture Model and the Measurement Model.

The appropriate stage of development for each of the case study companies is identified initially in terms of the general characteristics proposed in Chapter 4 and this is then validated in detail through the systematic identification of the domains within each of the three parametric models.

The real importance of the industrial case study data comes not from the ability to adequately characterise five different companies, but from the insights and understanding provided by the theoretical framework proposed in this research into what the companies have done and the developmental benefits that have occurred.

This has assisted the companies in more readily recognising the changes that have taken place and planning further Quality developments more effectively.

8.1.3 The Basis of the Selection of the Industrial Case Studies

The five companies examined in the industrial case studies were selected from a range of industrial collaborators based upon the following factors:

- the companies represented a range of industrial sectors, manufacturing classifications, sizes and market positions;
- the companies were involved in collaborative work with the author over a number of years;
- the companies were representative of each of the stages of Quality development and corresponded to a range of domains in the parametric models.

Two companies were chosen as representative of the systems orientation stage of development and a further two companies were selected as representing the improvement orientation. The final company was chosen as an example of a prevention orientated organisation.

The method of research collaboration has been two way, with the companies being provided with the 'technology transfer' from the university in terms of the tools techniques and methodologies (provided in a classical way and without reference to the research framework) and the university being provided with the data and the observations in terms of systems structures, measures of culture change and quantifiable results.

A different set of case study companies and indeed a different number of studies could have been selected but the information provided below was adequate within the research brief of providing additional indicative evidence of the theoretical developmental models. The case studies are to be taken in conjunction with the industrial survey data shown above in Chapters 6 and 7 as indications of the validity of the framework and models proposed in this research, rather than as definitive proof. The subject area does not permit controlled experimentation on multi-variable phenomenon but instead requires rigorous insights supported by indicative industrial data.

8.2. Case Study A - Rewind & J.Windsor & Sons (Engineers) Limited

8.2.1. Case Study A - Background

Rewinds & J.Windsor & Sons (Engineers) Limited (RJW) were founded in 1939 as an electro/mechanical engineering company based in Liverpool. Currently they operate from two sites, one in Liverpool and one in Wallasey and employ approximately 100 people at both sites. The company is privately owned by the members of the Windsor family and has a current turnover of around £1M. The main product areas are:

- the electrical repair and refurbishment of rotating electrical machines;
- the manufacture of fractional horsepower motors and power transformers, including flameproof;
- the mechanical machining and fabrication of parts to customer specification;
- the dynamic balancing of rotating components;
- the repair of industrial electronic systems and controllers

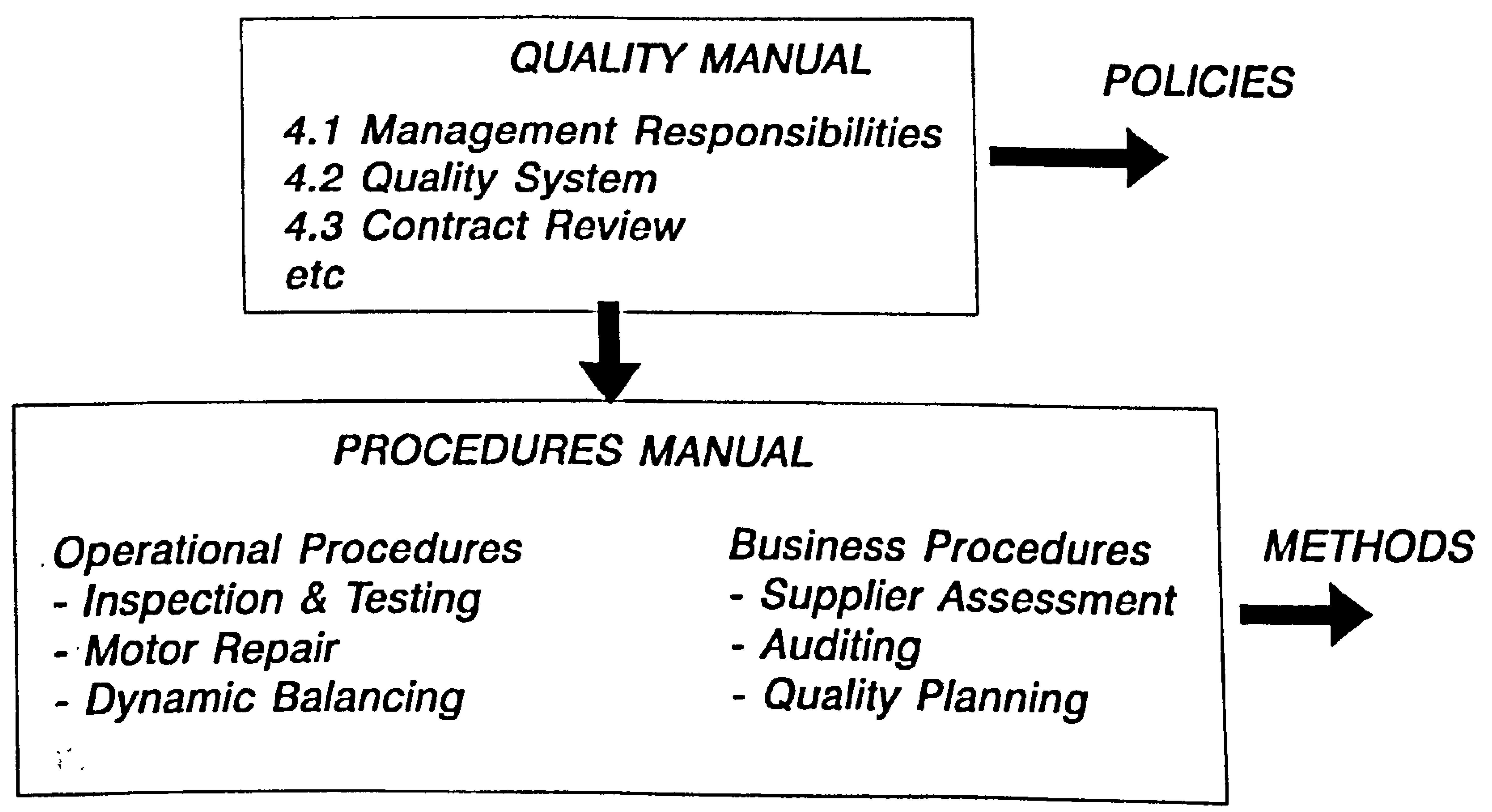
The company provide electrical and mechanical engineering services to a range of major international manufacturers in the Merseyside area including Shell, ICI, BICC, Ford and Vauxhall Motors. The nature of the customer base and the requirement to provided flameproof engineering services has meant that the Quality profile of the company has been an extremely important and perhaps primary business concern. The company's reputation amongst the competitive armature winding companies in the area has been one of high quality, at a high cost. The company has had a tradition of high levels of investment (for a comparatively small company) to maintain a technical edge over its competitors.

Collaboration with the university began in 1987 with a request for assistance in the design and implementation of a Quality system to meet the requirements of the then BS 5750 Part 2. The work was undertaken as part of two final year undergraduate projects and since 1987 a number of collaborative projects have been undertaken to support the Quality management efforts within the company.

8.2.2. Case Study A - The Quality Development Orientation

The company's primary Quality objective is stated in the company Quality Manual and is to "maintain a consistent level of product and service quality in accordance with the requirements of the customer" [92,1988]. The primary activity within the company to support this objective has been the development and implementation of the Quality System shown in figure 8.2.2.

Figure 8.2.2 Quality System at case study A



The company's Quality System shown in Figure 8.2.2. was accredited in 1989 to ISO 9002: 1987 by the British Standards Institution and has been subjected to twice yearly surveillance visits since accreditation. The complete system was re-assessed and approved to the revision of the standard in 1994, BS EN ISO 9002. The company's Quality System was also assessed and accredited in 1994 to the requirements of the Ford Motor Company Q101 standard and the Shell internal Quality assessment standard. The main Quality development emphasis from the company has been internally orientated in the preparation and maintenance of the procedures and controls. The major benefit has been the second and third party accreditation of the company's approach to Quality management.

The main tools and techniques employed by the company have been those associated with Quality System design and implementation (specifications, procedure writing, sampling, definition of responsibilities, traceability and calibration) and with the maintenance of the system (internal audits and management review). The main features of the Quality culture within the company are the recognition that all the employees contribute to the assurance of Quality and that conformance to standard is the expected norm. The company is mechanistic in terms of its organisational structure and the Quality developments have had little impact upon the functional arrangement of the business. The primary measures used by the company to signify its Quality development are the systems certification (external measure) and the Quality costs expressed in terms of a reduction in external failure costs as a percentage of sales revenue (internal measure). Both of these measures together with the results of the internal audits are monitored regularly at management review meetings.

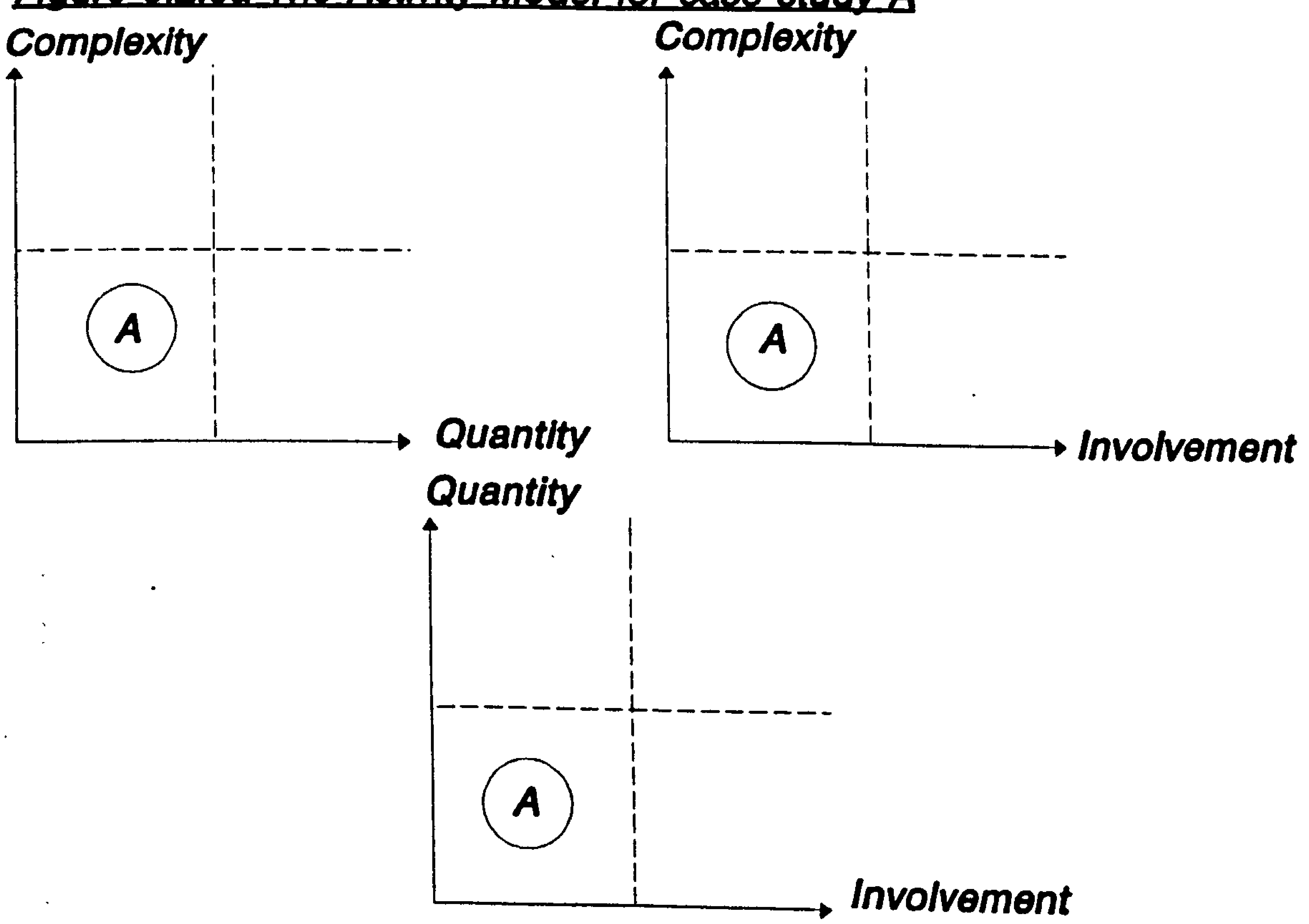
Overall the characteristic features of case study Company A correspond to the stage of Quality development described as a **systems** orientation in Chapter 4 above.

8.2.3. Case Study A - The Parametric Models

Having established the general orientation of case study Company A, the company was then evaluated against the dimensions proposed in each of the three parametric models of Quality development.

Taking first the Activity Model representation of the Quality developments at Company A, the activities undertaken are positioned according to the axes of complexity, quantity and involvement as shown in figure 8.2.3.a).

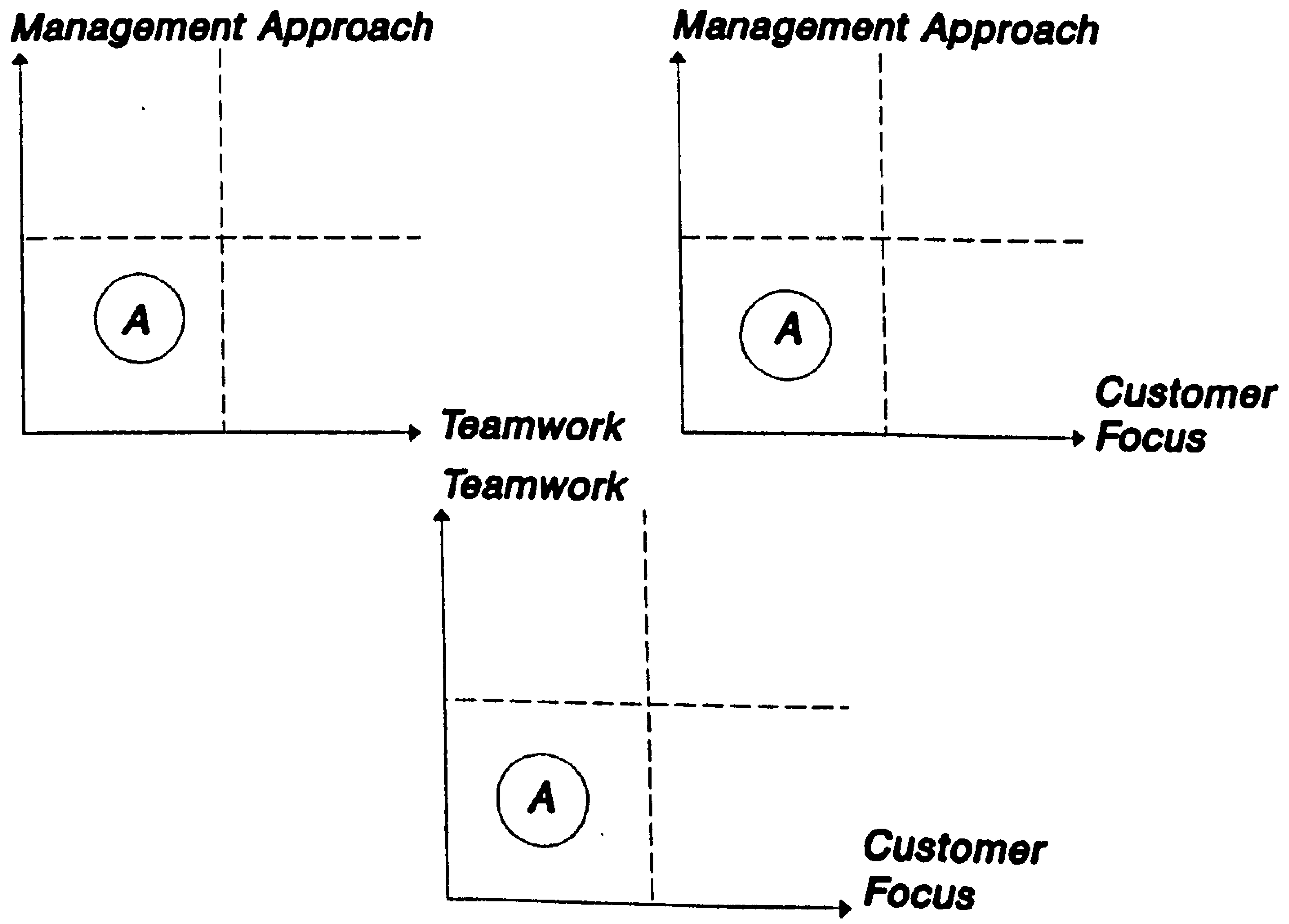
Figure 8.2.3a The Activity Model for case study A



In terms of the complexity axis, using the criteria established in Chapter 5 positions company A in the lower quadrant as only the activities of ISO 9000 have been employed. Statistical process control has been evaluated by Company A but the techniques of advanced Quality planning are not understood or implemented to any extent. The company employs four of the techniques evaluated in the industrial survey 1 data quoted in section 6.2.2. (Quality awareness programmes, internal audits, Quality costs and BS 5750/ISO 9000) and this parameter again places Company A into the Lower quadrant for the quantity of techniques employed. Finally the involvement activities adopted by Company A have primarily been awareness programmes for staff and have not involved any significantly team-based activities. In terms of the involvement parameter Company A is again in the lower quadrant as shown in figure 8.2.3.a). The Activity Model indicates Company A to be within the T1 (systems) domain.

The Culture Model for Company A is shown figure 8.2.3.b).

Figure 8.2.3b The Culture Model for case study A

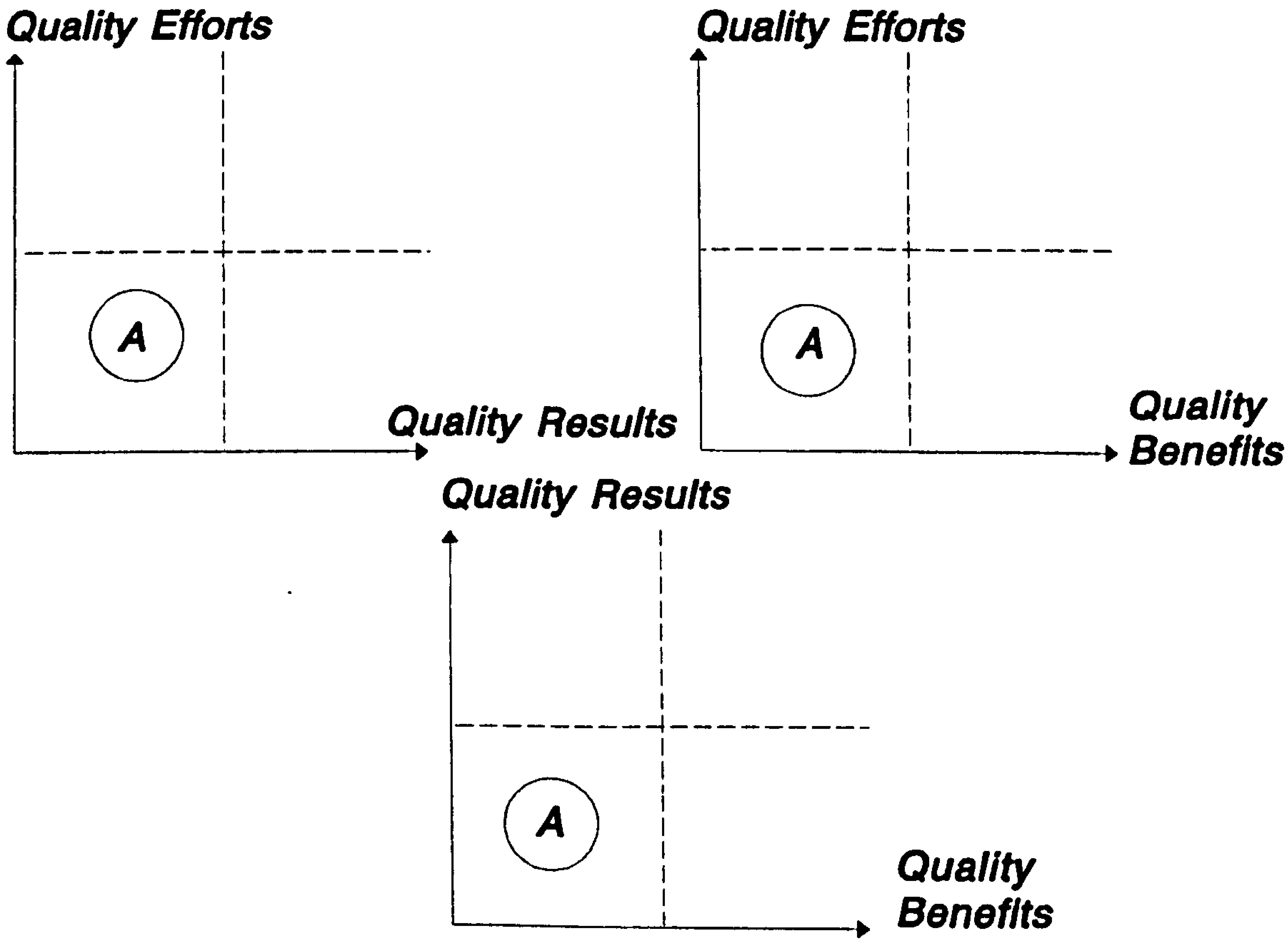


Considering the management approach parameter the prevailing style within Company A remains primarily 'controlling' as described in Chapter 5. In terms of the criteria used in section 6.3.2, the emphasis has been upon the Quality management training for managers and to date there has been no significant efforts to establish improvement programmes within the business or to improve the effectiveness and integratedness of communication within the business. The management approach parameter therefore positions the company in the lower quadrant as shown. The teamworking dimension also positions the development of Company A into the lower quadrant as neither deployed nor voluntary teams exist within the company and only limited Quality awareness training has been provided for staff and operators. Finally in terms of customer orientation of Company A, regular contact is made by sales staff as would be expected of a small company in a competitive market but no coherent effort has been made to focus the manufacturing or technical staff on developing customer relationships and anticipating needs. Customer contact on Quality matters is primarily initiated by the customer. Overall the Culture Model also indicates Company A to be within the T1 (Systems) domain defined in Chapter 5.

The Measurement Model for Company A is shown in figure 8.2.3.c).

Considering the efforts made by Company A these have been primarily internally focused as described in Chapter 5 and in terms of the criteria used in section 6.4.2. the main thrust of the company's approach has been to define and implement the Quality policy expressed in the Quality Manual. The results of this effort has been to achieve systems accreditation to both ISO 9000 and Q101 but little is known about process capabilities within the company or Quality related performance in comparison with competitors. Both the efforts and results dimensions therefore characterise Company A into the lower quadrants.

Figure 8.2.3c The Measurement Model for case study A



The same also applies to the benefits of Quality development enjoyed by Company A which have been primarily expressed through the collection of Quality (failure) costs and market share is seen only in terms of potential loss due to poor Quality. Overall the Measurement Model is consistent with both of the other two views of Company A and the parameters depict a T1 (systems) classification.

8.2.4. Case Study A - Summary

From the examination of the activities, culture and achievements of Company A, it is apparent that the company is identifiably at the systems stage of development which is appropriate to a company competing on a regional basis and supplying services to a range of Quality mature customers.

A consistent (systems) classification also emerges from case study Company A in all three of the parametric models and clearly the company has made the 'classical' transition proposed in Chapter 4 from a Quality Control based organisation to a Quality Assurance orientated company. The company's approach to Quality management, the prevailing Quality culture and the rewards from quality development are extremely well depicted by the theoretical framework proposed in this thesis.

8.3. Case Study B - International Flavours and Fragrances Limited

8.3.1. Case Study B - Background

International Flavours and Fragrance (IFF) Limited are part of the IFF Corporation of the U.S.A. and established manufacturing facilities at Haverhill, Suffolk in 1957. Currently the company has two divisions at the Haverhill site, the Flavours division and the Fragrance Ingredients division both of which have autonomous management structures and operate as separate profit/cost centres. The company employ approximately 250 people at Haverhill with 70 within the Flavours Division and the remainder within Fragrance Ingredients and site services. The current turnover is approximately £70m.

The main product areas are:

- powder, liquid and concentrate flavourings for all sectors of the food industry
- aromatic intermediate chemicals for subsequent blending by the fine perfume and personal products industries

The Flavours division provides products directly for the major U.K. and mainland Europe food manufacturers including Unilever, Premier Brands, United Biscuits and Associated British Foods. The marketplace is therefore extremely Quality safety orientated and has seen significant pressures from the U.K. food retailers for increased food Quality levels in recent years. The Flavours Division of IFF is perceived as the market leader in the U.K. primarily due to the development both in the U.S. and the U.K. of extremely innovative products based mainly on the worldwide supply of ideas and constituents. The division is highly profitable with a portfolio of unique recipes which has a clear technical advantage over competitor products. The customer base, however, is becoming dominated by a relatively small number of important purchasers and the company have been encouraged to conform to food industry standard norms in terms of their approach to managing Quality.

The Fragrance Ingredients division primarily provide products for other IFF affiliate companies who blend the finished perfumes and fragrances. The marketplace is therefore captive and the demand for the company's product consistently exceeds the capacity to supply. The Fragrance Ingredients division is primarily a batch chemical operation, reacting and distilling chemical derivatives such as Galaxolide and the majority of the management team are graduate or postgraduate chemists or chemical engineers. The technology and formulations possessed by the company are a significant part of their competitive lead in the marketplace. The pressures for Quality development for the Fragrance Ingredients division came primarily from within an enlightened management team recognising the benefits from improved product consistency on product yield and therefore manufacturing efficiency. In addition the Haverhill site competes within the IFF Group for investment and the Quality profile of the division is an important strategic element in the selection of the manufacturing site to establish new (particularly chemically advanced) products.

Collaboration with the University commenced in 1993 with a request to assist in establishing a Quality profile required by major customers (Flavours Division) and a bring a more professional focus to the Quality initiatives being undertaken at the time (Fragrance Ingredients Division). Postgraduate masters projects have been undertaken within the company and a research grant was provided by the company in 1995 to undertake an examination of the requirements for more integrated systems within the company.

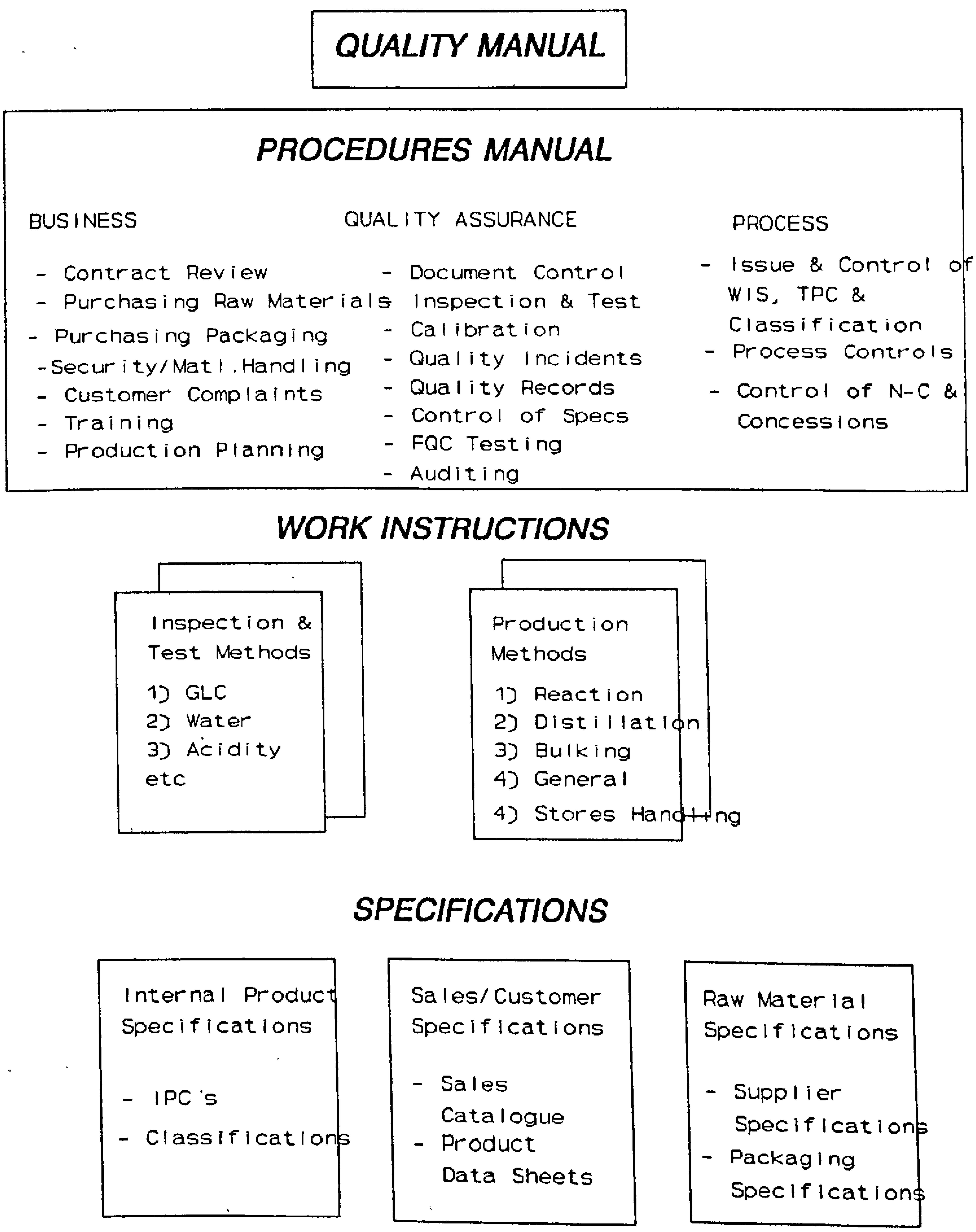
In recent years therefore, both divisions of IFF have been subjected to either external or internal pressures to demonstrate their effectiveness in managing Quality and developing approaches to support the product and process developments which are central to the business.

8.3.2. Case Study B - The Quality Development Orientation

The company's primary Quality objective is to manufacture products in accordance with the IFF international product coding system which defines the constituents and properties of every product supplied by the Group Worldwide. The Quality systems developed in both divisions to ensure the ongoing conformance to product specifications are shown in figure 8.3.

The company's Quality Systems were accredited in 1995 to ISO 9000: 1994 by the Lloyds Register of Quality Assurance. The major benefits derived from the adoption of a formalised Quality System for Company B have been from the system maintenance and review activities. The company has traditionally employed an informal and fragmented approach to Quality Assurance and the impact of the ISO 9000 based approach has been to 'close the loop' in which the systems employed are formally audited and therefore adhered to as described by Fox [40,1995]. This systems discipline has also had the effect of providing a mechanism for the 'capture' of system developments which can now be incorporated in the documented methods and procedures within the company rather than ad hoc amendments to informal practices. The Quality System specification and audit framework provided by the developments within Company B have also formed the basis of the company's future approach to other manufacturing systems developments in the areas of health and safety and also compliance with environmental standards such as BS 7750 [15,1992].

Figure 8.3.2 Quality Systems at case study B



In addition to the techniques associated Quality System design and maintenance the company have also begun to develop their approach to process control through the application of statistically based control charts. At present these statistical tools are used primarily to augment the process specification in controlling the stages of manufacture rather than to promote process improvement. The main organisational and cultural developments within the company have involved the increased management involvement in the maintenance of the Quality Management System and the increased involvement in the corrective actions required in response to non-conformances. The functional-based organisation structure remains although the company have re-engineered its approach to responding to customer complaints and for embodying the resultant recommendations into the procedures and work instructions. The primary measures of Quality performance employed by Company B are the external accreditation of the Quality System and the internal indicators including batch rejection rates customer complaint levels and the number of audit corrective actions in each of the operational areas.

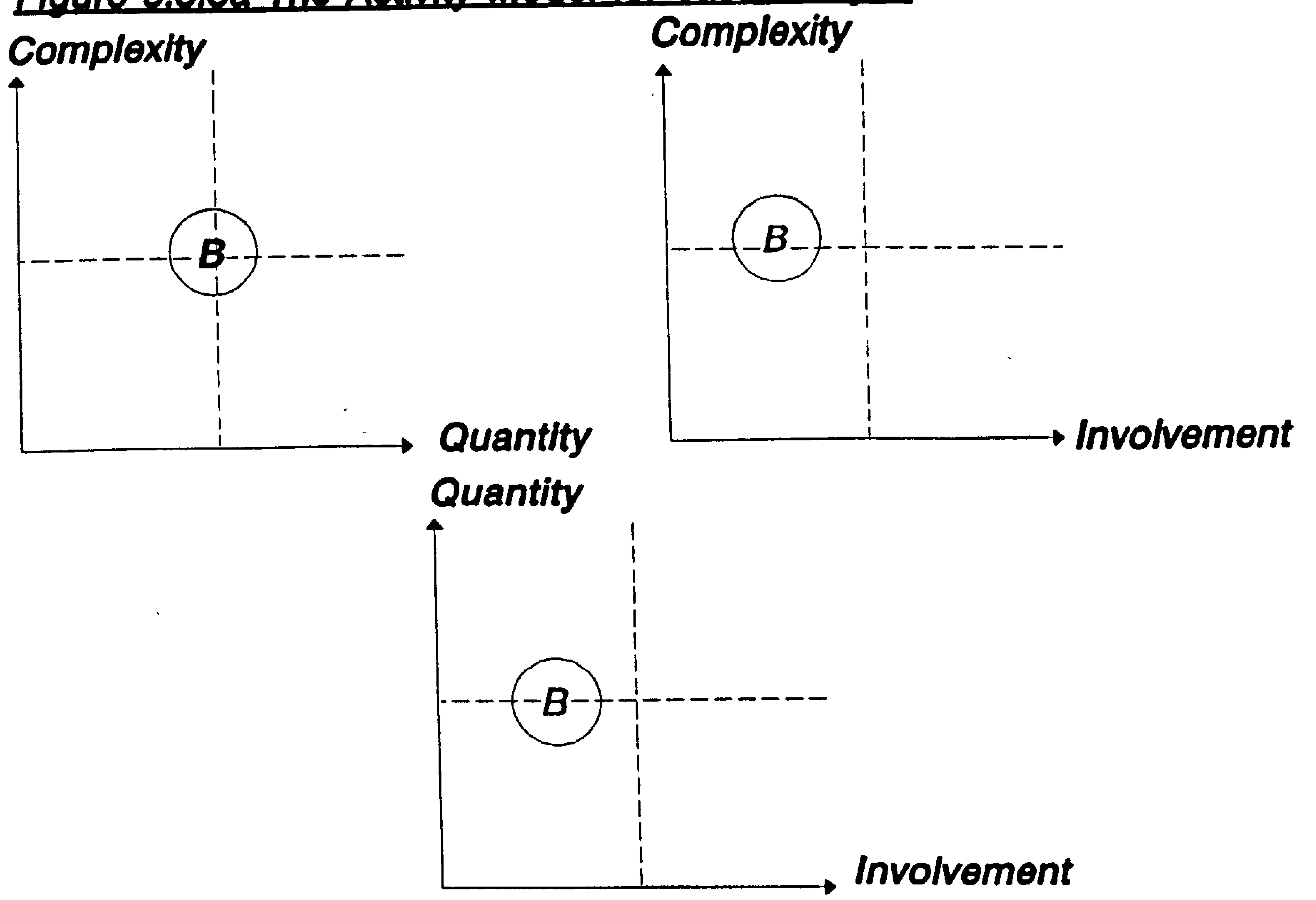
The overall emphasis of the approach of Company B is to ensure product conformance to international standards through the application of Quality assurance specifications and procedures. This level of development corresponds to the SYSTEMS orientation described in Chapter 4 above.

8.3.3. Case Study B - The Parametric Models

Company B, having been characterised as corresponding to a systems orientated approach to managing Quality was then modelled using each of the three parametric models.

The Activity Model representation of case study Company B is shown in figure 8.3.3.a.

Figure 8.3.3a The Activity Model for case study B

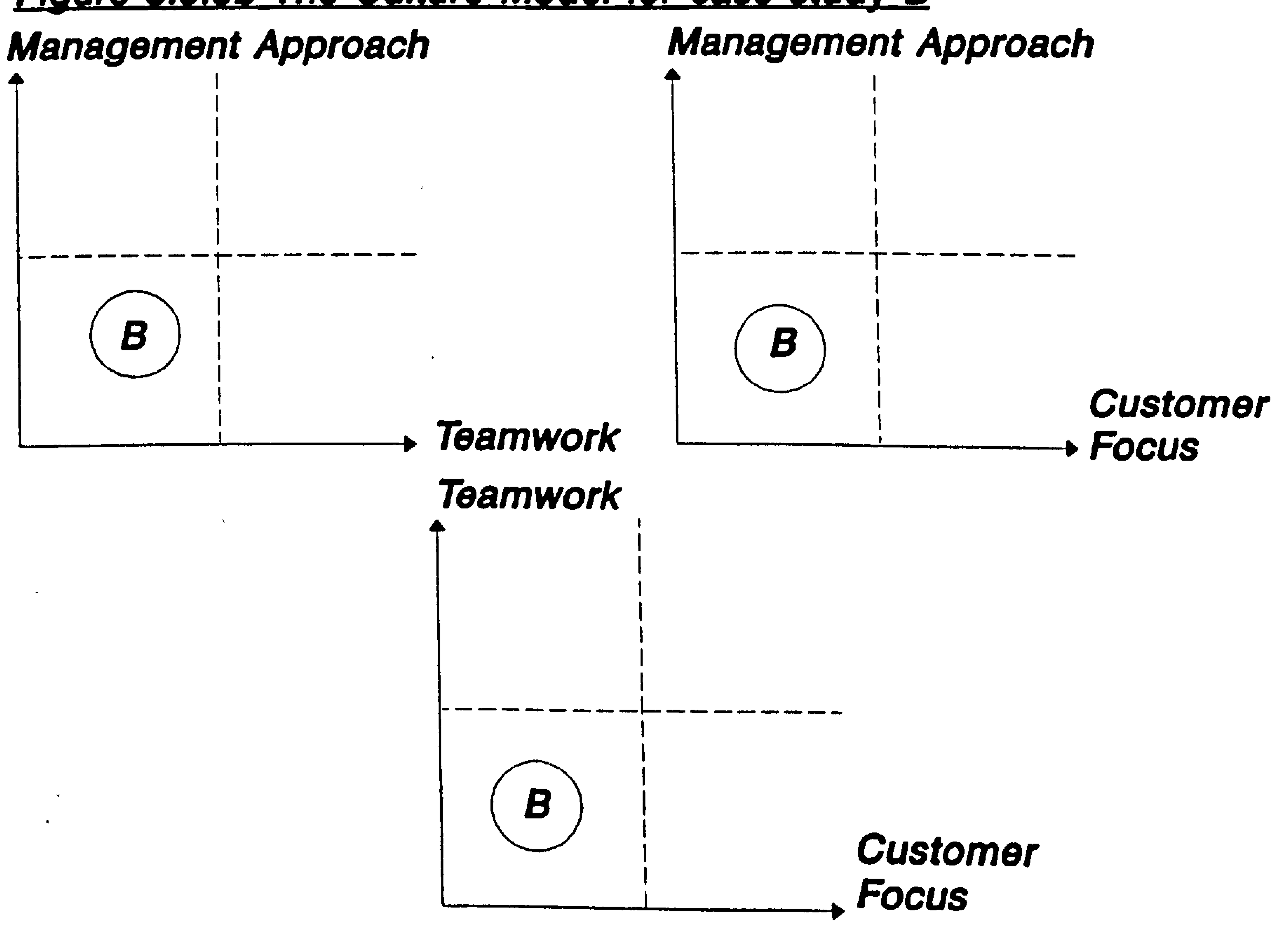


For complexity, Company B is positioned towards the mid-point of the axis as both ISO 9000 and the initial aspects of Statistical Process Control have been employed. Similarly the company are also positioned towards the mid-point of the quantity axis, employing five of the techniques evaluated in industrial survey 1 (Statistical sampling, Quality awareness programmes, internal audits, statistical process control and ISO

9000). For the third axis of the Activity Model company B are positioned in the lower quadrant with awareness programmes being the only mechanism for the widespread involvement of staff in the Quality developments taking place. To date the company have not used teamworking as a significant contributor to the Quality activities employed. The activity model shown in figure 8.3.3.a) shows Company B to be within the T1 (systems) domain but progressing towards the T2b (techniques orientated process improvements) transition.

The Culture Model for company B is shown in figure 8.3.3.b).

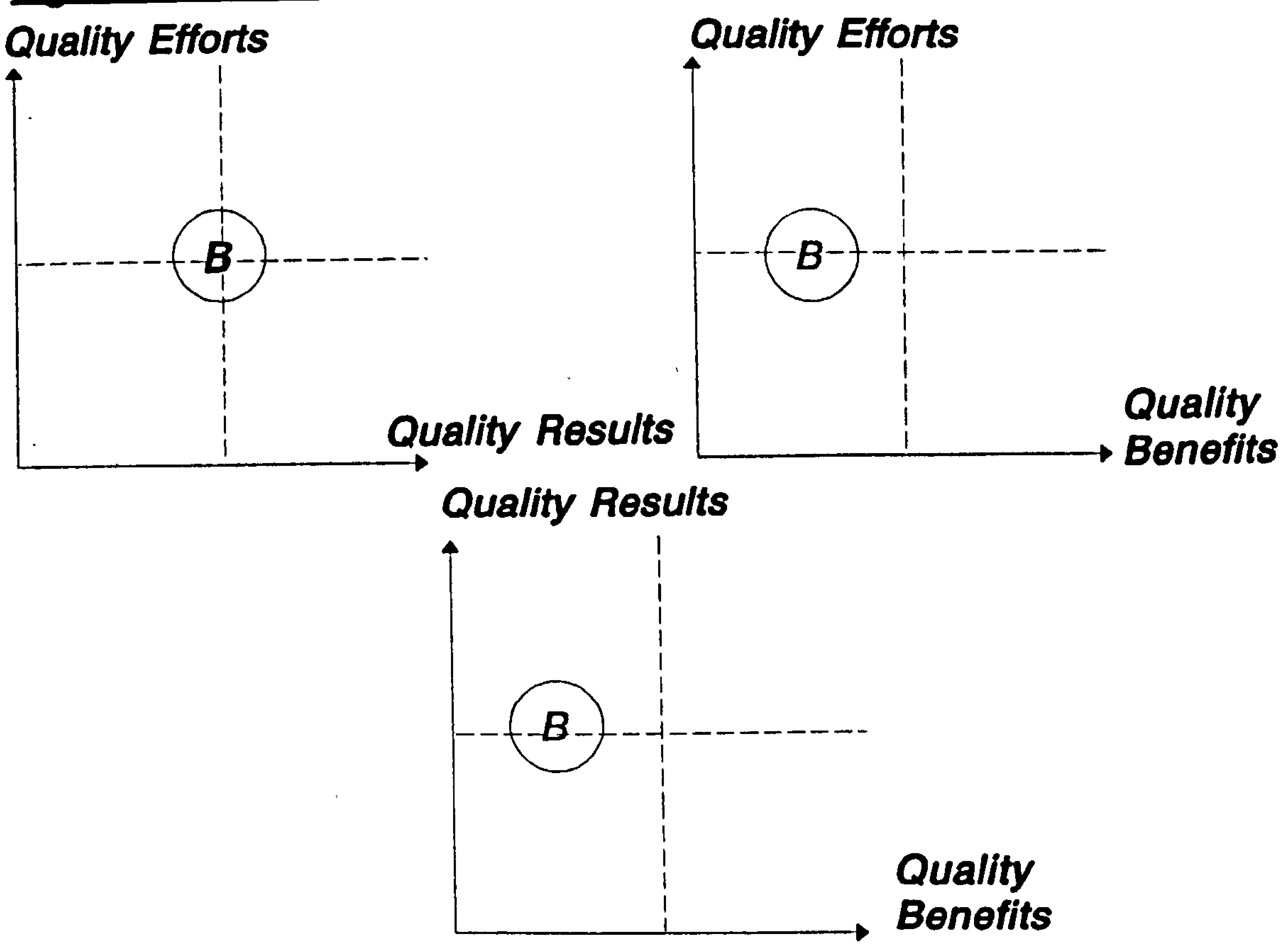
Figure 8.3.3b The Culture Model for case study B



The predominant management approach exhibited by company B is controlling and in terms of the factors used in section 6.3.2., the emphasis has been upon Quality System training for managers with rather uncoordinated attempts across the two divisions to integrate improvements and interactions. The management approach adopted by Company B positions it in the lower quadrant. Similarly the absence of their deployed or voluntary teams and the use only of staff Quality briefing sessions positions the company in the lower quadrant in the teamworking dimension. Finally the customer orientation exhibited by Company B also indicates a position in the lower quadrant with the focus being upon regular sales visits and some limited improvements at the customer complaints interface with little or no emphasis upon external customer relationships and little formal involvement of the customer in product or process developments. To some extent the customer orientation of Company B is distorted by the fact that the primary customer for the Fragrance Ingredients division's products are (internal) affiliates of the IFF corporation. The key indicator here though is that the affiliates are primarily perceived as colleagues within the IFF group rather than as customers. With the Flavours Division a responsive culture exists in terms of new product developments for customers rather than a preventative approach as outline in Chapter 4. Overall, the Culture Model depicts Company B as being within the T1 (systems) domain.

The Measurement Model for company B is shown in figure 8.3.3.c).

Figure 8.3.3c The Measurement Model for case study B



In terms of the Quality efforts dimension of the Measurement Model, company B are positioned towards the mid-point having established a formal Quality policy and procedural framework and also having a coordinated approach to Quality training not only in terms of the organisational level at which the training is deployed, but also covering systems awareness, auditing and development issues. The results of these efforts also positions the company at the mid point of the grid as the company have not only achieved ISO 9000 certification but have also enjoyed comparative improvements in both product and process performance. The international reputation of the divisions is not yet perceived to be market leader in terms of Quality.

The business benefits accruing from the Quality developments within the company remain rather limited, however and position Company B in the lower quadrant in the benefits dimension. Some reduction in the cost of managing Quality has occurred but competitive performance and increased market share or customer loyalty has not been forthcoming. The company have made some preliminary progress in terms of measurably improved levels of customer satisfaction (through making it easier for customers to complain) also this has not been converted into increased market returns due to the threshold effect identified by Sasser and Jones [95,1995] in which increased loyalty is generated only when customers reach a level of satisfaction corresponding to 'delight'. Overall the Measurement Model also depicts the company within the systems domain but the relevant transition is the T1b state in which limited improvement in the Quality results is in evidence.

An assessment of Case Study Company B based on all three parametric views illustrates the company to be a systems orientated company with a commitment to further quality development having made the initial steps towards improvement from a techniques base.

8.3.4. Case Study B - Summary

The overall orientation of the level of Quality development achieved by Company corresponds to the systems classification proposed in Chapter 4. The company has traditionally based its competitive advantage upon a unique range of products and processes developed within the IFF group. The internal competition due to the rationalisation of worldwide production facilities and the external pressures due to competitor advances have been reflected in terms of the commitment to further Quality development.

As with case study Company A, Company B also exhibits a systems classification based upon the three parametric models although the primary focus at company B is to achieve a transition towards becoming a Quality improvement orientated organisation. The theoretical framework proposed in this thesis identifies clearly the main developmental challenges facing company B, namely the development of a more team based approach and an increased customer orientated culture.

8.4. Case Study C - Burtons Biscuits Limited

8.4.1 Case Study C - Background

Burtons Biscuits Limited are a group company of Associated British Foods Limited and operate at three major manufacturing sites in the U.K. (Blackpool, Edinburgh and Llantarnam) with a Head Office based at Bracknell. Burtons Biscuits employ approximately 2000 people in the U.K. with a current turnover of around £120M.

The main product groups are:

- biscuits including both branded and own label products
- snacks, primarily starch based
- confectionery including both liquorice and gelatine based products

In most of its market sectors, Burtons Biscuits is either second or third in terms of market share with an overall proportion of the U.K. biscuit and snacks market of approximately 14%. Growth in both market share and profitability has been significant in recent years due to two major developments in the U.K. food retailing sector. Firstly, since the early 1980's food retailing in the U.K. has become dominated by a relatively small number of extremely powerful retail groups. These retailers have increasingly sought to compete on a market perception of Quality and have been in a position to impose ever more stringent Quality requirements and performance levels on suppliers. In order to compete in the commodity food products sector where margins are volume based, then the major retailers need to be seen as essential customers whose requirements are paramount. Secondly, related to the restructuring of the retail market, the demand for own label products has increased dramatically from around 15% of the market in 1980 to around 40% in 1994.

These market developments have created an extremely competitive environment in which the Quality performance of the products and service levels have been at the forefront of competition. The main quality challenge to the company in the late 1980's was to establish a high degree of product consistency across the range. The main challenges of the 1990's have been to improve the customer service levels and this is seen as the primary determinant to market share for a particular product group. Additionally the increased level of food safety regulatory requirements from the U.K. and EU authorities and the implications of the consumer protection legislation have required a much more professional approach to Quality management to be adopted.

The biscuits manufacturing process is primarily a large batch processing operation with the products being mixed, formed, baked and packed in an in-line sequence. The company is product led and is unable to sustain market share solely through the strong brand position enjoyed by the market leader (United Biscuits). The scope for innovative product development is limited by the extremely high capital costs and most of the new products introduced into the marketplace are adaptations of existing products.

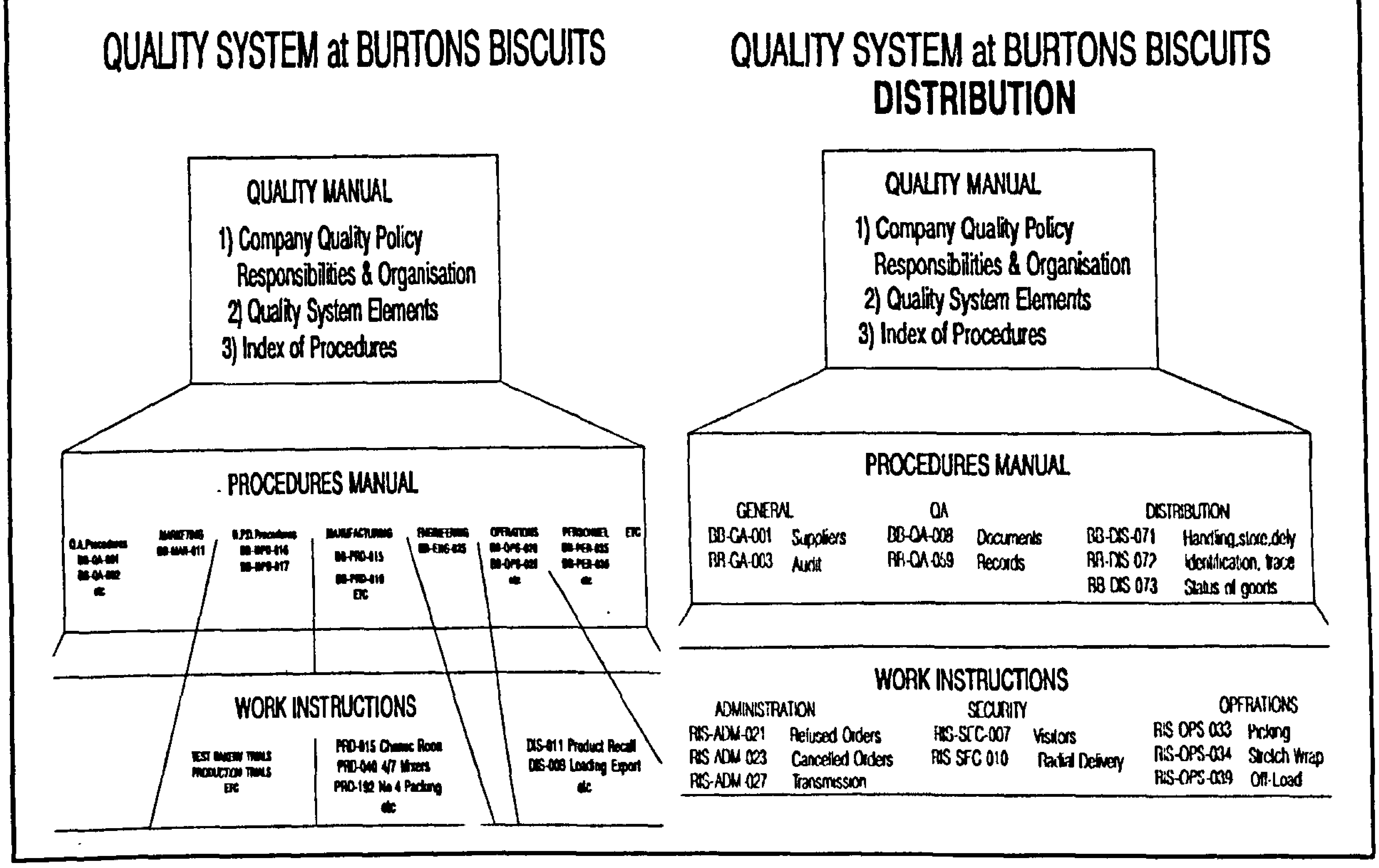
The sequence of strategic Quality developments has involved an emphasis initially upon the manufacturing area with focus upon product consistency and then to the business supply chain to enhance the customer service levels. The business success of this strategy in what is seen as an extremely tough commercial environment has fuelled the commitment to a culture of progress through Quality.

Collaboration with the University began in 1988 with support for the Quality Assurance developments within the business and this was formalised into a major collaborative programme funded by the Teaching Company Directorate which commenced in 1992. Collaborative projects have included the development of a Hazard analysis and Critical Control Point (HACCP) methodology for the company to assist in the identification and audit of food safety issues, the implementation of statistical process control, the implementation of preventative maintenance systems and finally the development of a computer based finite scheduling system. Each of the Teaching Company associates was also involved in the support of the company's Total Quality Initiative which was launched at the beginning of 1991. In addition to the Teaching Company programme two MSc (Eng) projects have been undertaken to develop improved product information systems within the company as described in Kehoe and Greig [62,1995].

8.4.2. Case Study C - The Quality Development Orientation

The company's stated Quality objectives are to provide products which conform to laid down specification or to agreed customer requirements and to provide industry sector leadership in terms of customer service levels. To achieve improved groupwide product consistency, the company established Quality systems across all the manufacturing divisions conforming to the Part 1 requirements of BS 5750 (ISO 9001). To achieve greater service consistency the company also implemented Part 2 Quality Systems across the product distribution network and both systems are illustrated in figure 8.4.2.a).

Figure 8.4.2a Quality Systems at case study C



The Quality Systems within the manufacturing divisions were accredited during 1989/90 to BS 5750 : Part 1 (1987) (now BS EN ISO 9001 : 1994) by the Lloyds Register of Quality Assurance (LRQA) and became not only the first biscuit manufacturer in the U.K. to be accredited to the National Quality System Standard but also one of the very first food companies to be assessed against Part 1 of the standard. The distribution organisation was accredited to Part 2 of the standards in 1991, again by LRQA.

The adoption of a more formal Quality Assurance rather than Quality Control approach had a major impact in a number of areas of product Quality. Improved raw material and packaging specifications together with formal vendor assessment programmes improved significantly the consistency of incoming materials. Process specifications and audits improved the control of the biscuit manufacturing lines and in particular led to greater repeatability of the new products introduced by the company. Formalising the marketing and new product feasibility process also led to a more efficient packaging development process for new products through the clear specification of packaging data at an earlier stage in the development process.

The market success enjoyed by the company in the late 1980's and early 1990's was clearly attributable to the Quality developments that had been made and this connection was identified by both senior managers within the business and also by customers. The transition made by the company during this period is characteristic of the development of a systems orientation described in Chapter 4. The main tools and techniques employed were Quality Systems based and the culture change was limited in terms of organisational structure and management approach but important in terms of establishing the foundations for further development. The systems orientated development achieved by the company was used by senior managers to promote the importance of Quality management both downwards to all operators and staff and also upward to the Burtons Biscuits board of directors.

In the early 1990's market conditions deteriorated as major food retailers in the U.K. competed for market share and as the market sector leader and other competitors in the biscuit/snacks sector began to emulate the Quality System developments achieved by case study Company C. The lack of long term Quality competitive advantage from achieving the systems stage of development became apparent to Company C together with the limitations in terms of the impact of the Quality System upon the effectiveness of the supply chain to deliver improved levels of customer service. The launch of the Total quality initiative in 1991 was intended to further develop Quality management within the business and to meet the market challenge facing the company.

The primary objectives for the second stage of Quality development within Company C were the deployment of the business objectives of improved customer service and increased process efficiency (yield). This was to be achieved through the identification of a range of improvement projects each contributing to the overall business objectives. To improve the customer service processes within the business a number of cross-functional Quality improvement teams were established to work on specific improvements designed to contribute to the overall service objectives. Process improvement teams were also set up in the manufacturing areas together with process improvement engineers responsible for the implementation of statistical process control for key biscuit characteristics such as size, coating quantities and level of baking. The company trained team members in basic problem solving tools such as pareto analysis, cause and effect diagrams, run charts and scatter diagrams and developed a structured problem solving methodology which was employed using trained facilitators. The company used Belbin techniques to determine the team roles of individual managers and to select improvement team members. The problem solving methodology and team profiles for case study company C are shown in figure 8.4.2.b).

Figure 8.4.2b Team methodology and roles at case study C

Burtons Biscuits Problem Solving Methodology

STAGE 1 - Problem Identification

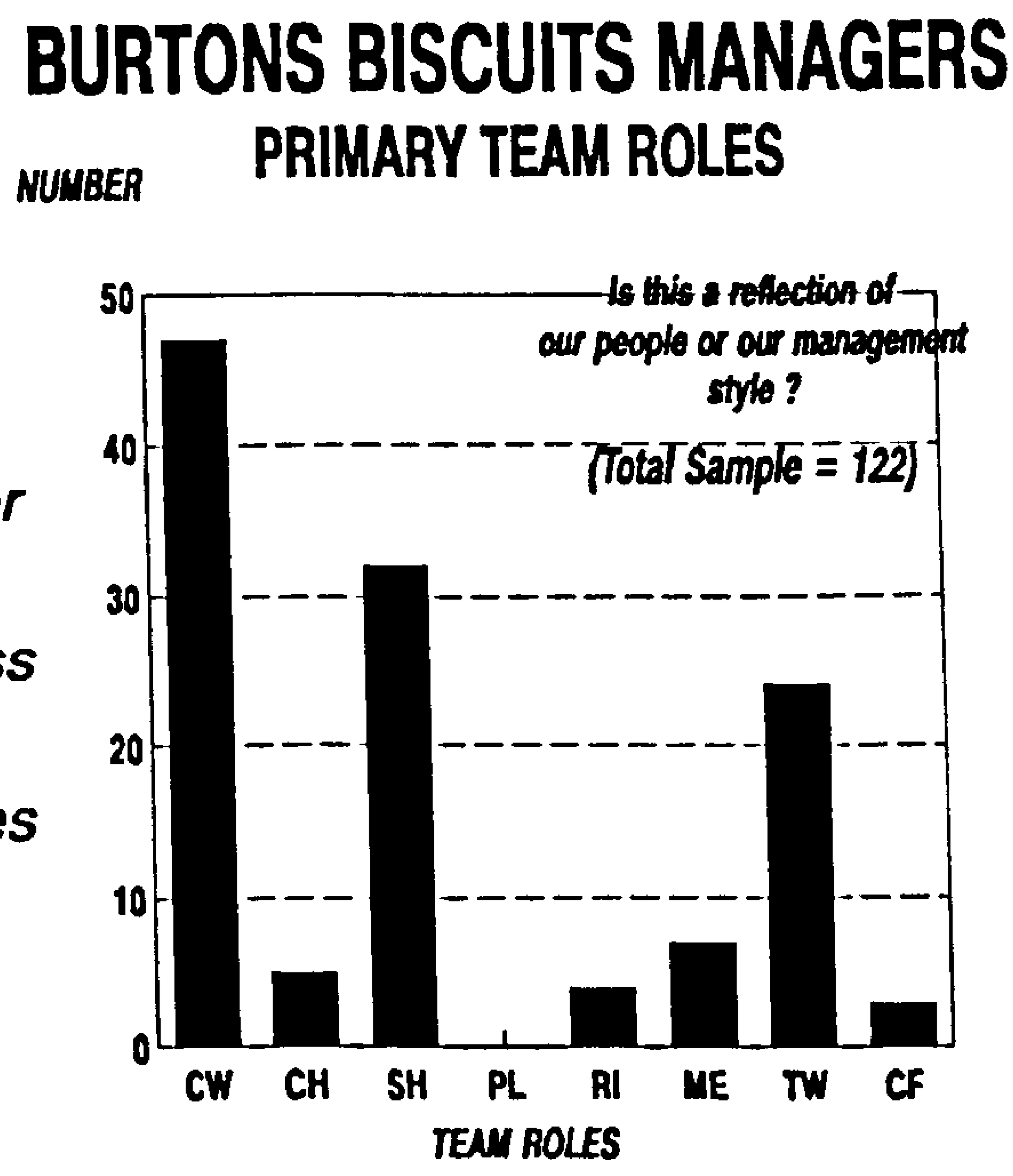
STAGE 2 - Appoint Team & Leader

STAGE 3 - Define Problem Process

STAGE 4 - Determine Root Causes

STAGE 5 - Propose Solutions

STAGE 6 - Monitor Progress



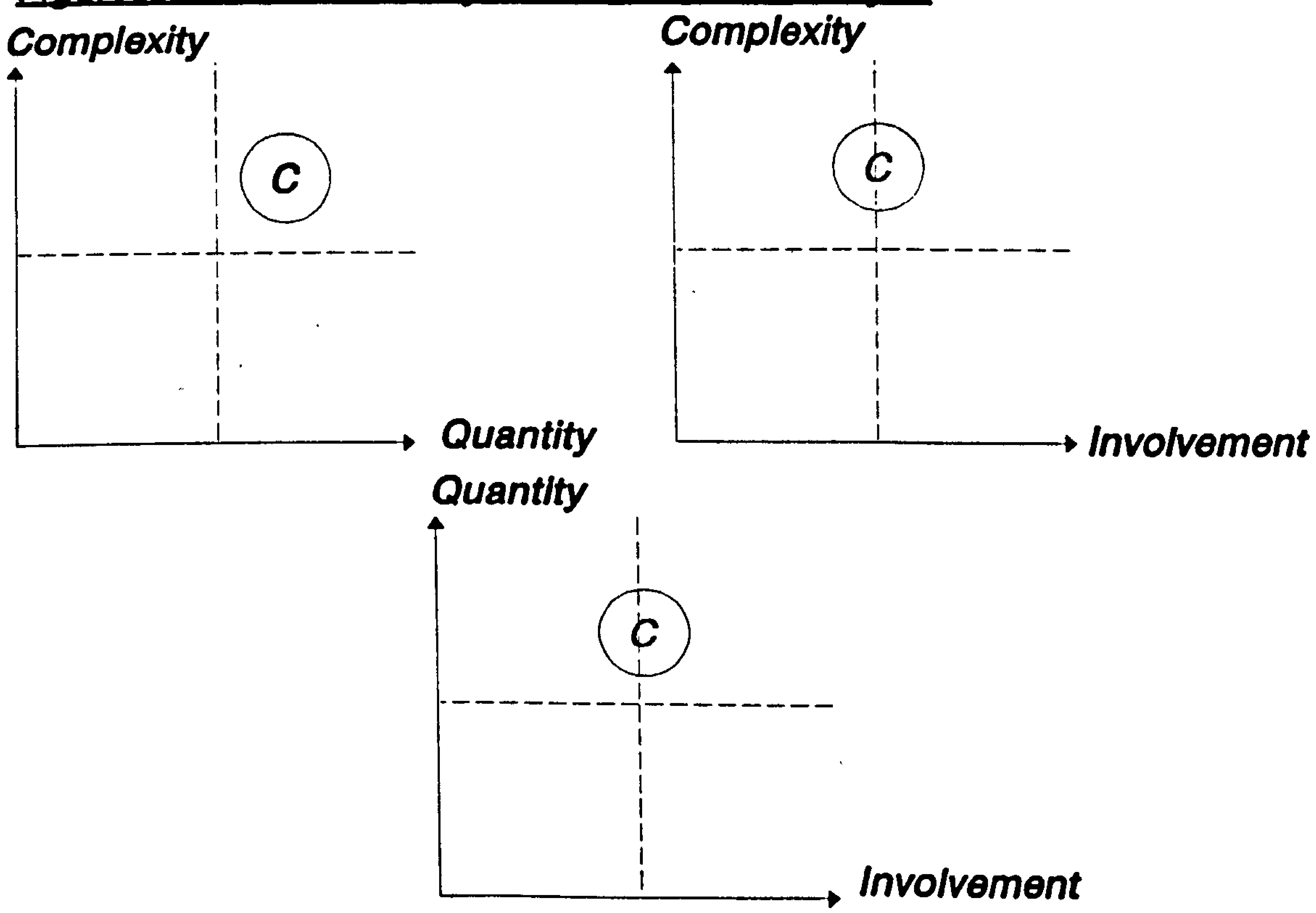
The primary Quality measures employed during this period were process capabilities, process yields (measured in terms of turn of scale error), customer returns, customer service levels (measured in terms of order completions) and the cost of Quality. the company's management approach became measurement orientated with a matrix of measures being generated to reflect progress towards the business objectives. Overall the Quality management approach adopted by company C corresponds to the **improvement** orientation described in Chapter 4, having undergone a transition from a systems orientation.

8.4.3. Case Study C - The Parametric Models

The characterisation of company C as an improvement orientated organisation was then examined in more detail using the parametric models of development.

The Activity Model representation of case study Company C is shown in figure 8.4.3.a).

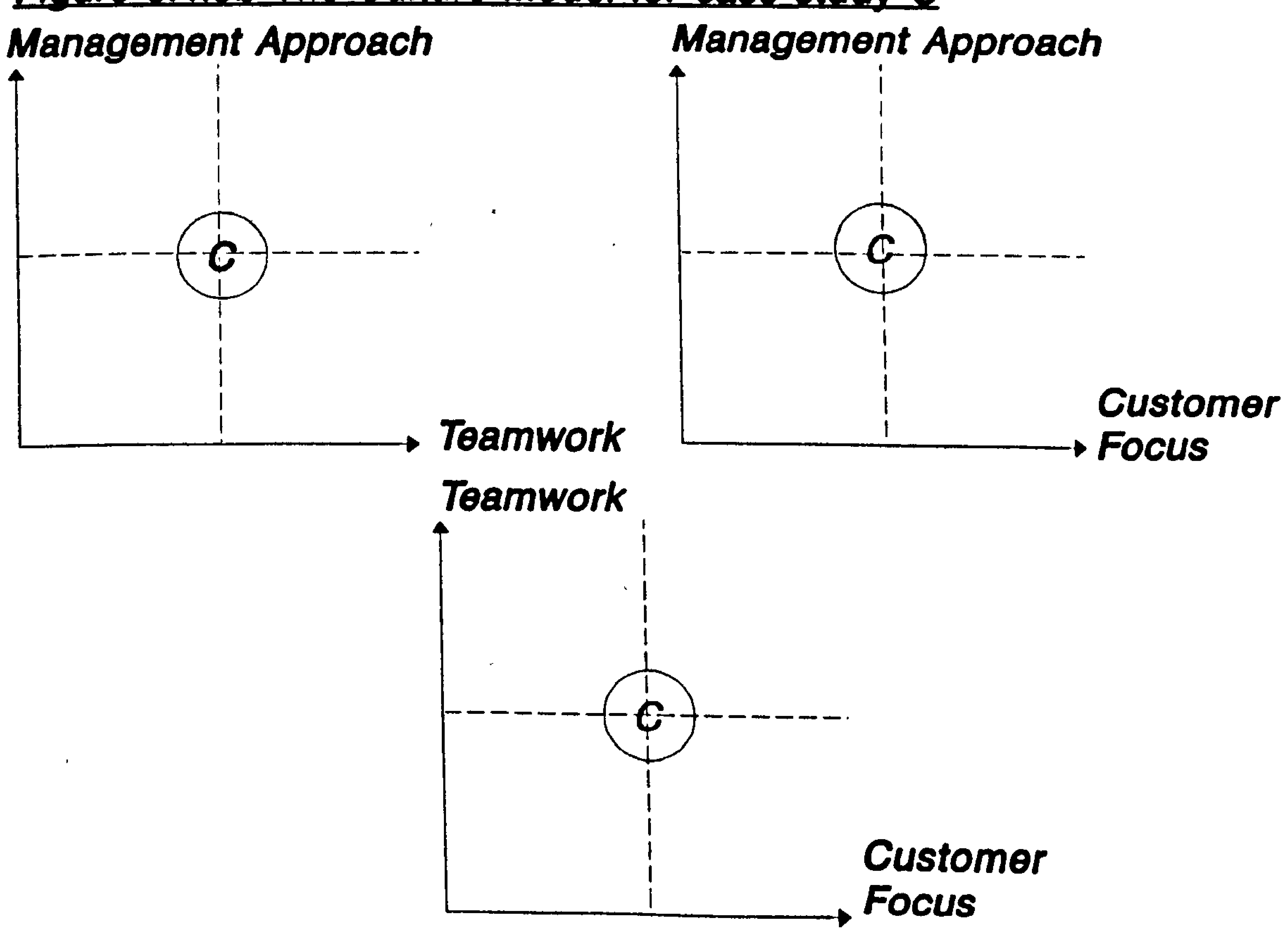
Figure 8.4.3a The Activity Model for case study C



For the complexity dimension, Company C is positioned in the upper quadrant as the company employs ISO 9000, statistical process controls and a food industry version of FMEA (HACCP). In terms of the quantity axis the company employs seven of the activities evaluated in industrial survey 1 (problem solving, Quality awareness programmes, delegated teams, internal audits, statistical process control, Quality costs, BS 5750 / ISO 9000) which again positions the company above the axis mid-point. For the third axis, Company C have involved employees through awareness programmes and has used delegated teams although there has been little application of voluntary improvement teams. The company are therefore positioned at the mid-point of the involvement axis. The Activity Model positions Company C within the T2b domain (improvement) with the company progressing towards the T2a transition with an increased emphasis upon team based activities.

The Culture Model for company C is shown in figure 8.4.3.b).

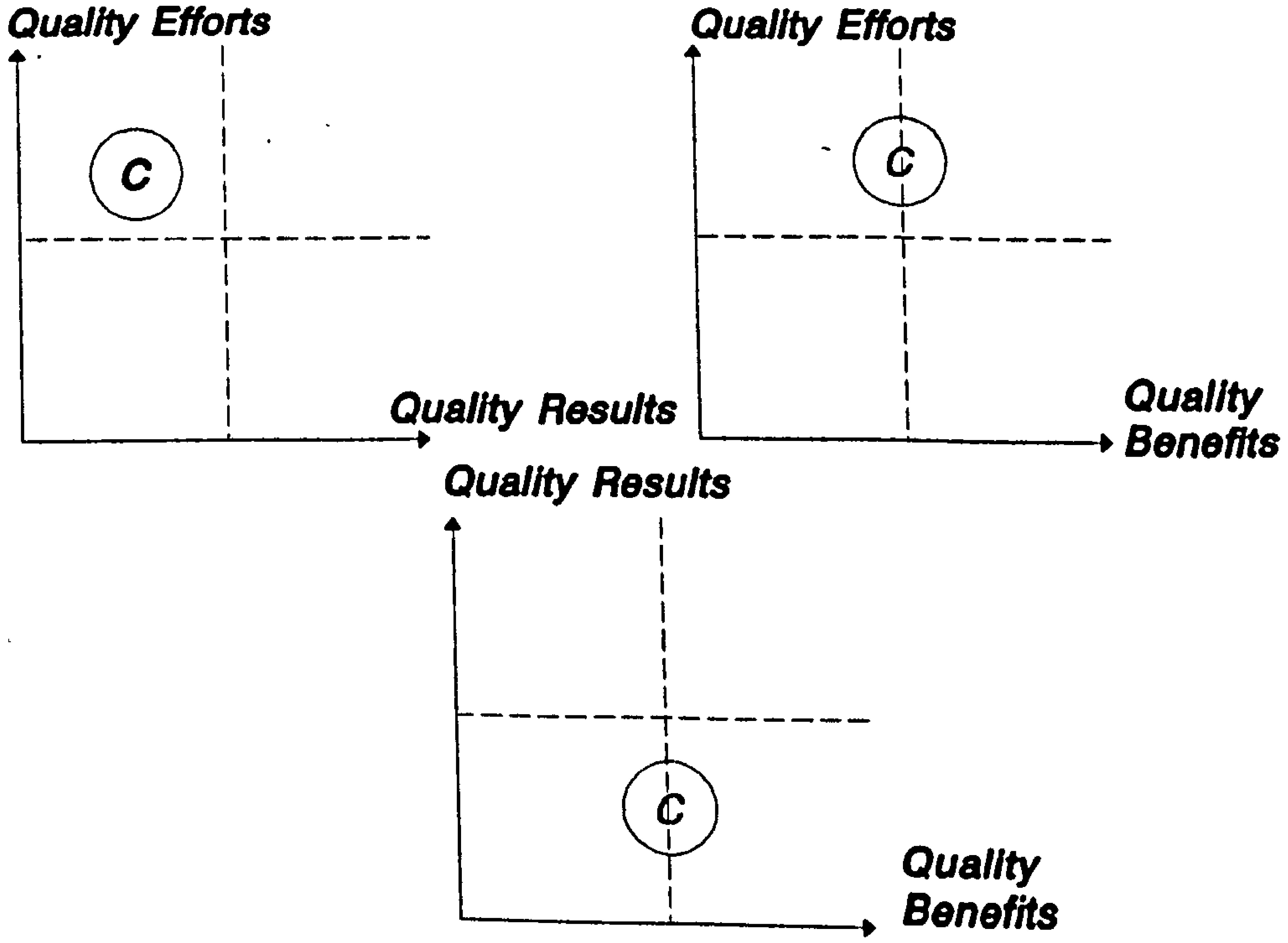
Figure 8.4.3b The Culture Model for case study C



The Quality culture exhibited by Company C characterises the transitions which organisations undergo as they move from a controlling, functional approach to an empowered, team-based approach to Quality. The predominant management approach parameter positions Company C at the mid-point with both training and improvement change agents employed. Similarly the company is positioned at the mid-point of the teamworking axis with delegated teams employed but not having extended the culture to voluntary teamworking.

The customer orientation of Company C is somewhat distorted by the market domination of a relatively few customers. In addition to regular contact from account managers, Company C also monitors service level performance through customer surveys although customers do not participate actively in the product or process development processes. The customer focus parameter positions the company at the mid-point of the axis. The Culture Model positions Company C in the T2 (improvement) domain.

Figure 8.4.3c The Measurement Model for case study C



The developmental efforts made by case study company C to employ quality management techniques is reflected in their positioning in the upper quadrant of the efforts axis. In addition to policy and training efforts the company has also focused considerable organisational resource onto improving the customer service supply chain. The results achieved by Company C have been rather limited with accreditation to ISO 9000 representing the most significant Quality related result. The company's comparative performance in product and process terms is not known and due to the impact of brand perception, the company have not established a market lead for Quality. The results axis positions the company in the lower quadrant. The business benefits have included improvements in the cost of Quality and selective improvements in market position due to Quality. In terms of the business benefits axis, the company is positioned at the mid-point of the axis. Company C is therefore classified through the Measurement Model as being in the T2 (improvement internal processes) domain.

Overall the three parametric models depict company C as classically an improvement orientated organisation with an emphasis upon a problem solving approach to process and supply chain improvements. Although the company have included the design process within the scope of the ISO 9000 Quality system, the prevention orientated approaches to product and process design, have not been emphasised to date and are not formally part of the management culture.

8.4.4. Case Study C - Summary

The overall orientation of Company C corresponds in the improvement stage of Quality development proposed in this research. The company has achieved significant progress through the adoption of Quality management methods and techniques and Quality development is seen by the organisation's senior managers as a route to business improvement. Competition on Quality and service has been established by the major customers as the basis of the market sector.

The three parametric models confirm the improvement orientation of Company C with the emphasis upon techniques-based, deployed improvement teams. The regeneration of the Quality developments within the company now requires greater customer focus and further empowerment of employees.

8.5 Case Study D - Castrol UK Ltd

8.5.1. Case Study D - Background

Castrol UK Ltd are a member of the international Burmah Castrol group of companies and operate at two major manufacturing sites in the UK (Stanlow and Hyde) and have their head office at the international headquarters at Swindon. Castrol UK employ approximately 1,100 people in the UK with a turnover of approximately £110M.

The main product groupings are:

- lubricant oils including natural and synthetic oils used primarily for engine lubrication.
- greases including both light and heavy grades.
- industrial lubricants for use in the machine tool and wire drawing industries.

Castrol UK are the leading specialist lubricant manufacturer in the UK and the GTX brand is the leading engine oil with approximately 20% of the market. Castrol's major competitors however, include international oil (refining) companies such as Shell and BP and the company had traditionally maintained its market lead through a customer perception of product Quality. The increase during the 1980's of the large UK DIY retail chains led to intense competition from own label products which were manufactured to standards lubricant specifications and sold at significantly lower prices. In order to maintain the Castrol reputation for Quality the company made Quality development the primary business objective.

The lubricant manufacturing process is primarily a batch chemical blending operation in which the product is blended from bulk oils and additives and packaged in-line into either packs, drums or bulk tankers. Increasing environmental legislation during the late 1980's also required the company to re-process waste oils and to re-claim packaging materials.

The customer base for Castrol UK consists primarily of major industrial companies, major retailers and motor servicing organisations. The pressures for Quality development came initially from the industrial sector with customers such as Ford, Jaguar and Rover demanding evidence of Quality assurance from suppliers in the mid 1980's. By 1990 Castrol were under pressure in almost all markets to improve both product and service Quality and internally were required to reduce the cost of Quality to bring business performance in line with their european Castrol counterparts.

Collaboration with the University began in 1990 with a request from the senior managers at the Stanlow site to provide Total Quality awareness training for managers. This programme was extended in 1991 with a major collaborative project between the company and the Quality and Reliability Research centre at the University led by the author.

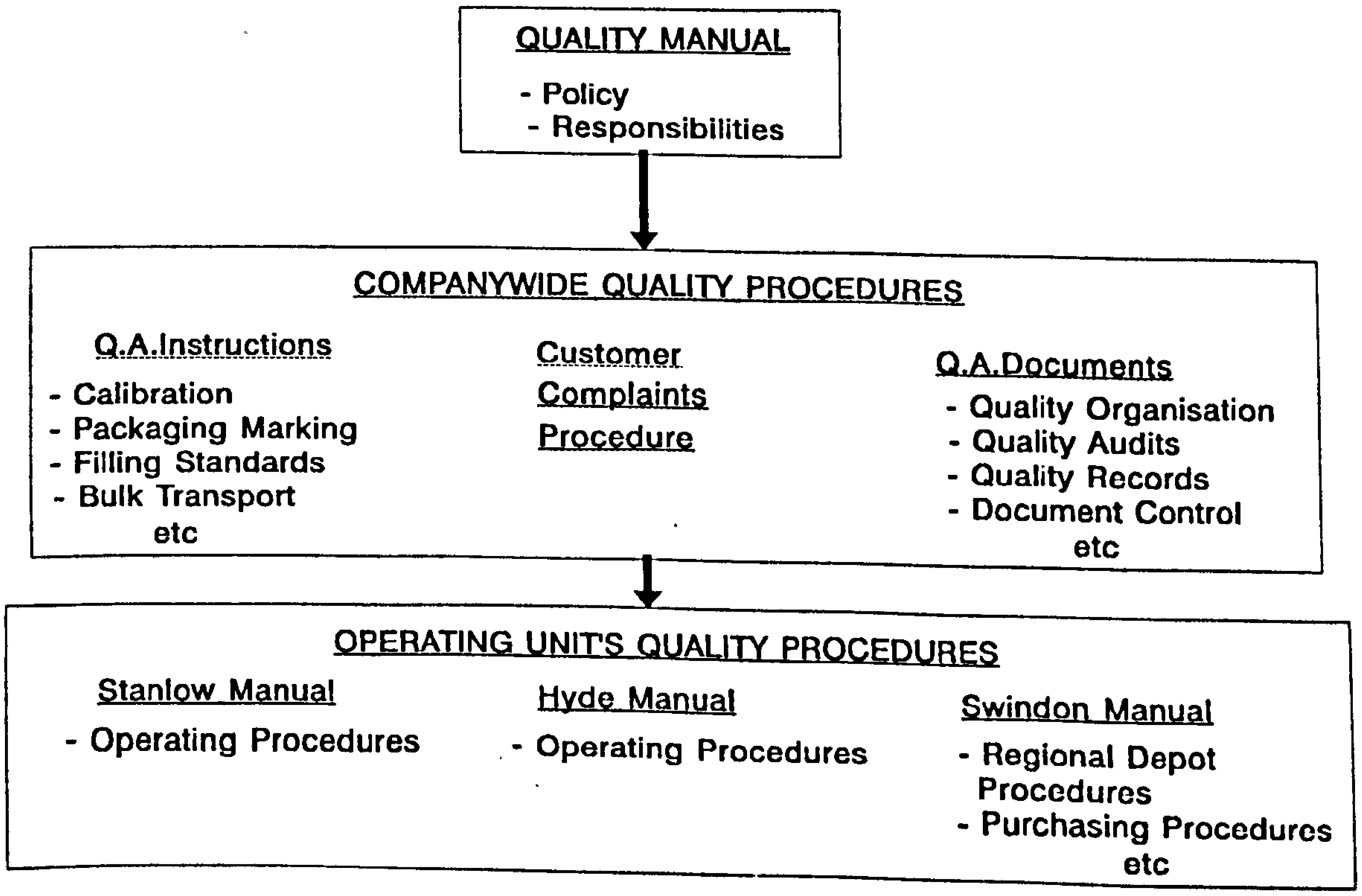
The primary driver for the Quality programme developed in conjunction with the University was the appointment of a new UK Chief Executive who had experienced the business benefits of Quality improvement during a period as head of Castrol's operations in Singapore. The research collaboration undertook to develop a Quality improvement framework for the company which addressed the organisational, methods, techniques and training issues. The programme, entitled Quality, Productivity and Service (QPS) was structured in terms of a steering group (comprising executive managers), site steering committees and deployed QPS teams.

8.5.2 Case Study D - Quality Development Orientation

During the late 1980's the company's stated objective was to meet the requirements and to work in partnership with customers. The primary mechanism for delivering these objectives was the implementation of BS 5750 : Part 2 (ISO 9002) and Castrol UK was accredited in 1989 based upon the Quality system illustrated in figure 8.5.2.a).

Figure 8.5.2a Quality System at case study D

QUALITY SYSTEM AT CASTROL UK LTD

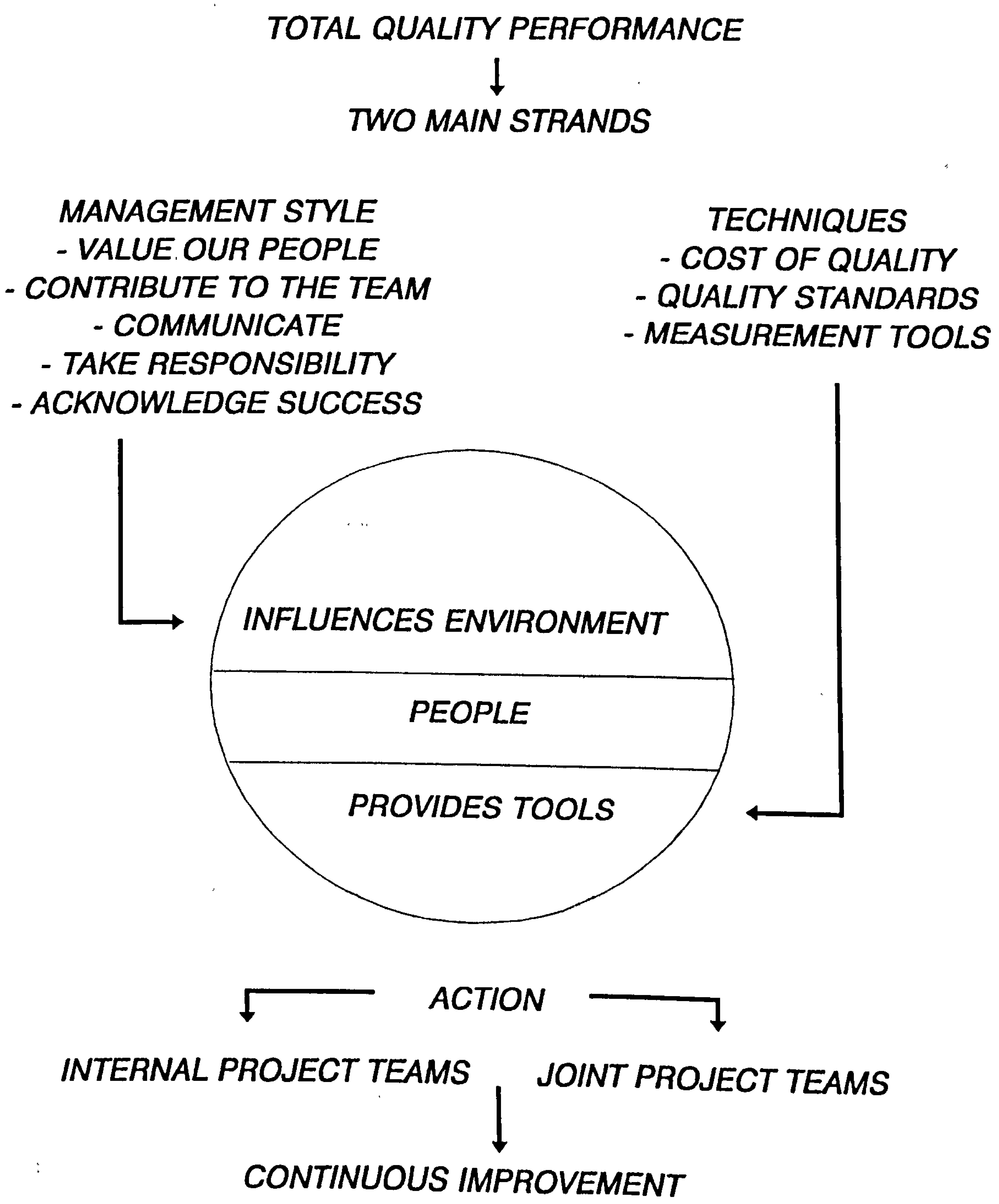


The Quality system developments within the company were perceived by the senior management team as primarily a defensive strategy in meeting the vendor Quality assurance demands of customers such as the Rover group. As market leader for Quality the systems developments undertaken to achieve BS 5750 accreditation did not provide significant market advantage in terms of reputation nor did the Quality management system provide improvements in internal operational Quality performance. This period of development within the company was characteristic of the **systems** orientation described in Chapter 4 with the main tools employed being Quality systems implementation and the culture changes being limited to the defining of responsibilities and Quality assurance training.

The benefits from developing a systems orientation were rather limited for Company D and it was the frustration over the limited gains achieved that encouraged the company to seek further Quality development. The company faced a position in the early 1990's where it sought to position it's products in the marketplace as premium, high Quality lubricants but externally appeared to be manufacturing 'standard' products using a system equivalent to its competitors.

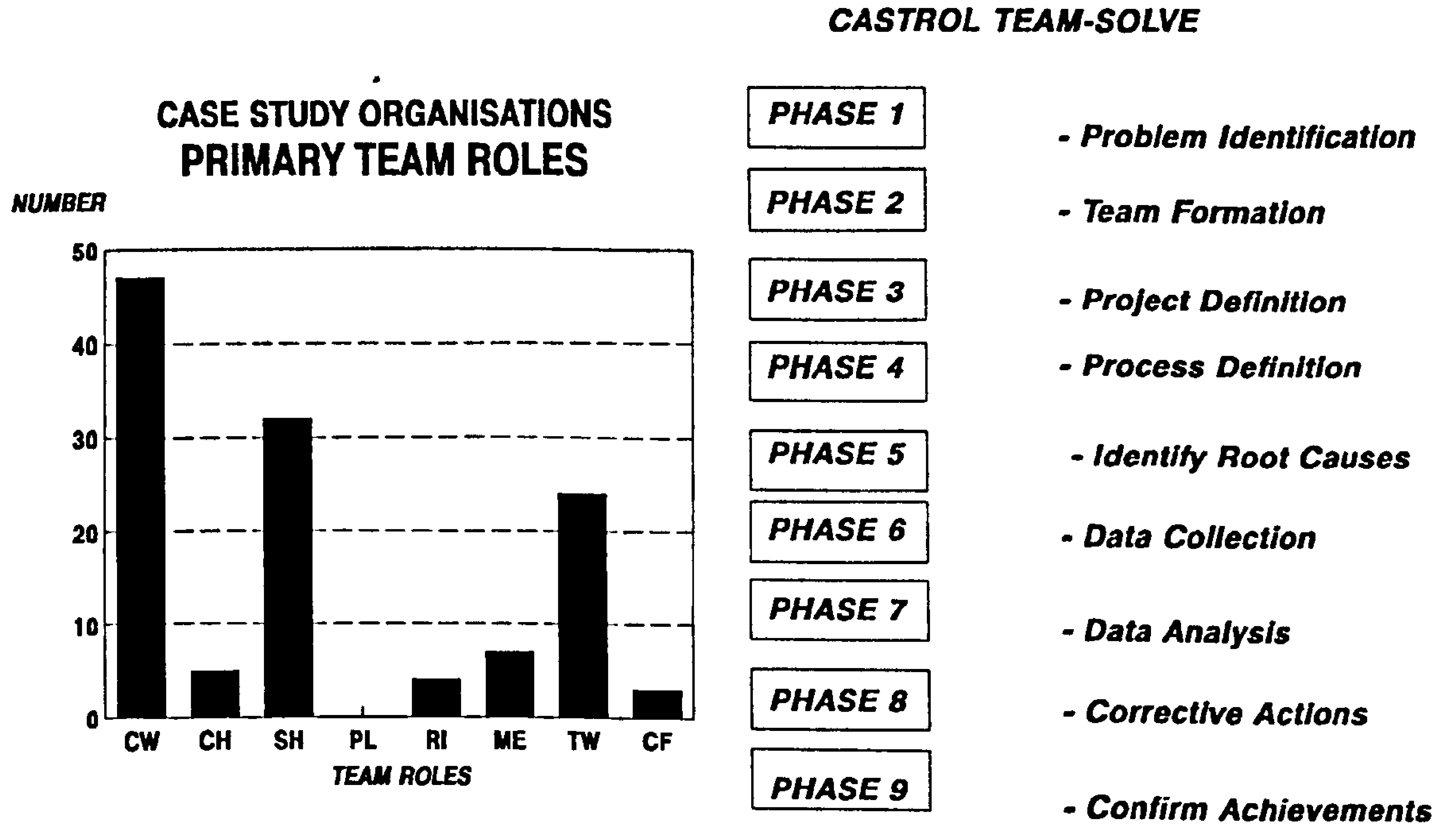
The second phase of development began in 1991 with the launch of the QPS programme. The QPS steering group was established under the chairmanship of the Chief Executive and the programme mission was to develop 'an approach to producing good services which continually meet the customer's requirements and involves everyone in an integrated effort for improvement'. The QPS process developed in conjunction with the University had two main components, one addressing the change in management style required and the second providing the tools and techniques of Quality improvement as shown in Figure 8.5.2.b).

Figure 8.5.2b The QPS process at case study D



Teamwork was central to the QPS process at Company D and the company employed team role profiling techniques and problem solving methodologies as illustrated in Figure 8.5.2.c).

Figure 8.5.2c Team roles and problem solving methodology at case study D

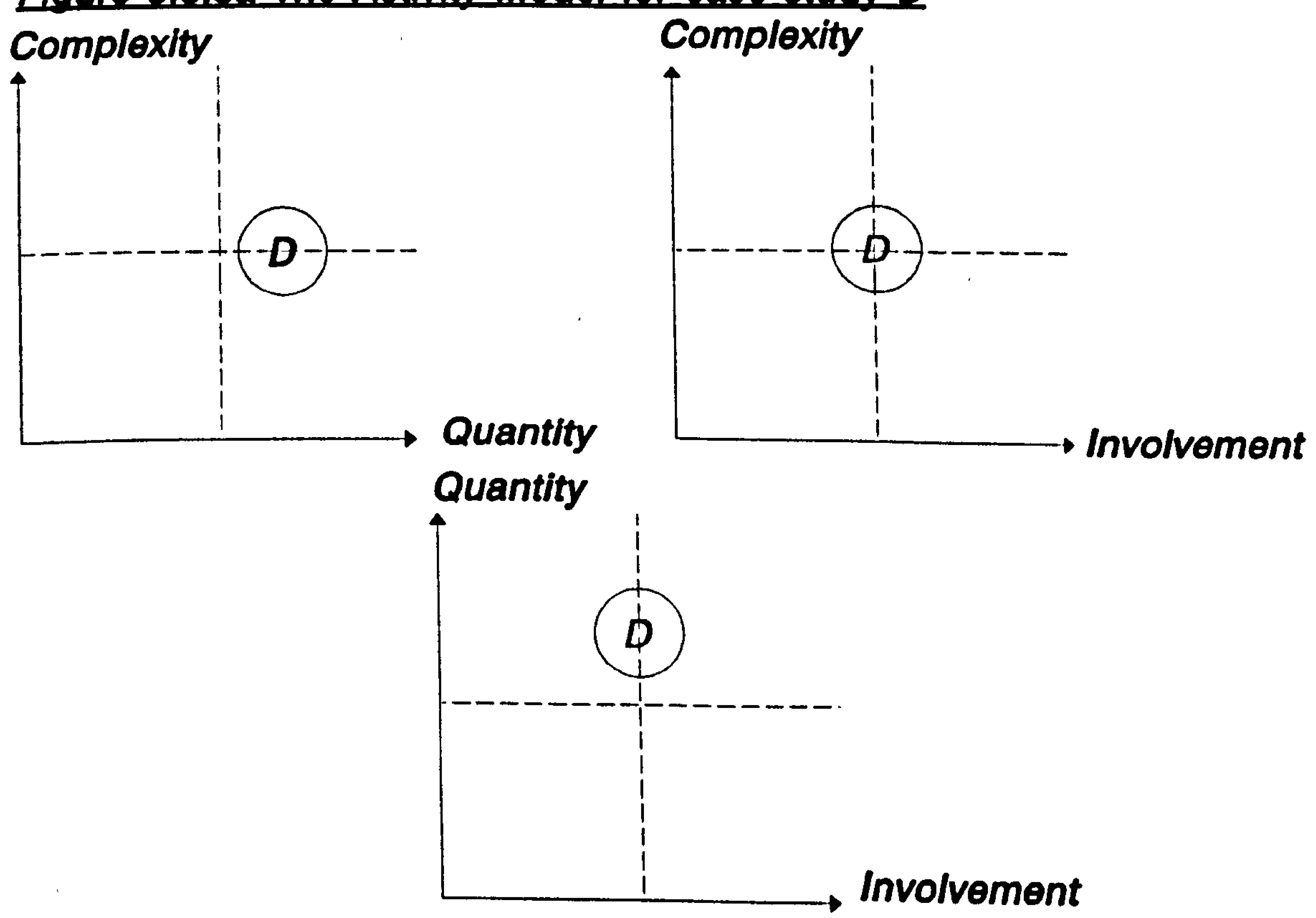


Two key elements of the QPS process were team facilitation and measures deployment. The company developed a formalised approach to team facilitation which is described in Haynes and Kehoe [45,1991] and involved the formal specification of the facilitators role and a preferred facilitation style. The companies business objectives were deployed down through improvement objectives to improvement measures which were then delegated to the QPS teams at both corporate and site level. The team based, improvement orientation was fundamental to the company's operation by the end of 1993 and was being reflected in improved business performance. The overall degree of Quality development exhibited by Company D corresponded to the **improvement** orientation as described in Chapter 4.

8.5.3 Case Study D - The Parametric Models

Considering the Quality development of Company D in terms of the three parametric models of development confirms the orientation of the company as improvement. The Activity Model representation of Company D is shown in Figure 8.5.3.a).

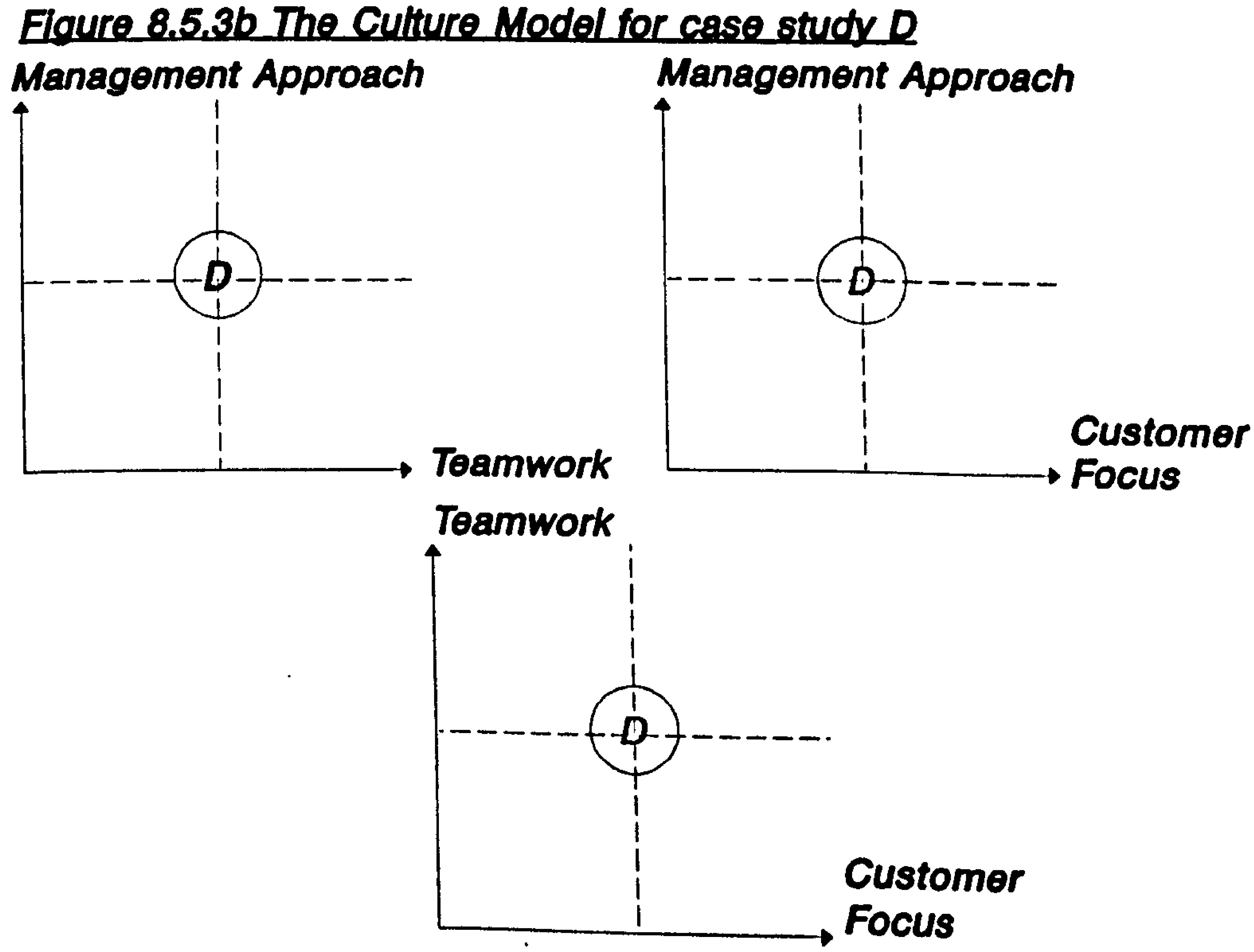
Figure 8.5.3a The Activity Model for case study D



For the complexity axis, Company D were positioned at the mid-point of the axis with both ISO 9000 and statistical process controls being employed. For the quantity axis the company employs seven of the activities evaluated in industrial survey 1 (problem solving, statistical sampling, Quality awareness programmes, delegated teams, internal audits, statistical process control and ISO 9000) which positions Company D above the mid-point for the quantity parameter. For the involvement axis, Company D have utilised awareness programmes and delegated (QPS) teams and although the traditional voluntary improvement has not evolved within the company the project teams operated at both intra and inter departmental level as shown above in Figure 8.5.2.b). the inter departmental project teams were focused specifically at customer service improvements whereas the internal project teams addressed delegated projects within a department. Company D are therefore positioned around the mid-point of the involvement axis. The Activity Model positions Company D within the T2 a) domain having a team orientated improvement approach.

The Culture Model for Company D is shown in figure 8.5.3.b).

<u>*Figure 8.5.3b The Culture Model for case study D*</u>



The primary cultural development exhibited by Company D is towards a team-based improvement orientated organisation in which all employees are expected to contribute to the improvement efforts. Individual contributions and team improvements have been recognised as part of the QPS programme and an open, self critical culture has been encouraged to create an atmosphere receptive to change.

The predominant management approach involves both the formal training of managers in the tools and techniques of Quality improvement and also company wide involvement in improvement programmes through the QPS process. These factors position the company at the mid-point of the management approach axis of the Culture Model.

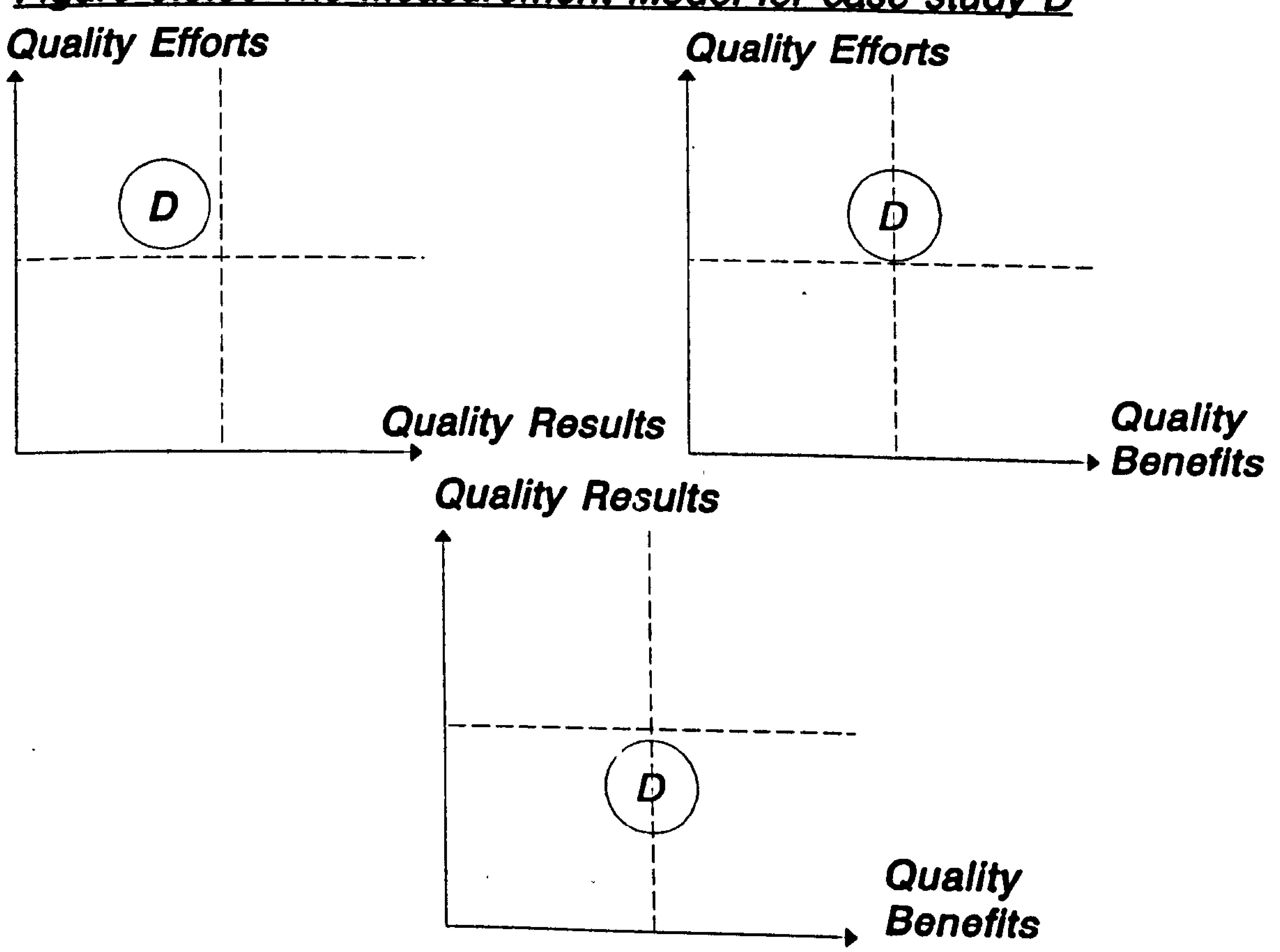
Similarly the company is also positioned at the mid-point of the teamworking axis with QPS training undertaken for all employees and the widespread operation of delegated improvement teams.

In terms of the customer orientation of Company D the company use extensive customer survey date, regular customer visits and have integrated significantly into the customers' business processes (such as technical support, maintenance planning and lubricant management systems) but have not included customers into the internal product and process developments to the same extent. Company D have a strong sense of their role as a supplier rather than as a manufacturer or product developer. The company has traditionally employed extremely successful (award winning) advertising campaigns which focus upon the excellence of the products ('liquid engineering') and the Castrol brand name (GTX) rather than upon the manufacturing or product development facilities. This has led to a developmental paradox in which the company has inhibited the customer orientation in the business processes for fear of exposing perceived weaknesses to the customers. Company D are therefore positioned around the mid-point of the customer orientation axis.

Overall the Cultural Model also positions Company D as an improvement orientated organisation within the T2 (improvement) domain.

The Measurement Model for Company D is shown in figure 8.5.3.c).

Figure 8.5.3c The Measurement Model for case study D



The developmental efforts made by Company D have been considerable and include all three parameters covered in survey 1 described in Chapter 6. The company have formalised policy, mission and vision for Quality, have undertaken comprehensive training programmes and have addressed both supplier and customer service issues as part of the QPS programme. This positions the company in the upper quadrant of the efforts dimension.

The developmental results achieved by Company D have included ISO 9000 and Ford Q101 accreditation and limited product (rather than process) competitive comparisons. In terms of customer service the company are not perceived as market leader although the product brand name has an international reputation for Quality. The results development of Company D again correspond to the mid-point of the axis.

Finally the benefits occurred by Company D also position the company around the mid-point of the axis with a reduced cost of Quality (around £3M during the period 1991 to 1993) and the introduction of benchmarking into the QPS programme. The main impact of the Quality developments within the company was to prevent further loss in market share rather than to positively increase this parameter.

Overall the Measurement Model classifies Company D as being within the T2 (improved internal processes) domain.

As with case study Company C above, Company D is characterised by the three models of development as exhibiting an improvement orientation with a focus upon team-led improvements particularly in the customer service and customer support activities.

During the period covered by the research collaboration, however, the product and process design activities were not predominant and this reflected in the company's approach to Quality management primarily being improvement rather than prevention orientated.

8.5.4. Cast Study D - Summary

The overall orientation of Company D corresponds to the improvement level of development and this has been achieved primarily through the commitment of the company to the QPS programme led by the Chief Executive. Quality development is seen as both a defensive business strategy in terms of sustaining the brand image and also a positive strategy in terms of reducing the cost of operations.

The three parametric models also characterise Company D as an improvement orientated organisation with deployed teams operating on both a departmental and cross functional basis. The company have committed considerable organisational efforts and resources to effective team operation although they have retained the functional management structure of the business. The next stage of development for the company will involve integrating the customer orientation into the product and process development processes.

8.6 Case Study E - Ford Motor Company, Halewood

8.6.1 Case Study E - Background

The Ford Motor Company manufacturing facility at Halewood on Merseyside is part of the European operations of the Ford Motor Company Incorporated of America. the Halewood plant was built in 1961 with volume car production commencing in 1962. Halewood has sister plants at Saarlouis in Germany and Valencia in Spain all manufacturing the Escort models for Europe and the Far East. Halewood employs approximately 7000 employees and in 1995 produced 161000 Escort models with an approximate sales value of $1.45BN. The main products manufactured at Halewood are:

- Ford Escort models in 3, 4 and 5 doors and also vans
- Escort transmissions and transmission components
- Escort component parts for assembly at Ford facilities around the world.

Ford are the market leader in the UK and the Halewood - built Escort has traditionally been the number one selling vehicle. This case study focuses upon the ford approach to Quality management for replacement vehicles, codenamed the CW170, which, following its launch initially in Europe, will be Ford's first truly 'World Car'. Competition in European manufacturing has been particularly fierce with both overcapacity and japanese market penetration leading to competitive trading conditions. Ford at Halewood has to compete on the basis of Quality price and delivery not only with other non-Ford car manufacturers but also with Saarlouis and Valencia for market share and capital investment within the Ford Motor Company itself.

Halewood operates within the most competitive (small family saloon) sector of the car market and has pursued a policy of Quality development since the early 1980's. In recent years the Halewood facility has achieved accreditation to ISO 9002 and, in 1995, Ford Q1 approval which represents the existing Ford Quality award corresponding to world class performance in terms of plant process control.

Competition in world markets has led Ford to develop the Ford 2000 vision which is a programme of global car manufacturing driven by a customer orientated Quality philosophy unifying production and product objectives. The key mechanisms for delivering the Ford 2000 vision are Plant Vehicle Teams (PVT) to reduce the cost of Quality, robust design methodologies and company wide vehicle improvement committees. The programme involves re-structuring the product introduction and manufacturing operations within Ford and aims to make the company the leading global car manufacturer.

Collaboration between Ford Halewood and the University began initially 1990 with a comparative analysis of process capability indices undertaken between Halewood and Valencia and also working with Ford Suppliers on Merseyside to achieve the Q101 Quality Assurance standard. Since 1994 projects have been supervised by the author as part of the University's Integrated Graduate Development Schemes examining the cost of Quality at Halewood and also the development of advanced Quality planning methods to assist in the Ford 2000 programme and the introduction of the CW170 model. The research collaboration with Ford at Halewood has included a review of the Quality development programme within the company and an assessment of the business benefits attributable to this development.

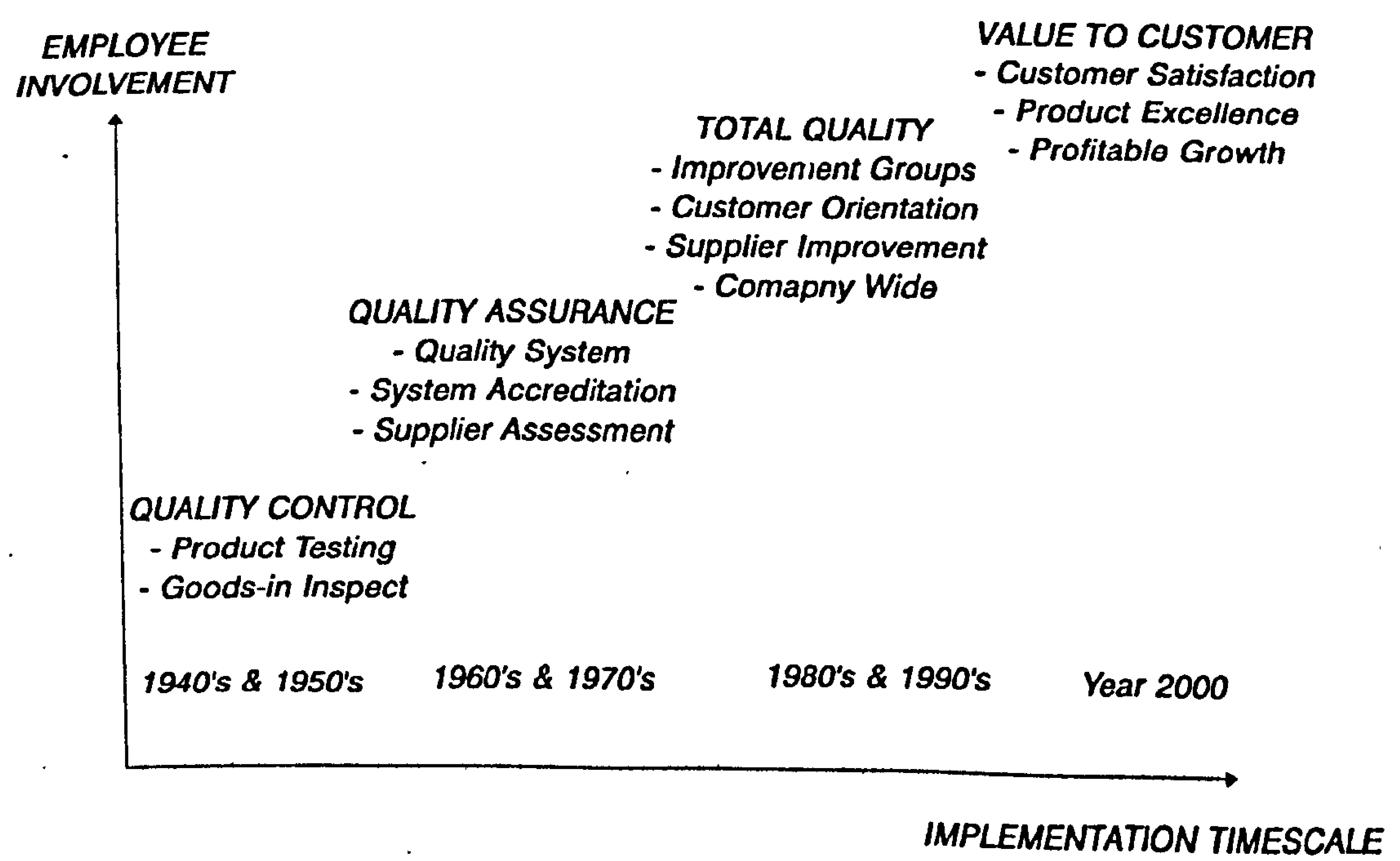
8.5.2. Case Study E - Quality Development Orientation

The Ford operating philosophy statement [39,1995] defines the company's commitments to Quality:

The operating philosophy of the Ford Motor Company is to meet the customers needs and expectations by establishing and maintaining an environment which encourages all employers to pursue never-ending improvement in the Quality and productivity of products, its supply base and its dealer organisation!

Since the 1960's Ford has increased and changed the company's approach to Quality management and has moved from Quality control philosophy to the Total Quality philosophy embedded in Ford 2000 as a illustrated in figure 8.6.2.a).

Figure 8.6.2a Quality management development at case study E (Source: Ford Motor Company)



The company's values in achieving the operating philosophy are expressed [39,1995] in terms of:

* people - our people are the source of our strength. They provide our corporate intelligence and determine our reputation and validity. Involvement and teamwork are our core human values.

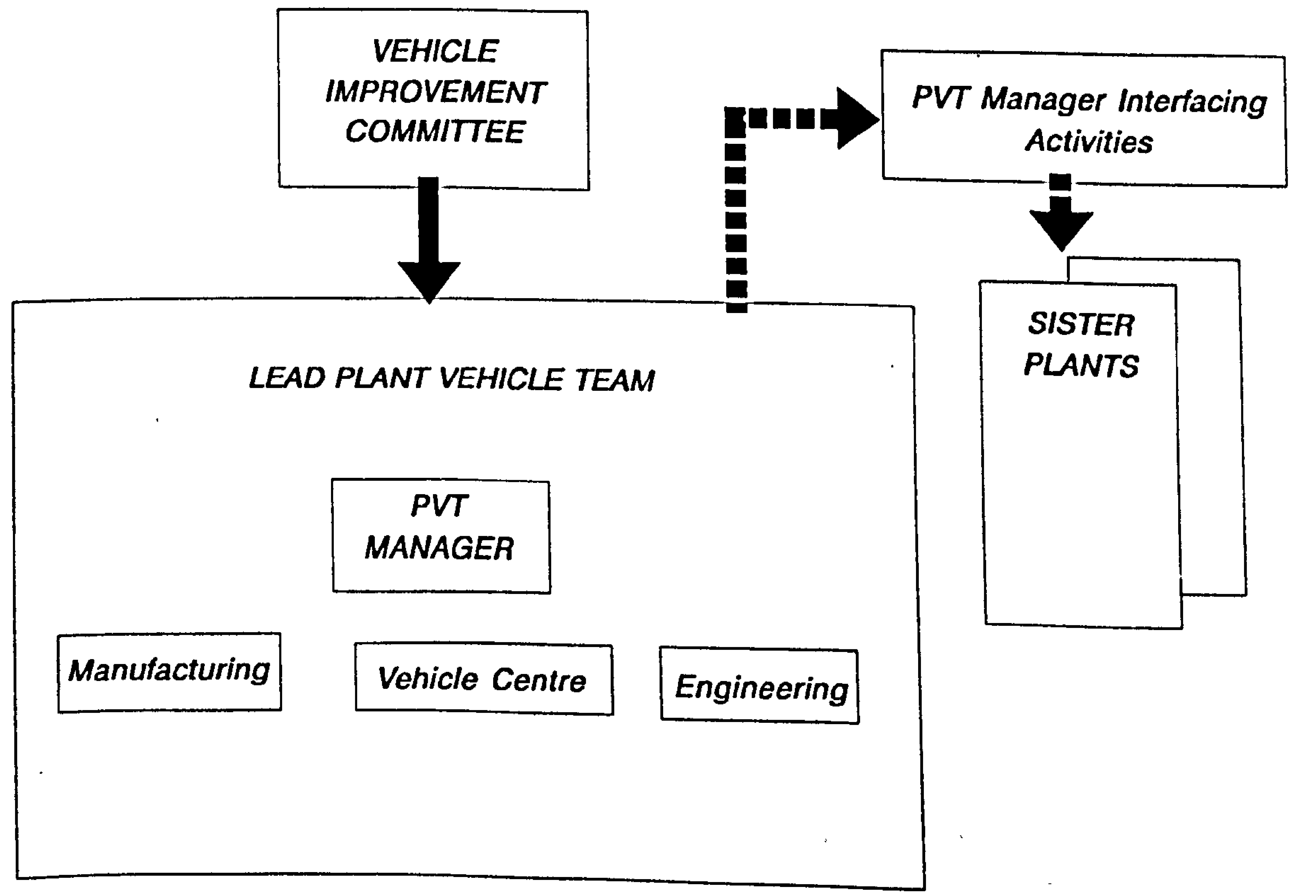
* products - our products are the end results of our efforts and they should be the best in serving customers worldwide. As our products are viewed, so are we viewed.

* profits - are the ultimate measure of how efficiently we provide customers with the best products for their needs. Profits are required to survive and grow.

The significant Quality development at Halewood during the 1990's has been the attainment of the Q1 Quality award. This development has involved the plant-wide formalisation of statistical process control, achieving process capabilities and capability indices greater than 1.33, the application of both process and design failure mode effects and analysis and extensive supplier development programmes. Whilst the Q1 development at Halewood has resulted in a significant change in the Quality management emphasis at the plant, particularly in terms of the application of advanced Quality planning techniques and an investment in prevention costs such as training and supplier development, it has not resulted in a significant organisational change. Functionally based departments still predominate at Halewood for the manufacture of existing models and teamworking is seen as an additional rather than replacement activity to functional arrangements.

The CW170 project which represents Ford of Europe's contribution to Ford's 2000 vision takes the management of Quality at Halewood to a further stage of development. The emphasis for the CW170 manufacturing programme is upon prevention and the company and the facility have invested significant resources to producing robust designs and monitor closely the concern resolution times and the quantity engineering changes. The performance standards for the new vehicle are extremely bold (including a vehicle reliability mission of 150k miles/10years) and Ford 2000 has required re-engineering the new vehicle manufacturing programme. The organisational changes have including basing the Quality management for the CW 170 on the generic plant vehicle team (PVT) structure shown in figure 8.6.2.b).

Figure 8.6.2b Generic plant vehicle team structure



The primary aim of the PVT approach is to reduce the overall cost of Quality to Ford to levels associated with best practice Total Quality. As part of the collaborative research programme with the University the cost of Quality for the PVT approach has been estimated at around 3.9% of sales with an objective for Ford 2000 of 2.5%.

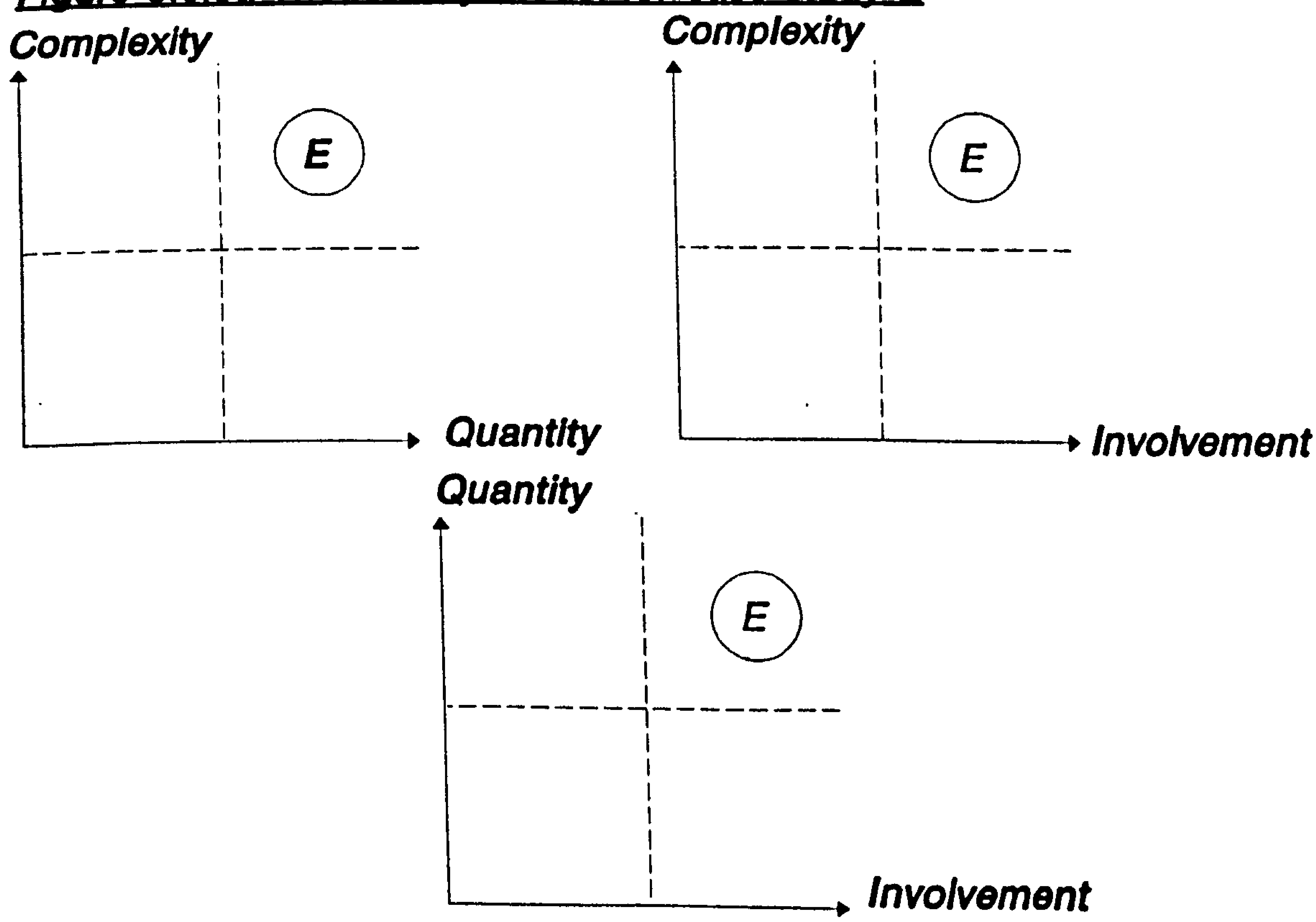
The overall level of Quality development exhibited by case study Company E corresponds to the **prevention** orientation as described in Chapter 4.

8.6.3. Case Study E - The Parametric Models

To evaluate the characterisation of Company E as a prevention orientated organisation the three parametric models were applied.

The Activity Model for Company E is shown in figure 8.6.3.a).

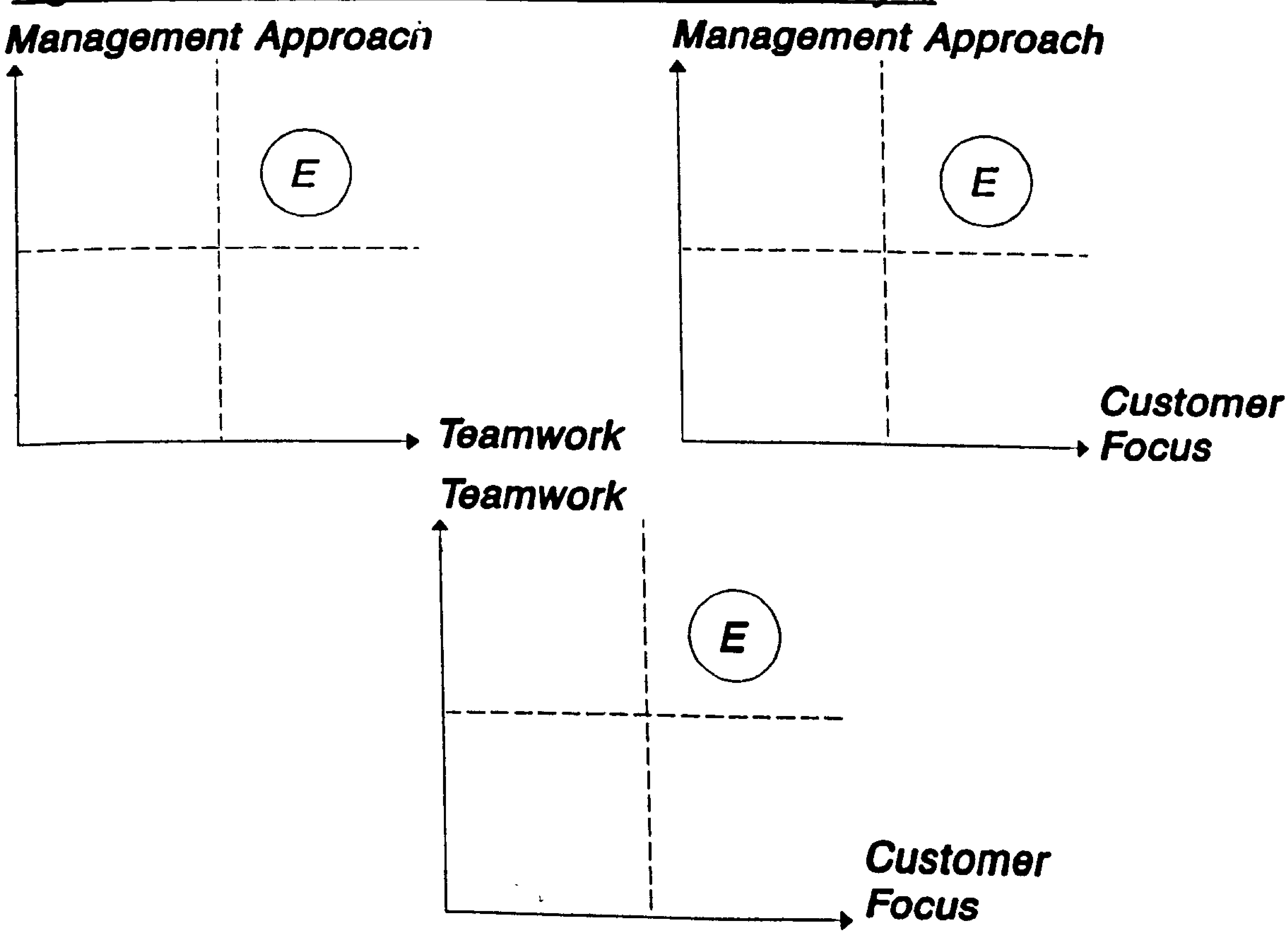
Figure 8.6.3a The Activity Model for case study E



Company E are positioned in the upper region of the complexity axis as the company employ ISO 9000, statistical process control and Taguchi methods for robust design. For the quantity axis the company employ all of the activities evaluated in industrial survey 1 which again positions in the upper quadrant in the complexity/quantity grid. In terms of involvement assessment, company E have employed awareness programmes extensively over a period of years at the plant and use delegated and voluntary teams as part of the PVT process. The concept of a voluntary team within company E is represented in terms of the normal operational structure as represented above in figure 8.6.2.b). Clearly the Activity Model of Quality development depicts company E as being within the T3 domain having a prevention orientation.

The Culture Model for Company E is shown in figure 8.6.3.b.

Figure 8.6.3b The Culture Model for case study E



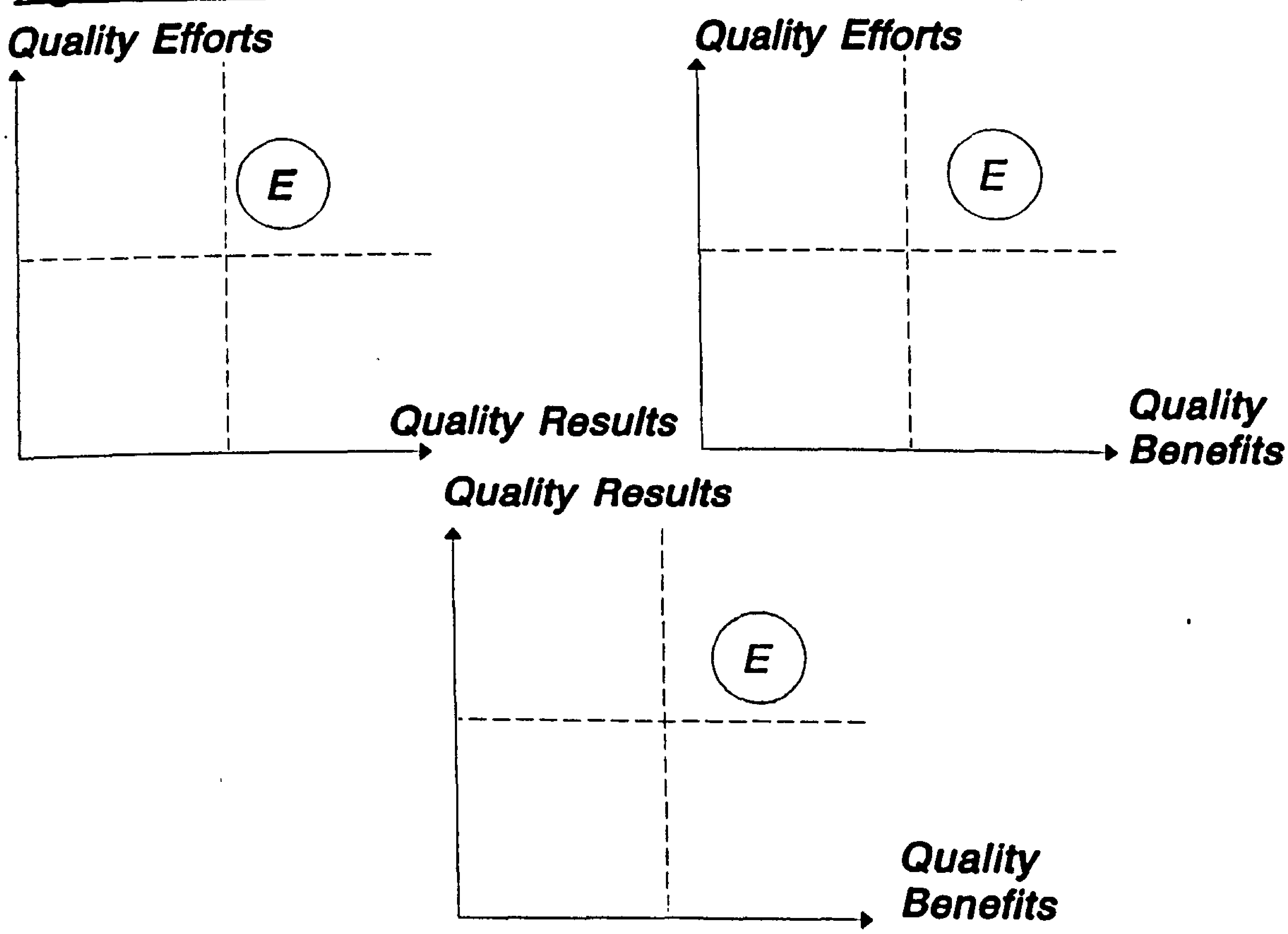
The Ford 2000 vision programme at company E is aimed at producing a customer driven, team based organisation capable of competing in global markets. The predominant management philosophy at company E is investment in prevention to increase customer satisfaction and reduce the cost of Quality. The management approach involves formal training for managers, involvement in the improvement process and also improving inter-company communication and particularly the communications between product development and assembly operations. Teamworking forms a fundamental component of the culture within company E with Quality training undertaken at all levels within the organisation and delegated improvement teams operating in addition to the established PVT's. Company E do not strictly use the Japanese type Quality Circle groups but do work in cross-functional teams as an integral part of the business operations. Company E are therefore positioned in the upper quadrant in terms of management approach and teamworking as shown in figure 8.6.3.b).

Finally Company E are also representative of a customer driven organisation and have developed a number of mechanisms for providing customer focus including owner survey (both Quality Telephone Surveys and Quality Audit Surveys), customer clinics and dealer review programmes. A key component of the PVT process is the application of Quality Function Deployment and Concern Review to embody the 'voice of the customer' into the new model development programme. Company E are therefore also classified in the upper quadrant of the customer focus axis.

Overall the Culture Model of Quality development also depicts Company E as having a prevention orientation with the company moving from the T3a (prevention-functional) to the T3b (prevention-integral) domain as part of the Ford 2000 programme.

The Measurement Model for company E is shown in figure 8.6.3.c).

Figure 8.6.3c The Measurement Model for case study E



The Quality efforts made by company E include the development of formal policies for Quality, Quality Training for all employees (including the EQUIP Engineering Quality Improvement Programme as part of the Ford 2000 vision) and has created an integrated supply chain employing black box design whereby all suppliers are Q1 approved and supply initial sample warrants for new parts to the PVT for review. Company E also supervise trials at supplier organisations and involve vendors at an early stage of the product design (via QFD) and concern resolution processes. These developments position the company in the upper quadrant of the efforts dimension.

In terms of results, company E are certified to both ISO 9000 and Q1 and undertake detailed comparative product and process studies both within the group and also with competitors. The Quality reputation for company E is high although research from the Motor Industry Research Association indicates that the current model does not enjoy 'best in class' status. One of the stated aims of the PVT process within the Ford 2000 vision is to create market leader status in terms of Quality for the CW170 model. The results axis therefore positions company E above the mid-point.

Collaboration between company E and the University since 1994 has identified the cost of Quality within various operations in the organisation. The estimated cost of Quality within the existing Press Shop facility are approximately 8% of sales revenue compared to an estimated cost of Quality for the corresponding PVT based operation of around 3.9%. Company E also extensively apply competitive benchmarking both within and outside the group companies and undertake performance benchmarking as part of the QFD process. The business benefits from Quality development in terms of increased market share are rather more difficult to identify and the retention of the market lead in the U.K. is the face of widespread domestic and international competition represents the clearest indication of the business benefits accrued from the company's approach to Quality management.

Company E are therefore positioned in the upper quadrant of the benefits axis and overall the Measurement Model characterises the company as a T3 prevention orientated organisation.

Case Study company E are therefore characterised by all three parametric models as exhibiting a prevention orientation with team based business processes and an emphasis upon advanced Quality planning and product and manufacturing process design. The Ford 2000 programme can be parameterised as an advanced approach to Quality Management with a corporate emphasis upon robust new product introduction methods to produce global vehicles and world class levels of customer satisfaction. The company retains the Quality systems developments associated with ISO 9000 and Q1 and has created an improvement culture throughout the manufacturing supply chain. The difference however between company E and the two improvement orientated case studies (C and D) is the emphasis upon Quality planning in terms of product and process design.

Case Study E - Summary

The overall orientation of case study company E is prevention, particularly when considering the management of quality for the next generation of products which will be manufactured on a global scale. The primary drivers for this advanced state of Quality development are fierce international competition in the marketplace and internal competitive pressures to retain manufacturing capacity. Quality development and customer orientation are seen as fundamental business philosophies within company E.

The three parametric models confirm the advanced nature of the Quality development within company E. Teamworking is the basis of the new organisational structure within the company and defect prevention is the major emphasis in the new product launch programmes. Company E need to retain the commitment to Quality Management and customer satisfaction in order to compete with products in globalised markets.

CHAPTER 9

RESEARCH CONCLUSIONS AND FURTHER WORK

This chapter considers the conclusions from the research in terms of the approach adopted, the main findings of the research and finally the future work prompted by the research. The conclusions also reflect the needs and objectives of the research described in Chapter 1 of the thesis and, through the case studies described in Chapter 8, the benefits of the research.

9.1. Research Approach

Chapter 1 of the thesis outlines the motivation for the research in describing the industrial and academic problems emerging during the 1990's in understanding the relationship between the approaches to the management of Quality and the organisational developments which result. The hypothesis formulated for the research was that a coherent developmental framework could be established for the subject area and that parameters could be proposed to characterise the stages of Quality development. The review of the literature in this area is described in terms of the historical context of the dimensions of Quality Management (Chapter 2) and also the prevailing models of Quality development (Chapter 3). From the review of the literature a new framework is proposed in Chapter 4 for a staged model of Quality development described in terms of systems, improvement and prevention orientations.

This framework is contrasted with existing models for describing Quality maturity and also the mechanisms for assessing Quality management performance within an organisation.

Having defined the framework for Quality development the parameters for describing and classifying the developmental stages are proposed in Chapter 5. The three parametric models are described as the Activity Model, the Culture Model and the Measurement Model and these are mapped onto the developmental framework using a series of transitional grids. Chapters 4 and 5 therefore outline the intellectual basis of the research which is then evaluated using established action based research techniques of industrial surveys and company case studies. Chapter 6 describes the approach adopted in the research to surveying industrial practice and the structuring of the data collection in terms of both data to identify the correlation between the parametric factors and Quality development and also the clustering of organisations corresponding to the proposed stages of development. The survey data was then analysed as described in Chapter 7 using correlation factor analysis to examine the parametric models and the sign test to evaluate the clustering of organisations into characteristic stages. The research significance of the industrial survey findings was to indicate the validity of the framework and the parameter models rather than to quantify in any absolute terms the proportion of organisations existing at each of the stages of development. In terms of the research approach the survey element of the work was used to illustrate the framework and to identify aspects of discontinuity particularly in terms of the data relating to the transition from one stage of development to another.

The industrial case studies presented in Chapter 8 are used to illustrate the application of the parametric models in describing the relative Quality development in five different manufacturing organisations. The case study data represents the time-based observation of Quality development and therefore supplements the statistically more significant (larger) sampling employed in the industrial surveys. Together this data represents the validation phase of the research and is presented as justification for the research approach.

9.2. Research Findings

The primary findings from the research are that a framework for development can be identified and that parametric models can be used to characterise the individual stages. The main contributions to knowledge provided by the research are as follows:

- First, the framework for Quality development describes identifiable stages of systems, improvement and prevention orientation which can be used to classify the tools, techniques and methods of Quality management and to depict the culture change associated with development. This framework provides a new academic structure to the subject area and develops a conceptual link between the application of techniques and the organisational changes which take place.

- A set of parametric models have been provided to characterise quality development and this approach using the three dimensional parameterisation of Quality management represents an important new research technique for integrating the data orientated survey-based research approach, the literature-led management theory approach and the case study based action research approach.

- The developmental framework is illustrated using both industrial survey data and case study examples. The cluster analysis of the industrial survey data using the Sign Test depicts statistically significant clustering of companies corresponding to both the systems orientation and the prevention orientation stages of development, although the transitional nature of the improvement stage was less well depicted.

- The correlation analysis of the industrial survey data illustrates significant correlation for each of the parametric models and supports the parameterisation approach and also the selection of the characteristics.

- The case study illustrates in a number of different manufacturing contexts the ralationships between the organisational activities and the organisational changes associated with Quality management and demonstrate the benefits in improving the understanding of the subject which the developmental framework provides.

The conclusions from the research are therefore that the Quality development of manufacturing organisations can be represented in terms of a series of descriptive stages and that this framework can be modelled in terms of parameters relating to the activities, the culture and the measures of Quality management. This new viewpoint represents an advancement in terms of the intellectual framework for the subject in terms of explaining the roles, effects and relationships between the various elements of Quality management and also for characterising the changes which take place. The theoretical framework and models are rigorously corroborated through both industrial survey and case study research methods.

9.3. Further Research

Research into Quality management science is ongoing at the University of Liverpool under the supervision of the author in areas resulting from this work. The framework for Quality development has identified a number of research issues relating to the evaluation of development and the relationships between the stages of development. These further research opportunities include:

- The examination of the important relationship between Quality development and business development to assess the need to include Quality planning into the business planning process. The research described in this thesis presents Quality development as an implicit organisational objective and therefore supplementary research is required to examine the explicit mechanisms for the integration of the planning for Quality development into the business planning of an organisation. This research theme is currently being actively pursued in the PhD programme of Bagheri.

- The investigation of critical transitions which occur at the interface between the systems and the improvement stages of development. The findings from the cluster analysis of the industrial survey data indicates that organisational transitions at this interface are more difficult to characterise and the routes to Quality improvement are poorly understood. This research theme is currently being actively pursued in the PhD programme of Najmi.

- The evaluation of the culture change techniques and mechanisms which are required for the transition from improvement to prevention orientation. A greater understanding of the enablers and timescales associated with culture change is required and in particular the relationship between existing cultural characteristics and the required cultural characteristics. This research theme is currently being actively pursued in the PhD programme of Adebanjo.

Overall the future research challenge is to provide a more coherent understanding of the way Quality management influences the performance of manufacturing organisations.

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APPENDIX A - RELATED PUBLICATIONS

[1] Kehoe, D.F. "ISO 9000 - The European Community Experience", keynote paper at the Universiti Sains Malaysia Conference on Quality Management, July 1993

[2] Mann, R.S. and Kehoe, D.F. "Methodologies for the Implementation of Total Quality Management Within Manufacturing Companies", Sixth National Conference on Production Research, University of Strathclyde, September 1990

[3] Mann, R.S. and Kehoe, D.F. "Factors Affecting the Implementation and Success of TQM", International Journal of Quality and Reliabilioty Management, Volume 12 Number 1, 1995

[4] Kehoe, D.F.and Zain, Z.M. "Part 1 - A System for the Measurement of Quality Position in U.K. Manufacturing Industries" International Journal of Operations and Production Management, 1996.

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TITLE: ISO 9000 - THE EUROPEAN COMMUNITY EXPERIENCE

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ABSTRACT

During the past 25 years Western Europe has developed into an increasingly integrated political and business community. The political development spanning from the Treaties of Rome to Maastricht have been mirrored by a maturing approach to Quality Management within the Community.

This paper outlines the developments and experiences associated with the implementation of EN29000 (International Standard ISO 9000) within Manufacturing Industry and looks forward to the Total Quality Management challenge of the 1990's.

DEVELOPMENT OF ISO 9000 WITHIN THE EUROPEAN COMMUNITY

The late 1970's saw increasing competitive pressure within the European Community for manufacturing companies brought about by:

- The proliferation of 2nd party assessment through increasing trade within the community.
- Competition from Japan in key manufacturing sectors.
- Increasing product liability requirements.
- Government actions

The move from product based national and international standards towards a 'systems' view based upon Quality Assurance rather than the inspection/testing approach continued throughout the 1980's. Increasingly national product approval certification became conditional upon also having Quality Systems approval and the developments in the U.K. during this period were typical of the establishment of the national Quality Systems standards.

1974 - BS5173 Published 'Guide to the operation and evaluation of Quality Systems'.
1979 - BS5750 Published 'Quality Systems Standard for Quality Assurance'
1982 - Government White Papers lead to the specification of BS5750 in government contracts.
1987 - Revision of BS5750 to bring in line with ISO 9000 and EN29000.

In a recent survey of over 130 European Manufacturing companies carried out by the University of Liverpool [1] the primary reasons for the adoption the national quality systems standards were as follows:

	% Companies Ranking as important
- To provide improved product or service quality	93%
- To assist in the marketing of company products	92%
- Customer Pressure	61%
- Product liability requirements	56%

As national and multi-national purchasing began to adopt and appreciate the benefits of 3rd party Quality Systems approval, the effects os section 4.5 (ISO 9002) whereby sub-contractor assessment becomes an organisational requirement led to the proliferation of ISO 9000 implementation throughout Europe. In the Liverpool survey companies identified ISO 9000 certification as being a supplier requirement in the following proportions:

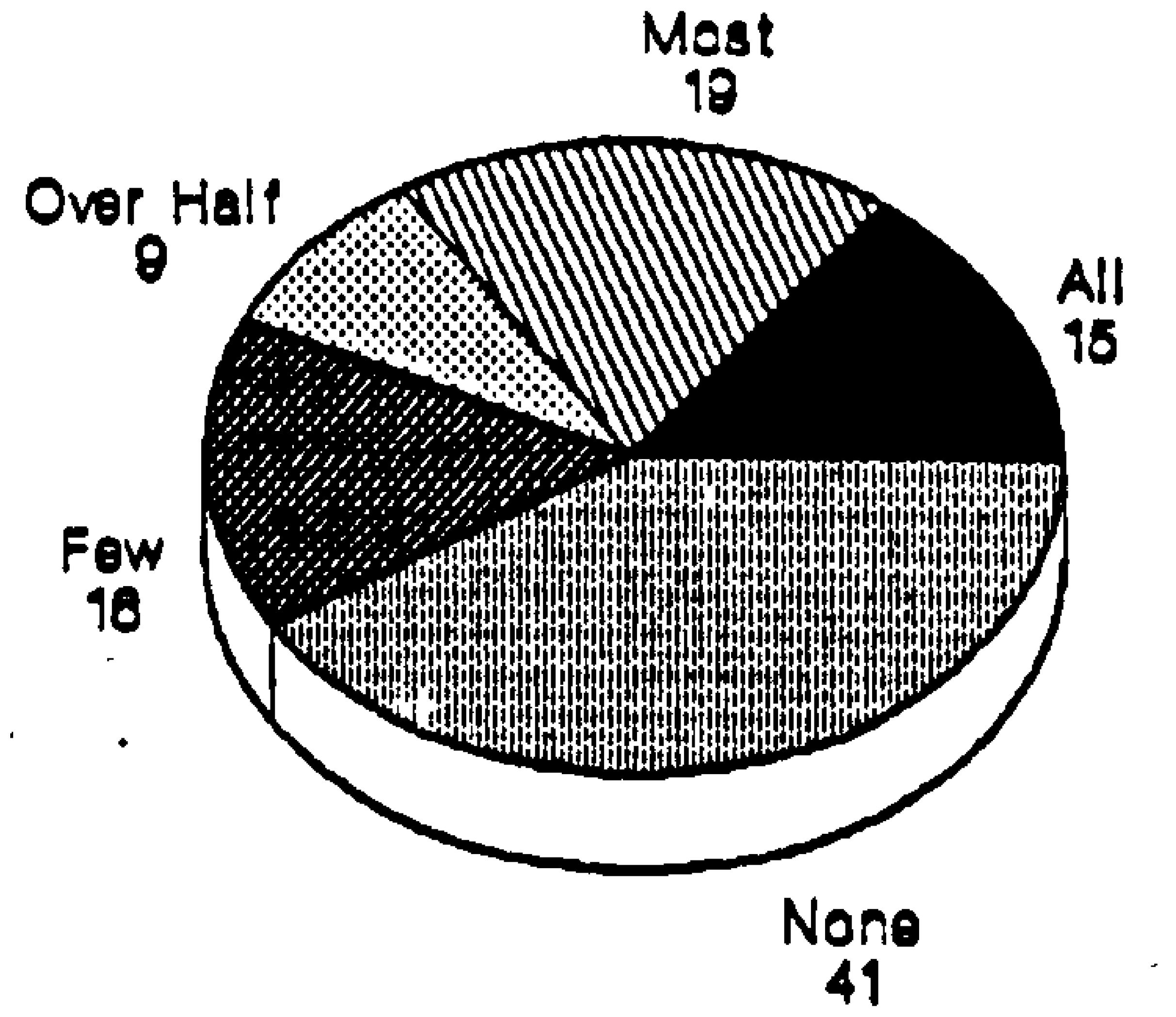


Figure Showing % Age Requirement For Suppliers to Conform to ISO 9000

These national developments were co-ordinated in 1987 with the publication of the European Quality System Standard EN 29000 and the international equivalent ISO 9000 series.

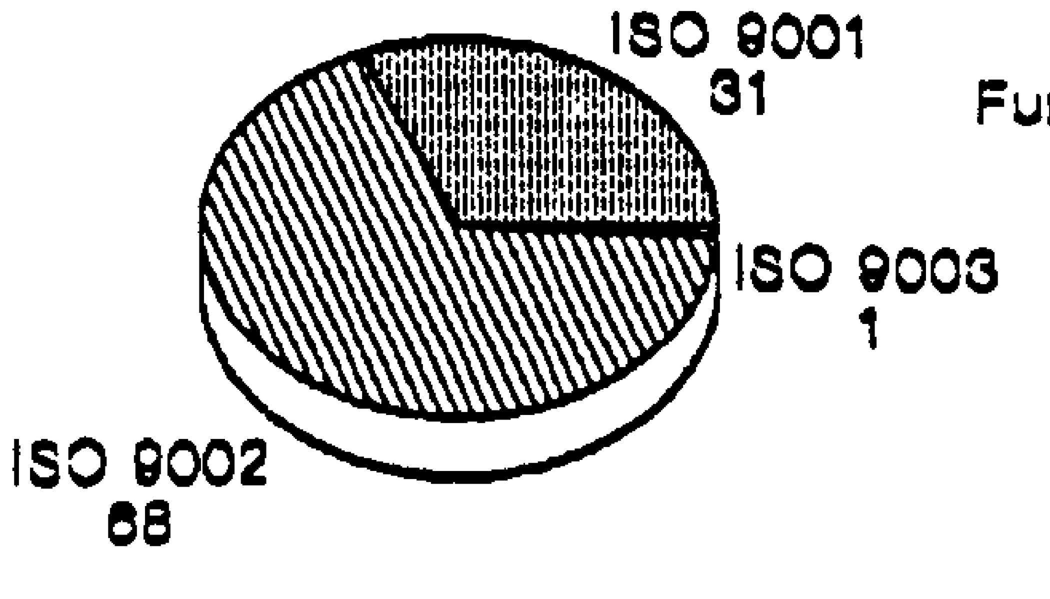
IMPLEMENTATION OF ISO 9000 WITHIN THE EUROPEAN COMMUNITY

The adoption of formal Quality Systems certification grew steadily throughout the 1980's and resulted in 1992 with the formation of the single market that many industrial sectors (Chemicals, Pharmaceuticals, Aerospace, Telecommunications etc) had established ISO 9000 equivalent approval as a basic requirement to supply.

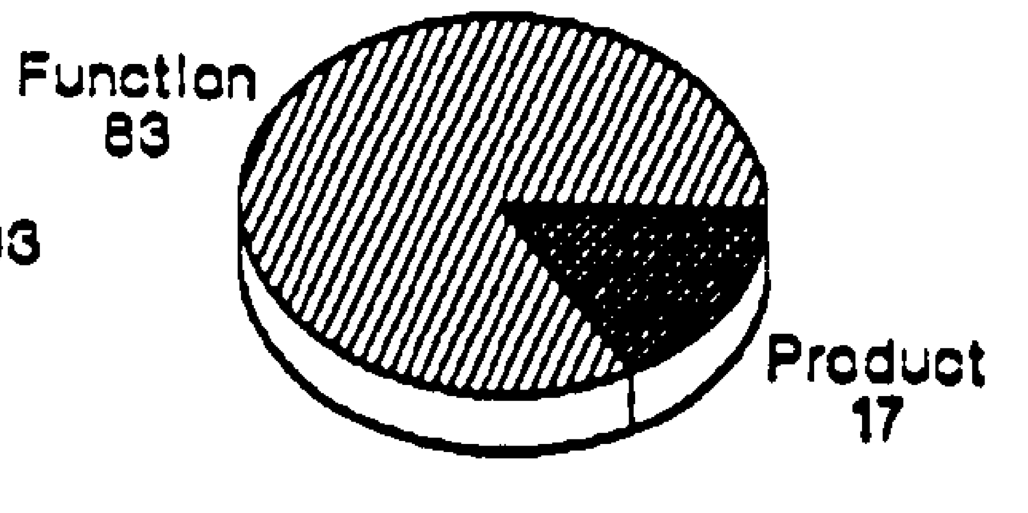
In terms of the industrial implementation of ISO 9000 the key issues to emerge were:

- Selection of the appropriate scope of the standard.
- Quality System Design
- Implementation costs and timescales

The survey quoted above has shown that Part 2 of the standard predominates in terms of European industrial implementation and that Part 3 is very rarely employed:



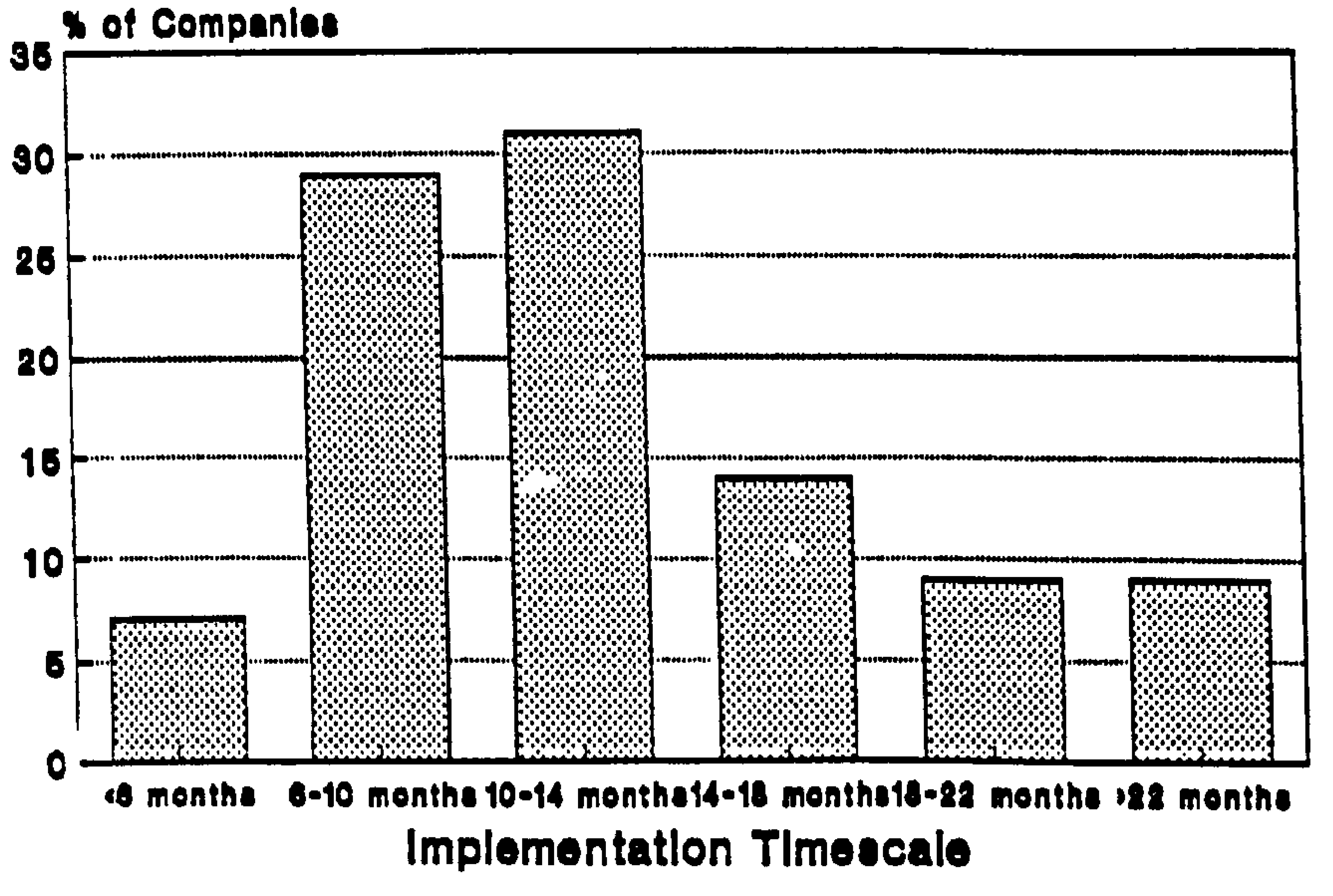
% Age of Companies Implementing Each of the Parts of ISO 9000

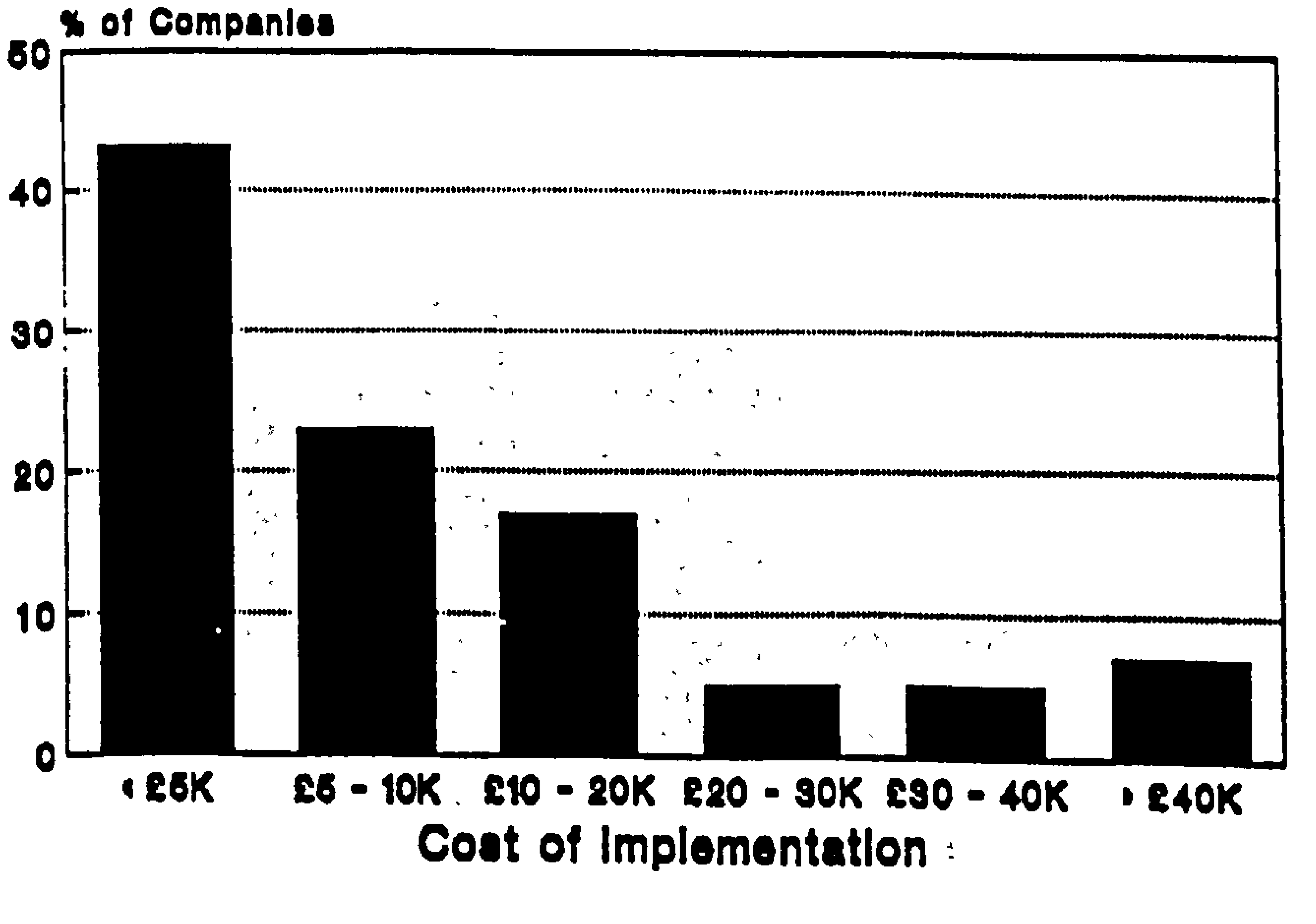


Proportion of Companies Implementing Function Based Procedures vs Product Based Quality Plans

When structuring the type of quality system employed within their organisation most companies surveyed adopted a functional based approach comprising a Quality Manual and Operating Procedures rather than a product based approach utilising Quality Plans.

Having established the scope of the certification and configured an appropriate form of Quality System then most manufacturing companies within the community achieved registration within 18 months and typically spent less than £20K on the implementation of ISO 9000. Most companies surveyed an estimated payback period of less than 3 years.



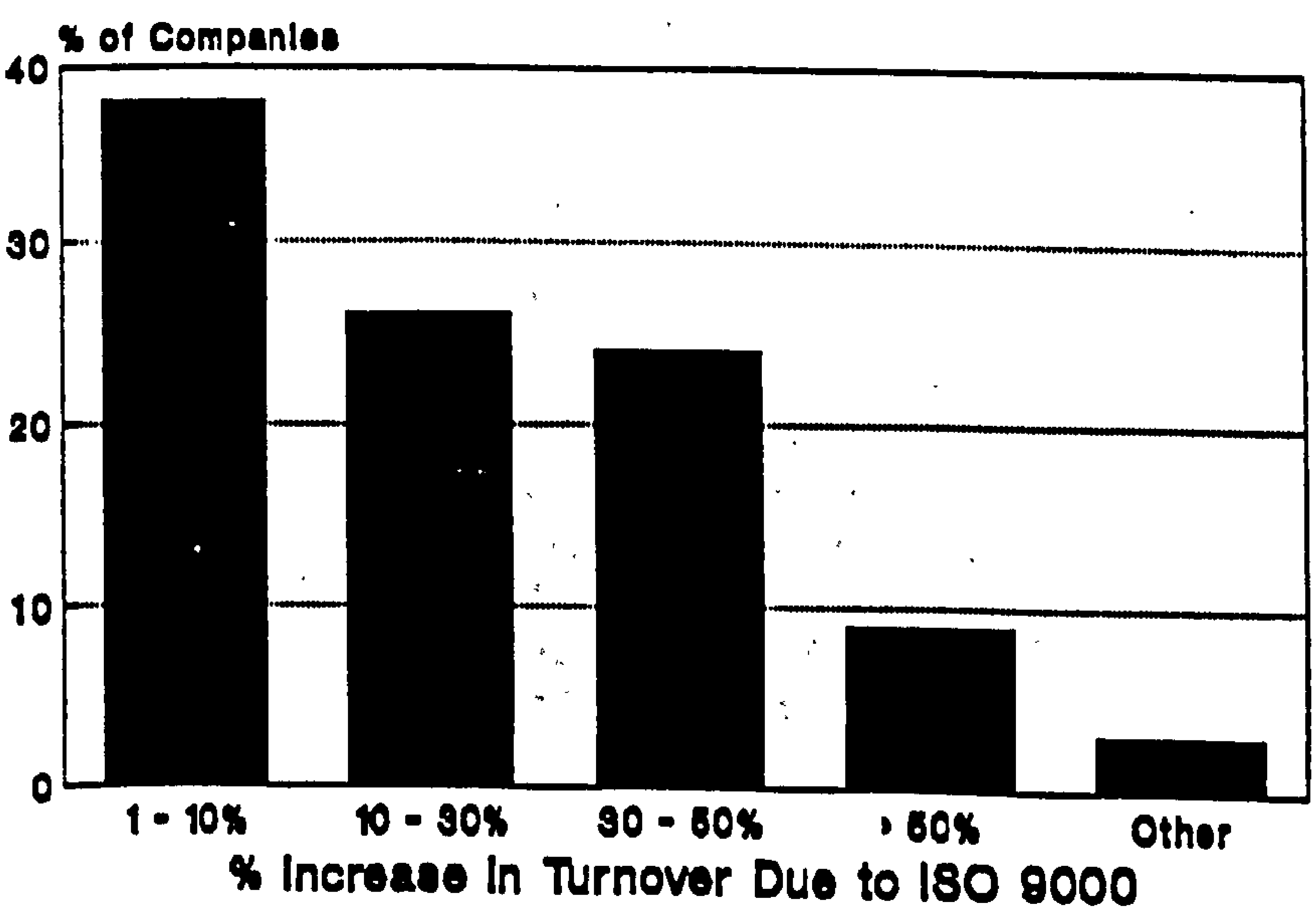


IMPLICATIONS FOR EUROPEAN COMPANIES OF ISO 9000

Most European companies have experienced significant business impact in the implementation of ISO 9000. The requirements of the standard has imposed organisational change together with process and test equipment enhancements and has realised a number of business benefits.
In terms of the manufacturing and inspection processes the general experiences of European implementation of ISO 9000 have been as follows:

	% age of Companies
- Major revision of Manufacturing Tolerances	60%
- Major investment in new process control technology	61%
- Investment in more than 5% new measuring/test equipment	63%

The organisational impact has been equally significant with most companies identifying an improvement in internal and external communications as a direct effect of ISO 9000 implementation. Whilst many organisations initially approach the accreditation process as a "defensive" business strategy, increasingly the positive effects in the marketplace are being identified.

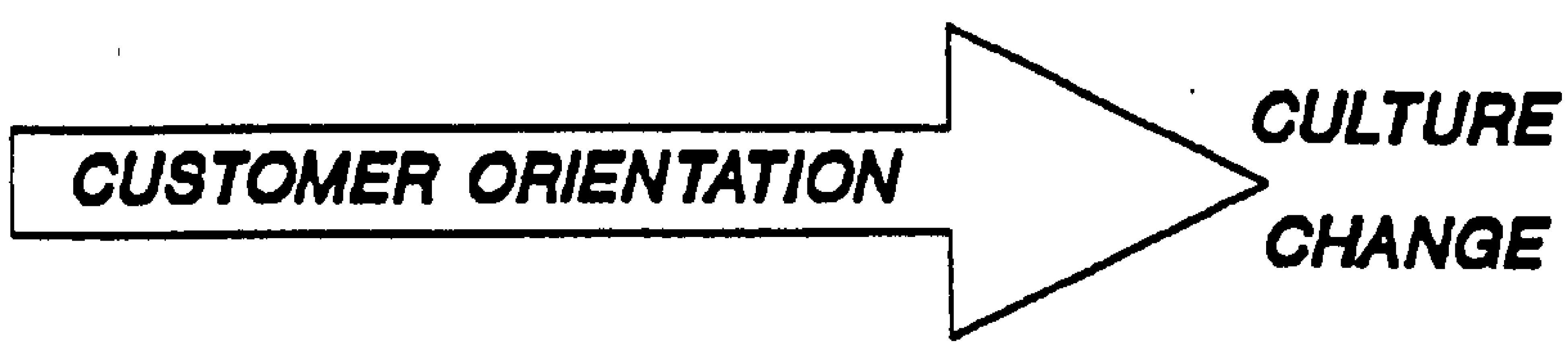


When asked how they would amend their implementation programmes in the light of experience, most companies identified increased education at all levels within the organisation as the key change.

FUTURE DEVELOPMENTS

The development of ISO 9000 series as first national and then international standards for the way in which Quality Systems should be managed, is seen in the European Community as perhaps the single most significant organisational development in the past decade. All major industrial sectors have been affected by the emergence of a systemic view of Quality Assurance to an extent that ISO 9000 is now perceived as a minimum requirement for international trade. In addition the establishment of effective Quality Systems is seen as a basic prerequisite in the evolution toward Total Quality Management.

THE STAGES TOWARDS TOTAL QUALITY



Develop a SYSTEMS Orientation STAGE I	Develop an IMPROVEMENT Orientation STAGE II	Develop a PREVENTION Orientation STAGE III
Actions		
- Definition of Quality - Definition of Requirements - BS 5750 - Management Involvement	- Team Based Involvement - Cross Functional Improvements - Basic Problem Solving Tools - Management Commitment	- Design Quality Dominates - Reorganisation - Advanced Quality Tools - Total Consistent Management Practices

The foundation for the future development of Quality Management within the European Community was established in 1989 with the formation of the European Foundation for Quality Management (EFQM) under the auspices of the President of the Commission. The EFQM is now active in promoting the developments in a professional approach to Quality Management which began with the introduction of ISO 9000.

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THE SIXTH NATIONAL CONFERENCE ON PRODUCTION RESEARCH
5-7 SEPTEMBER 1990

Methodologies for the Implementation of Total Quality Management within Manufacturing Companies

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In recent years manufacturing companies have begun to realise the importance that effective quality management has in terms of long term business success. Central to this development has been the adoption of Total Quality Management (TQM) within manufacturing companies as a way of achieving sustained, long term quality and improvement.

Research carried out at the University of Liverpool has been examining a range of companies to discover the true components of TQM and has been assessing the suitability of TQM implementation across a range of industries. The research has shown a methodology can be developed that will indicate the most appropriate course of TQM implementation based upon a company's existing market, manaufacturing and technological profile.

This paper discusses the development of a methodology for implementing total quality within a company based upon the company's current business position.

1. Introduction

In recent years, industrialists and academics have been consistently advocating the benefits of a TQM policy. At present there is no standard approach to implementing TQM. This paper details the functions required to achieve TQM and describes the actual methods used and their effectiveness. The development of a quality improvement model derived from these inferences is then discussed.

2. The Theoretical Approach Towards TQM

Quality practitioners generally agree on the main constituents of a TQM policy, refs [1,2,4 & 5]. Five major constituents have been identified:-

1) Quality Leadership
2) Company Wide Quality Commitment
3) Measurement and Reporting System
4) Customer and Supplier Focus
5) Education and Training

A list of functions was formulated which, when implemented, should meet the requirements of the constituents. Figure 1 shows the 5 constituents of TQM, the 7 functions and the quality techniques which help to ensure that these requirements are met. The arrows relate to which functions are primarily targeted at which constituents. For instance, the human function, statistical function and quality system function are directed at the needs of 'quality leadership' and 'company wide quality commitment'. Through the effective adoption of the bulk of these techniques, advocated by the functions, the organisation should be moving towards TQM.

3. The TQM Reality

The TQM companies were selected from two separate surveys which were undertaken by the University of Liverpool in July/August 1989:-

1. A survey of 650 randomly selected manufacturing organisations. Of the 142 companies that responded, 19 had implemented TQM.

2. A survey of 115 manufacturing organisations selected on the basis that they may have implemented TQM. Of the 115 companies, 65 responded with 46 having implemented TQM. The initial sample was drawn from articles in quality publications describing these organisations as TQM orientated, along with a selection of large multinational organisations.

TQM companies from both samples were aggregated and those who had implemented TQM prior to 1989 were selected for analysis, totalling 43 companies. The effects of TQM on these companies would then be significant. In addition to the 43 companies, 123 non-TQM companies from the first survey were selected for comparison.

The main characteristics of the TQM companies were:

- Most had implemented TQM since 1986.
- A high percentage were non-UK owned, particularly by the USA.
- The main manufacturing activities involved in were: electrical and electronic engineering, the chemical industry, mechanical engineering and office machinery and data processing.

- The main markets supplied were the automotive industry, information technology and the food and drinks industry.
- The main manufacturing methods used were: batch, process, flow and mass production.

In addition, TQM companies compared to non-TQM companies were:

- larger in terms of employee size and turnover.
- had a larger UK market share for their major product.
- exported more goods.
- produced more complex products.
- were more likely to use new technology.

The 'TQM reality' analysis will be structured in a similar way to figure 1: each constituent will be broken down into its 'functions' and data permitting, each function will be analysed according to:

1. Do TQM companies use more quality techniques than non-TQM companies?
2. What effects do the individual techniques have?

Quality Leadership and Company Wide Quality Commitment

Figures 2a, 2b & 2c describe the use by TQM and non-TQM companies of human functions, statistical functions and quality system functions. TQM companies consistently use more of all the techniques listed. Table 1 describes the effects some of the techniques had on the organisation.

Overall Quality improvement teams were the most effective method particularly for the human aspects of improved communication and morale and in improving product quality. Quality circles had similar effects but to a lesser extent.

Statistical Process Control (SPC), as a technique for reducing product and process variability, was highly effective at reducing quality costs and improving product quality. It was also effective at improving supplier and customer communication. Taguchi techniques generally had a low effect on most of the organisational factors but were effective at reducing quality costs and improving product quality.

BS5750 was, in comparison with the above techniques, most effective at improving business control. It was also effective at improving employee and customer communication. It was least effective at improving quality costs and employee morale.

Other data from the analysis indicated that TQM companies, compared to non-TQM companies, were more likely to have a separate quality assurance department, operators were given more responsibility and internal communication between departments was higher. Much of this is indicative of an effective quality system.

Measurement and Reporting System

70% of TQM companies use quality costs compared to 16% of non-TQM companies. No specific effects were measured but the provision of quality cost information would assist companies in directing their resources to the areas of greatest need.

Customer and Supplier Focus

Figures 3a & 3b describe the use by TQM and non-TQM companies of customer orientation functions and supplier improvement functions. As shown, TQM companies use more of all the techniques listed.

Additionally, in over 80% of TQM companies, quality personnel were involved in the product/part specification, supplier choice, monitoring, audits and visits compared to less than 60% in non-TQM companies. No specific effects of these functions were measured.

Education and Training

TQM companies educate and train their employees to a higher degree in all matters of quality (see figure 4). An effect of this was that 72% of TQM companies, compared to 42% of non-TQM companies, ranked increasing product quality as the most important strategic factor. Other strategic factors were to increase export markets, to increase UK market sales or to reduce costs.

Non- Specific TQM effects

Below is a list of effects attributable to TQM:

66% of companies believed it had increased their market share generally.
63% believed it had increased their market share in specific areas.
37% believed it had helped them establish a new customer base.
43% believed it had increased their export market.
15% believed TQM had had no effect.
24 TQM companies indicated that a policy of TQM resulted, on average, in a turnover increase of 11% a year.

Table 1, shows that TQM ranked most effective, particularly at improving employee communication, departmental communication and customer communication. TQM also ranked first as the most beneficial technique on the organisation as a whole, followed by quality awareness programmes, BS5750, quality improvement teams, quality circles, quality costs, internal audits, SPC, supplier improvement programmes and finally Taguchi techniques.

4. A Quality Improvement Model

By developing a quality improvement model, using the IDEFØ methodology [3], the complex interactions between an organisation and its environment can be decomposed. The correct quality improvement process, for an organisation, can then be devised. Figure 5, is the first stage of the decompositional model.

The figure depicts the main organisational aim as 'improve business performance'. The inputs to the organisation, which become consumed or modified, are materials. Three mechanisms help to achieve this: people and processes, quality improvement techniques and other techniques. The 'other techniques' cculd be advertising or the implementation of new technology. The effectiveness of the three mechanisms on improving 'business performance' will depend on four controls: the internal and external environment, the quality culture and the present performance of the business. The internal environment is dependent on, for example, the organisational structure, the presence of trade unions, the target market, the market concentration, and the organisations size. The external environment is dependant on such factors outside the influence of the organisation such as Government legislation, taxation, raw material shortages and international trade barriers. The quality culture is dependant on the level of development of quality leadership, company wide quality commitment, measurement and reporting system, customer and supplier focus and education and training. The business performance details project the present position on profits, market share, return on capital etc. The outputs from the model would be the products, changes in business performance, changes in quality culture and changes in the internal environment. Through decomposition of this model the output information would then become the controls.

The effectiveness of the quality improvement techniques, if the 'other techniques' are fixed, will depend on the internal environment and quality culture of the organisation. It is therefore important to tailor these techniques to the prevalent conditions.

To be able to decompose the model, future research will address the following:

1. At what stage of quality development (level of quality culture) should each technique be introduced.
2. Does the 'type of organisation' (internal environment) affect which techniques should be implemented.

This will provide a methodology such that a quality improvement process could be tailored to the needs of an individual company.

5. Conclusions

1. TQM companies use more of the techniques outlined in Figure 1
2. TQM does improve business performance.
3. The quality improvement model identifies the interactions between an organisation, its environment and 'quality approach' which require further research.

6. References

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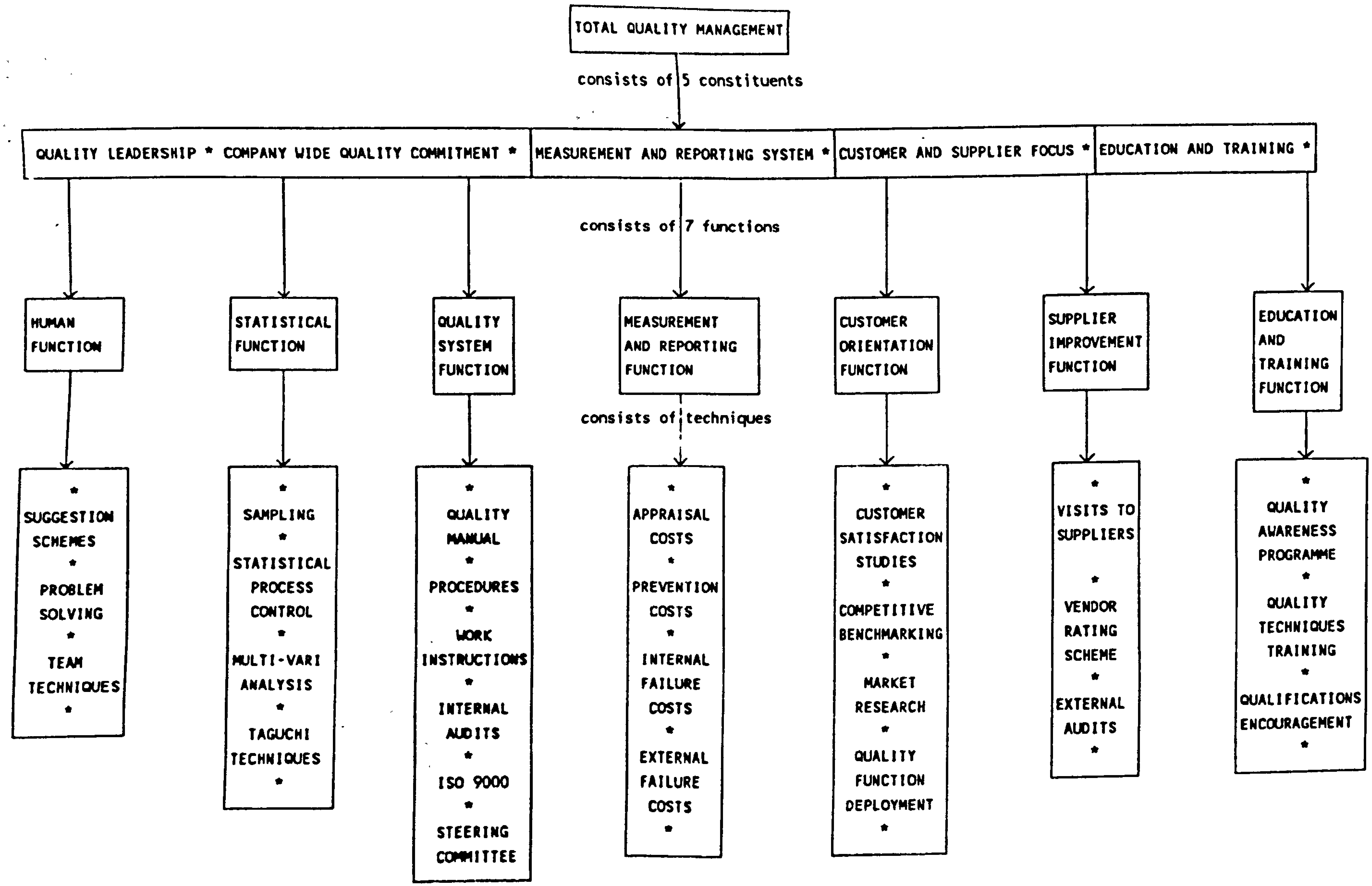
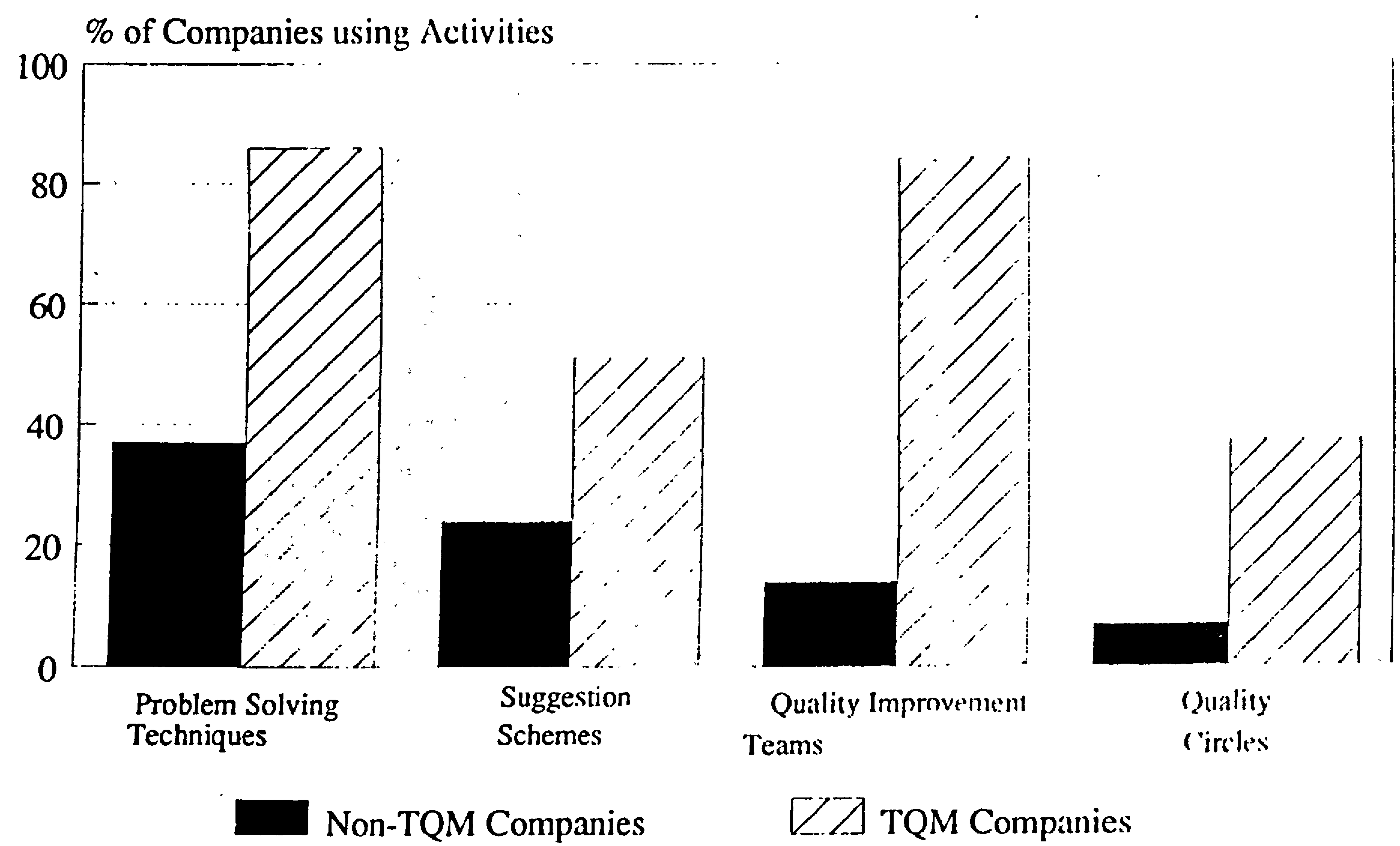


Figure 1. TQM constituents, functions and techniques.

TQM vs NON-TQM

Fig 2a

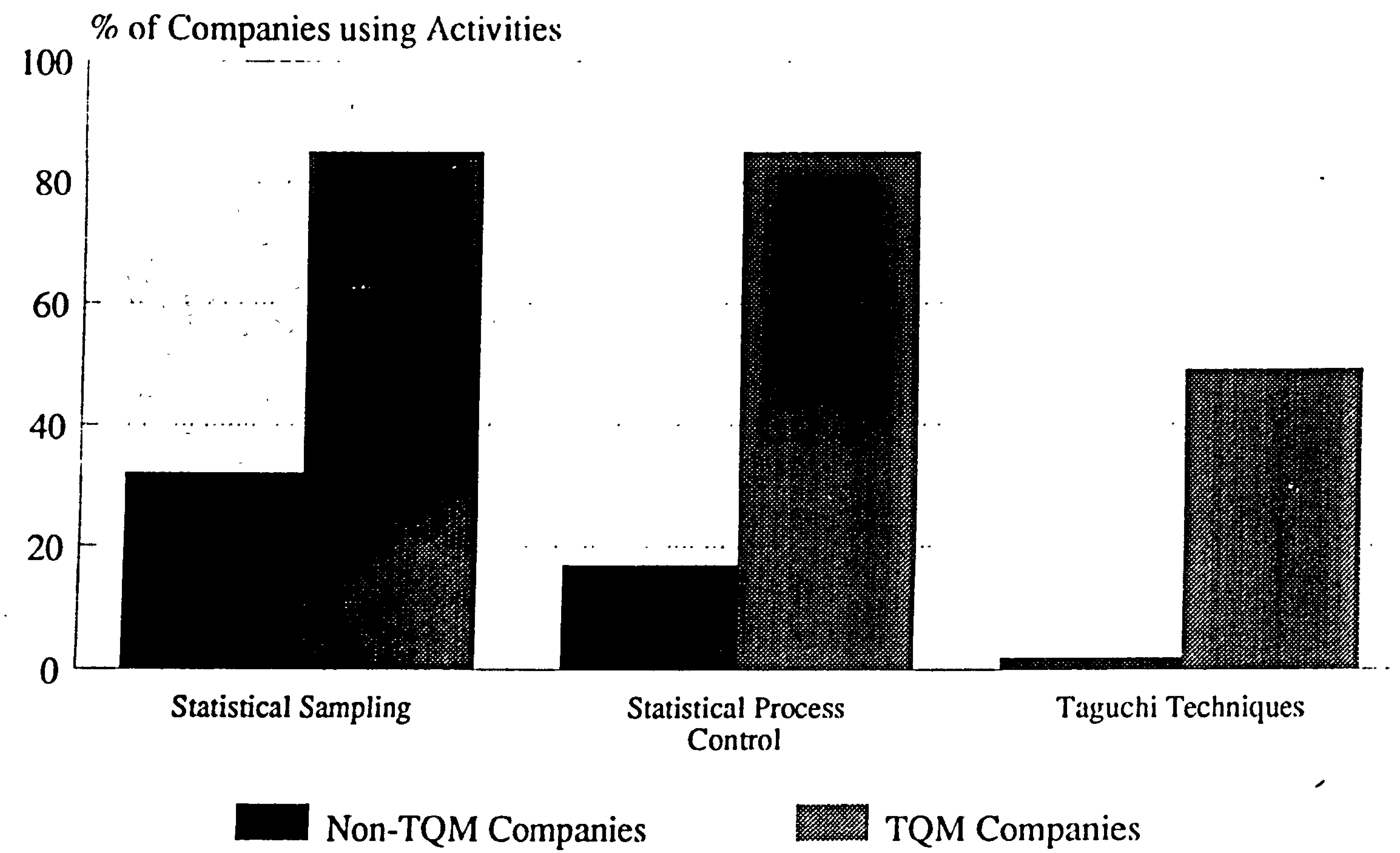
Human Function Activities



TQM vs Non-TQM

Fig 26

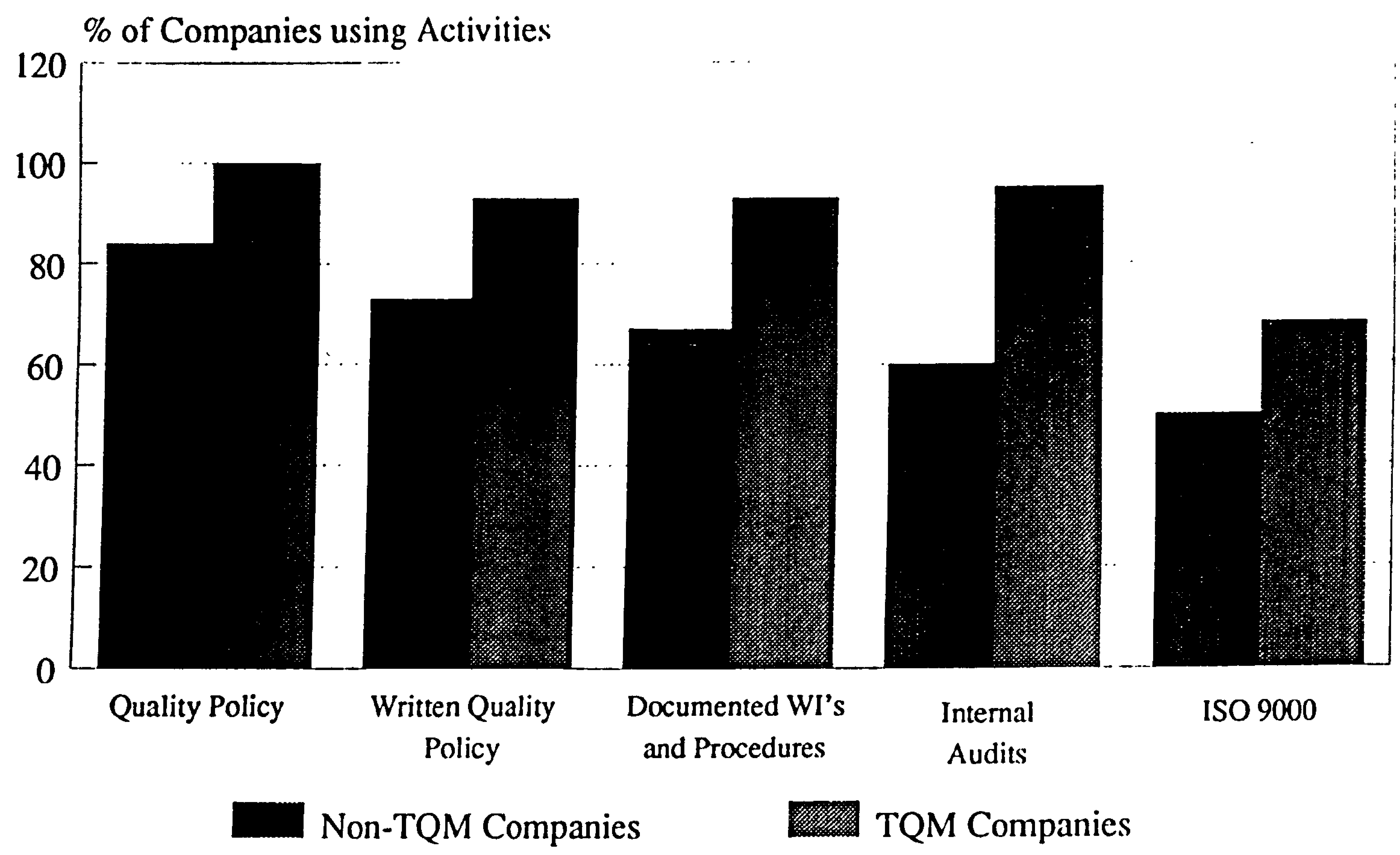
Statistical Function Activities



TQM vs NON-TQM

Fig 2c

Quality System Function Activities



	NUMBER OF RESPONSES	EMPLOYEE COMMUNICATION	DEPARTMENTAL COMMUNICATION	SUPPLIER COMMUNICATION	CUSTOMER COMMUNICATION	VENDOR PERFORMANCE	BUSINESS CONTROL	EMPLOYEE MORALE	QUALITY COSTS	PRODUCT QUALITY	
QUALITY IMPROVEMENT TEAMS	25	1.5 (1)	1.6 (1)	1.1 (2)	1.1 (2)	0.8 (3)	0.8 (3)	1.1 (2)	1.2 (2)	1.6 (1)	HUMAN FUNCTIONS
QUALITY CIRCLES	8	1.2 (3)	0.9 (3)	0.6 (5)	0.5 (5)	0.4 (5)	0 (6)	1.1 (2)	0.7 (5)	1.0 (4)	
SPC	21	0.9 (4)	0.9 (3)	1.1 (2)	0.9 (3)	0.9 (2)	0.6 (4)	0.6 (4)	1.3 (1)	1.3 (2)	STATISTICAL FUNCTIONS
TAGUCHI	9	0 (6)	0.2 (6)	0.1 (6)	0.3 (6)	0.1 (6)	0.4 (5)	0.3 (5)	0.9 (4)	1.0 (4)	
BS5750	7	0.9 (4)	0.5 (5)	0.8 (4)	0.9 (3)	0.5 (4)	0.9 (2)	0.1 (6)	0 (6)	0.4 (6)	QUALITY SYSTEM FUNCTION
TQM	30	1.5 (1)	1.5 (2)	1.3 (1)	1.5 (1)	1.1 (1)	1.3 (1)	1.2 (1)	1.2 (2)	1.3 (2)	

<u>Key</u> Central Box Numbers - These represent whether TQM Firms indicated that the techniques had an excellent (E), good (G), adverse (A) or no (N) effect on each factor 2 points were accredited to an E, 1 a G, -1 an A and 0 an N. The average of these points for each technique was then calculated.

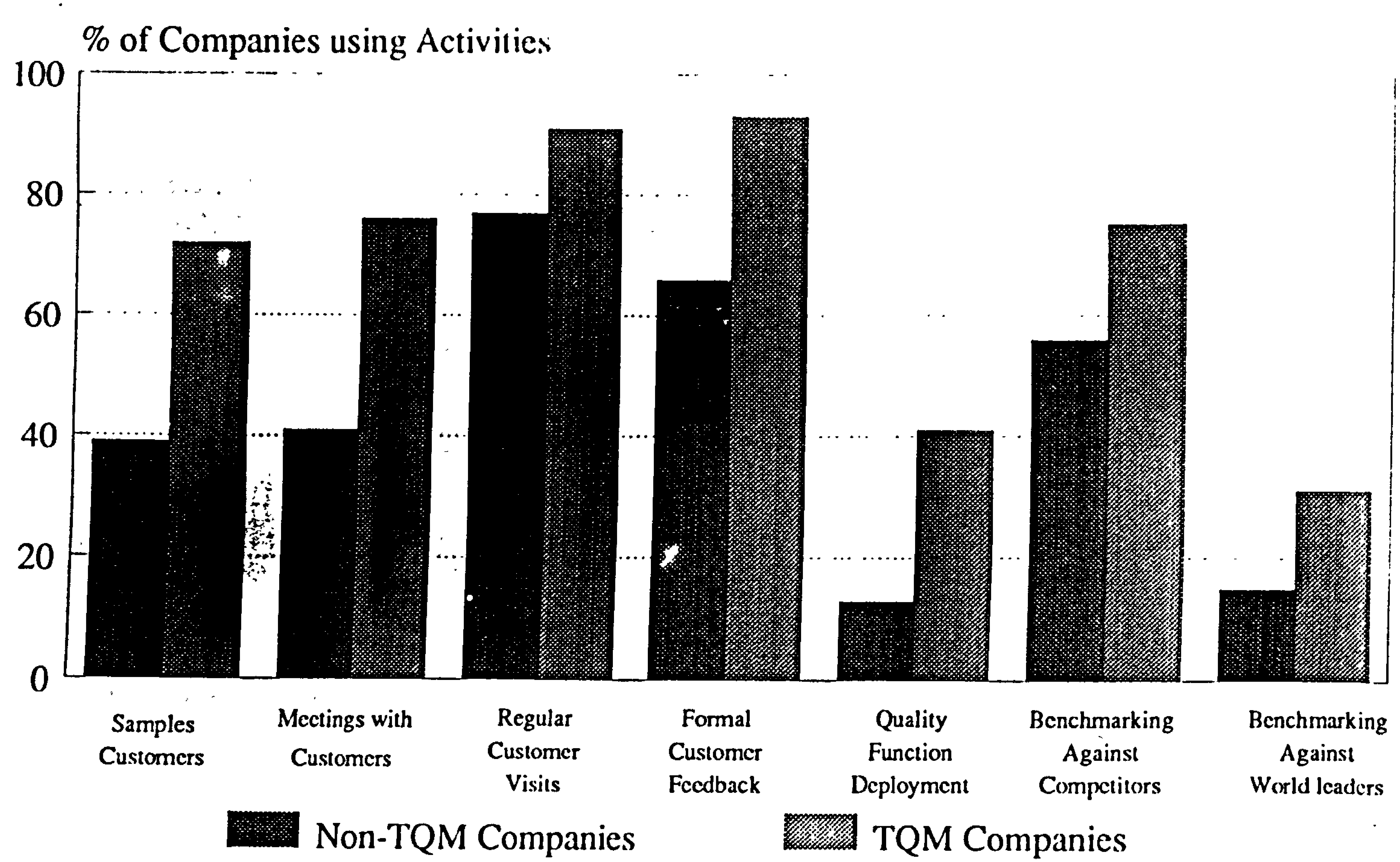
Right Hand Top Corner Box Numbers - These represent the ranking for each technique with regards to the organisational factors.

Table 1. The effects of quality improvement techniques on organisational factors.

TQM vs NON-TQM

Fig 3a

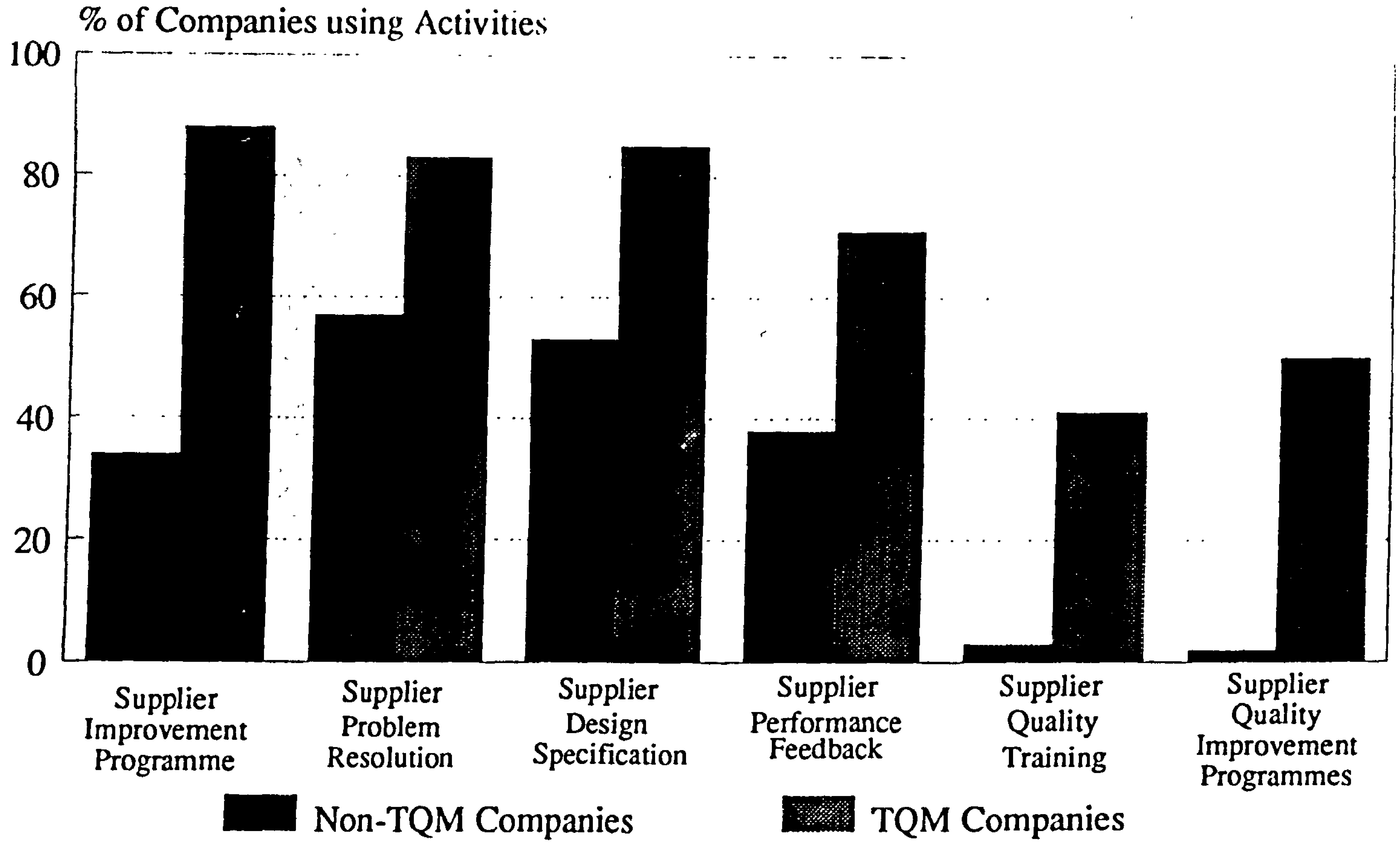
Customer Activities



TQM vs NON-TQM

Fig 3b

Supplier Activities



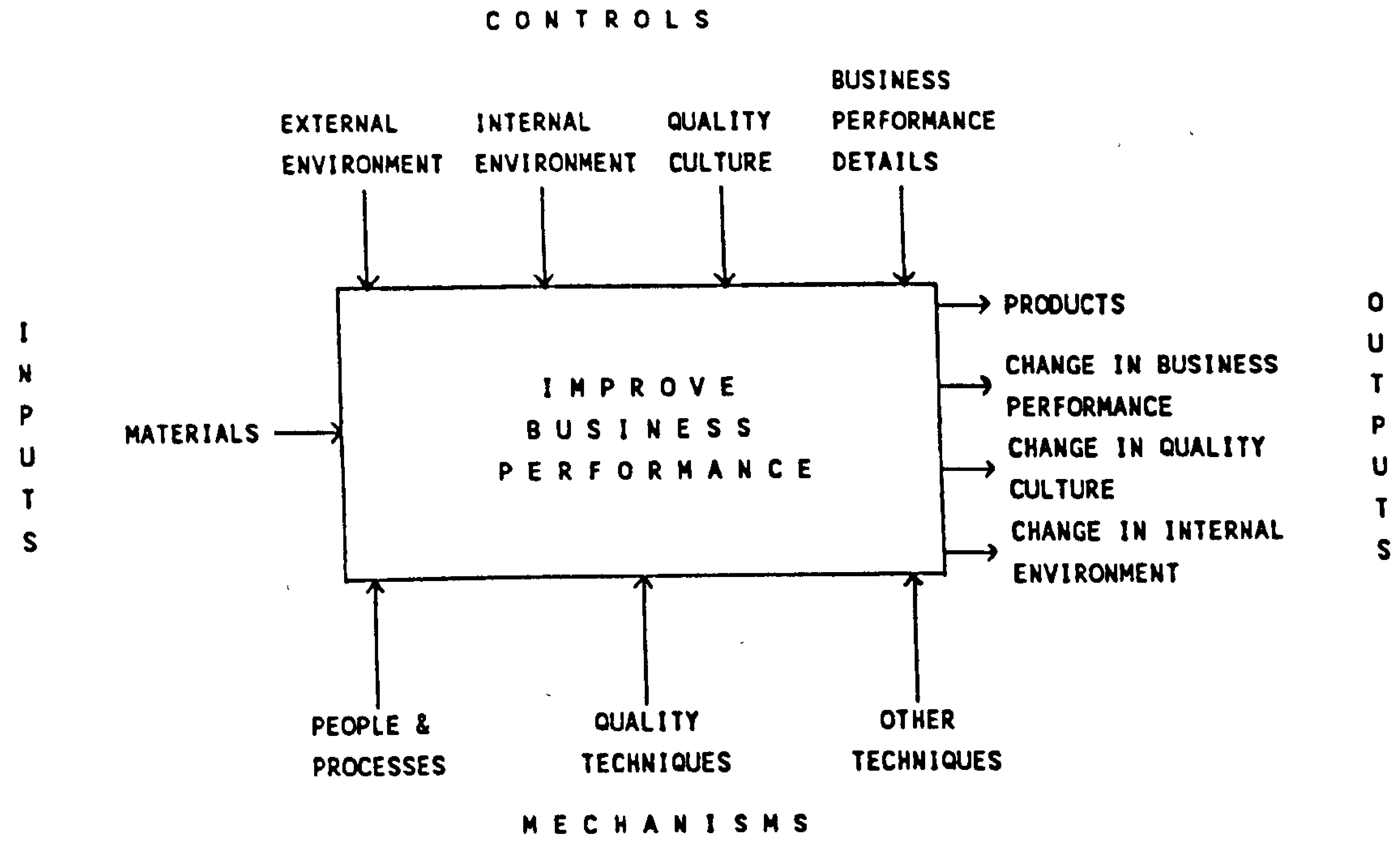


Figure 5. A Quality improvement model

ABSTRACT

Factors Affecting the Implementation and Success of TQM

by

Robin Mann and Dennis Kehoe

University of Liverpool

The importance of tailoring TQM to the specific needs of organisations is well known. This paper shows the findings of a research programme which investigated which organisational factors are important to consider when implementing TQM.

Questionnaires and structured interviews, involving the participation of over 200 companies, were used as the main tools for the investigation. As a result of the investigation 7 prime factors affecting the implementation of TQM were identified, these were:
- Process Factors;
- Type of Employees;
- Shared Values;
- Management Style;
- Organisational Structure;
- Number of Employees;
- and Industrial Relations.

It is recommended that organisations should give these factors consideration when developing their TQM approach. A guideline is provided, within the paper, to show how these factors are likely to affect the implementation of TQM.

INTRODUCTION

It is common sense that TQM should be tailored to an organisation's needs. Even so, little research has been conducted identifying which organisational factors should be considered when planning a TQM approach. The research undertaken at the University of Liverpool aimed to address this shortcoming. Research is shown which identifies the factors which most commonly affect the implementation of TQM. The paper then concludes by summarising how each factor can affect the 'level of implementation difficulty'.

Amongst the many quality practitioners who have stated that TQM needs to be tailored to the organisation were Atkinson [1] and Kees Van Ham [2] secretary general of the European Foundation for Quality Management. Atkinson stated 'organisations employ differing technology, have different histories and backgrounds, serve different markets with different products and employ people from different cultures, so the drive to improve quality has to be managed differently'. Kees Van Ham stated with regards to implementing TQM 'Organisations differ in terms of history, markets, style of leadership and cultural environment. This implies that every organisation has to develop, its own, unique way'.

The characteristics of an organisation can even affect the implementation of TQM at different sites within a company. This was emphasized by Van Der Akker [3] who described how TQM needed to be implemented differently within Aery Materials Group Europe due to the culture differences between the company's 8 manufacturing plants and 15 sales offices.

An organisation's level of quality development is one characteristic which is often cited as a factor to consider when selecting which method of implementation to use. The number of Quality Awards (European Quality Company Award; American's Malcolm Baldridge Award; Japanese's Deming Award), the different benchmarking Quality Databases and consultancy 'Health checks' are all indicators of the importance of this particular characteristic. Tito Conti, a major contributor and corporate quality director at Olivetti [4] stated 'To achieve continuous improvement, managers must know how to calculate the company's position since the last self-assessment was performed, and use their findings to plan the next part of the course - the next phase in improvement'.

As quality development is already well known as an important factor to consider (and is a subject in itself) it will not be discussed in detail within this paper. The research shown within this paper primarily concentrates on reporting the other, 'less obvious', factors which are important to consider when implementing TQM.

Research by Dale and Lascelles [5] has indicated the difficulty of such research. They investigated whether companies use techniques in any order or whether there is an ideal order in which to apply techniques. Through their studies they concluded that 'because of the variety of starting points and motivations for quality improvement it is not possible to identify an implementation plan detailing the order in which techniques should be used'. Whilst this is understood, it is believed that it is important to identify the most common factors which affect the implementation of TQM. The identification of such factors will encourage their consideration when companies are developing an appropriate implementation plan.

RESEARCH METHOD

In investigating which characteristics of an organisation affect the implementation of TQM the following terms were used:

The term 'Quality Activity' was used to describe a distinguishable tool or method used for quality improvement. These activities can range from control charts to IS0 9000 to TQM. TQM is considered to be a Quality Activity which is composed of many Quality Activities.

The term Quality Critical Organisational Characteristic was used to describe a characteristic that influences the effectiveness of a Quality Activity. For example, the level of education of employees, the organisation's management style, the organisation's prime manufacturing activity may all influence how beneficial it is to implement a Quality Activity.

From initial research involving over 200 companies participating in a 'Management of Quality' questionnaire programme (see Mann's PhD thesis [6]) it was identified that there were variations in the use of Quality Activities dependent on the characteristics of organisations. For instance, the following data showing the relationship between 'Number of Employees' and the implementation of TQM was obtained:

No. of Employees	No. of Companies in category.	% use of TQM
1-30	28	4
31-100	46	11
101-300	40	15
301+	27	27

This information indicates that companies with a large number of employees are more likely to have implemented TQM.

Findings such as this either show that:

a) certain types of organisations react more quickly to new ideas and methods such as the implementation of TQM,

b) TQM is more effective in certain types of organisations.

Further analysis of the questionnaire responses revealed that companies with different organisational characteristics rank the beneficial effects of Quality Activities differently. Unfortunately though, because of the complex inter-relationships between different organisational characteristics, it was too difficult to conclusively prove that particular Quality Activities were more effective in certain organisations.

Due to the difficulty of identifying QCOCs through using questionnaires a structured interview approach was adopted.

Structured interviews were undertaken at 21 leading TQM organisations between November 1990 to February 1991. Interviews involved the 'steerers' and 'planners' of TQM (therefore primarily Directors or Managing Directors). Questions investigated the factors affecting the success of TQM and other Quality Activities. Interviews were approximately three hours long. Further details on the companies visited can be obtained from Mann's PhD thesis [6].

The prime method used to investigate for QCOCs was to ask the interviewee directly which characteristics of their organisation influenced the implementation or effectiveness of a Quality Activity. This was followed by further questioning obtaining details on the difficulties experienced when implementing Quality Activities. After all the interviews had been conducted similar factors affecting the implementation of Quality Activities were grouped together enabling the identification of the most common QCOCs.

In investigating for QCOCs a number of important factors were identified:

a) *All QCOCs change with time.* For example, with time, the leadership style may change from authoritative to participative, the average employee age may increase, the method of manufacture may change from batch to mass production and so on. These changes are likely to affect which QCOCs are quality critical at one particular time.

b) *QCOCs vary for each Quality Activity.* For example, factors such as an organisation's method of manufacture, technological sophistication and level of product contact were identified as affecting the implementation of SPC but not the implementation of delegated teams (management led teams). Conversely organisational stability was mentioned as affecting delegated teams but not SPC.

c) *QCOCs vary dependent on the stage of Quality Activity development.* For example, trade unions were cited as a QCOC primarily in the initial implementation of TQM. Once TQM is implemented they usually cease to be a QCOC or a major factor in its success.

As a general guideline, one can distinguish between QCOCs affecting the 'implementation' and 'operational' stages of a Quality Activity. In the context of the research the definition used for Quality Activity implementation was 'the period of time between the planning of a Quality Activity to when the Quality Activity becomes operational. Operational describes the period from when the Quality Activity becomes embedded within the organisation and is self-sustaining'.

As QCOCs were found to vary based on the Quality Activity and stage of Quality Activity development the investigation concentrated, as it proceeded, on identifying the QCOCs affecting the implementation stage of TQM. An in-depth investigation of all the different Quality Activities (65 were identified by Mann & Kehoe [7]) was not feasible within the constraints of the research programme.

QCOCs AFFECTING THE IMPLEMENTATION STAGE OF TQM

Figure 1 shows the 24 Secondary QCOCs which were identified as affecting the implementation of TQM. These were then categorised into seven primary QCOCs for clarity.

Initial analysis indicated that these QCOCs were also the ones affecting the operational stage of TQM, although the degree with which each QCOC affected TQM differed. A detailed analysis of the QCOCs affecting the operational stage of TQM was not undertaken as:
1) most structured interview questions referred to the implementation stage of TQM;
2) only approximately half of the companies had entered the operational stage of TQM and of these most had only recently completed the implementation.

TAKE IN FIGURE 1

Figure 2 shows the percentage of interviewed companies which reported each factor as a QCOC. The most commonly reported factors were middle management's attitude to change and trade union support.

TAKE IN FIGURE 2

Figure 3 summarises the information in Figure 2 by showing the percentage of companies which indicated that at least one secondary QCOC from the primary QCOC categories affected the implementation of TQM. The most common QCOCs which affected the implementation of TQM were categorised as management style and the shared values of the organisation.

TAKE IN FIGURE 3

Due to the nature of the investigation, it was not possible to quantify the level of criticality of each QCOC (the extent to which each characteristic influenced the effectiveness of TQM). If the level of criticality was quantified, it is believed that, the responses to the structured interview question "What did you feel were/are the main threats to TQM?" would be the prime QCOC factors. This question revealed organisational stability and management commitment were the main threats to TQM.

These two threats were described clearly by one interviewee, 'TQM was initiated through a new managing director but it declined due to the backers/supporters leaving. TQM hadn't had time to settle and become ingrained into the company", he then went on to explain that, "the driving force for the teams was taken away with the merger and the reorganisation although there was some success. They basically though had little chance to succeed."

DIFFICULTY IN IMPLEMENTING TQM

Figure 4 shows the 'level of difficulty' an organisation can expect when implementing TQM. For each QCOC and for three measures of quality development the extreme conditions which are likely to cause a low and high implementation difficulty are given.

TAKE IN FIGURE 4

It is recommended that organisation's evaluate their 'level of difficulty' with regards to these factors. By identifying their most critical factors, methods can then be developed to minimise the difficulty. For instance, in situations where there is a high implementation difficulty it may be advisable for the management board to play a more prominent role in the implementation.

A number of companies, in a 'high level of difficulty' situation, decided that their management board needed to be fully involved not only in the steering of TQM but also its execution. This meant their involvement in lower level teams, education and training and recognition activities. They felt that their management needed to be 'seen' to be committed to TQM.

The remainder of this section will describe in greater detail each QCOC and how they can affect the implementation of TQM. These findings summarise the most common experiences of the 21 companies interviewed.

1. Process Factors

a) Method of Manufacture

An organisation's method of manufacture can hinder the application of Quality Activities. Traditional production methods and manufacturing layouts may encourage job specialisation and menial repetitive work. In these circumstances it may be difficult for employees to become actively involved in the improvement of work processes. It is though important, that they are involved in the TQM effort, to prevent any feelings of alienation. Many organisations are surprised how employees, given the correct support (particularly resources) and encouragement, can make an active contribution to the organisation and their working environment.

2. Type of Employees

The diversity of employees can present problems when implementing TQM. By considering the needs of all employees, as shown below, TQM can be more effectively implemented.

a) Skill Level

Highly skilled employees are likely to accept TQM more quickly than lower skilled employees. They are less likely to feel threatened by proposed changes and are more likely to understand their need. Improvements in cross-functional communication between these employees should assist the organisation in meeting its aims.

b) Level of Education

Employees with a high level of education are likely to accept TQM more quickly. A number of interviewees believed that individuals with a high level of education are more likely to judge TQM by its results rather than through its publicity. Whatever the level of education it is important to note that publicity and posters may be viewed cynically and can create high expectations which are difficult to meet.

c) Length of Employment

Employees who have worked in a organisation for a long time can be the hardest to convert to TQM. They are likely to have witnessed many new management approaches and initiatives. If these approaches were not as successful as expected, then these employees are likely to be sceptical towards the implementation of TQM. The most effective method of converting these employees to TQM is through their involvement in Quality Activities which produce improvements.

With regards to job ownership often employees who have worked in a certain position for a number of years do not want any increased responsibility. New responsibilities for some employees may cause distress. It is therefore important to consider the requirements of these employees.

d) Age Distribution of Employees

An 'old' workforce may not accept change as quickly as a 'young' workforce. An 'old' workforce may feel threatened at having to learn new responsibilities and use new work methods. It is therefore important to have a comprehensive education and training programme tailored to their needs. A gradual approach to TQM which gains their confidence, may be appropriate.

e) Employees Level of Product Contact

Employees in close contact with the product are more likely to accept TQM. This is because Quality Activities are typically associated with products rather than people or non-product processes. For this reason it is important in the planning of TQM to discuss how TQM will be implemented in low product contact areas (such as Staff Areas). A solution would be to develop specific training programmes for these areas providing practical applications of relevant Quality Activities. Quality Activities concentrating on improving the service (product) between internal suppliers and customers may be appropriate.

3. Shared Values

a) Employees Attitude to Change

A positive attitude by employees to change assists in the implementation of TQM. A negative attitude can be changed through education and training and the involvement of employees in Quality Activities which result in improvements. After the implementation of an education and training programme it is important that involvement shortly follows otherwise employees may become disillusioned.

The setting up of a communication structure between management and employees can help to alleviate problem situations. The organisation should aim to install a culture whereby employees recognise problems and solve them anonymously.

b) Business Performance

The relationship between business performance and TQM acceptance is complex.

Organisations with an excellent business performance may accept the need to change as a necessary prerequisite for success or alternatively employees may react against TQM as they fail to understand the need to change a successful system. Similarly organisations in a 'survival situation' may act positively to change as 'it's their last chance' or negatively due to previous poor experiences. The attitude of the employees, due to the organisation's business performance, should be considered when deciding the rate of implementation.

c) Organisation's Age

TQM is likely to be more quickly accepted in a 'new organisation' or a 'young organisation' rather than an established organisation. A new organisation or a young organisation can introduce TQM as a natural element of their organisation. An established organisation may need to change its QCOCs such as its shared values and managements style, which have developed over many years.

d) Work Methods

Employees used to traditional working methods such as 'production make it and quality inspect it in' are likely to find it initially difficult to accept the TQM concepts. These employees have probably been educated and trained in the values of job specialisation, delegation, inspection and control. Now the same management is advocating new values and new methods.

In contrast, employees using new technology are more likely to have experienced changing work methods. The experience of new work methods should encourage a more open attitude to new concepts such as TQM.

e) Understanding of Quality Improvement Need

Employees who understand the need for quality improvement are more likely to accept TQM. For this reason, acceptance is likely to be high for organisations with a high level of quality development which have witnessed the benefits of Quality Activities.

f) Salary

Employees with poor salaries are less likely to be enthusiastic for TQM. These employees are likely to feel undervalued by top management and will be suspicious of any new approaches. Organisations using a performance appraisal system will probably need to change the appraisal system to support the aims of TQM.

g) Working Conditions

Employees working in poor working conditions are less likely to be enthusiastic for TQM. These employees are likely to feel undervalued by top management and will be suspicious of any new approaches.

4. Management Style

a) Top Managements Attitude to Change

It is essential that prior to TQM implementation all members of the board support the proposed approach. If the Managing Director or board do not demonstrate their total commitment and total involvement in TQM then it is at risk. The top managers/directors need to be 'Champions of Quality'.

b) Middle Managements Attitude to Change

Middle management can be difficult to convert to TQM. Many may have been with the organisation for a number of years and are used to a certain style of management. It may be difficult for them to give greater responsibilities to employees and change to a more participative style of management. In addition they themselves may be controlled more by the incoming TQM structure.

To gain the middle managements commitment and confidence in TQM an education and training programme must address their needs and a support structure needs to be developed to assist them through the change period. Without the total commitment of middle management, team building and employee involvement will be affected.

c) Junior Managements Attitude to Change

Junior managers can have the same problems as middle managers in accepting change. Those used to fire-fighting and delegating to employees may have difficulty in changing to a more participative style of management. As they are often the direct link between employees and management it is important that they fully understand TQM. As the management style of junior managers is typically not as developed as middle managers they are likely to accept TQM more quickly.

d) Leadership Style

TQM aims to encourage a participative style of management throughout the organisation. An organisation with a participative style of management is likely to be more enthusiastic towards TQM and will have less need to change its systems and communication structure. Organisations with an authoritative style of management, whereby employees/managers are promoted who are aggressive, self-career minded and not team workers are likely to find it more difficult.

To achieve a participative management style it may be at first necessary to use an authoritative leadership style to implement TQM. This may consist of delegating and monitoring the performance of Quality Activities. Through the implementation of Quality Activities, such as teams, and top management leading by example, a more participative style of management can develop.

e) Management Planning

Organisations driven by short term planning may find it difficult to change to TQM where the emphasis is on long term planning. Rewards, such as promotion for quick results involving fire-fighting, need to be redirected to rewards for prevention and participation activities. Long term planning can begin by implementing a comprehensive education and training programme.

f) Departmental Interaction

Organisations which are function orientated and/or encourage specialisation may have difficulty in converting to TQM. Barriers to departmental interaction, such as departmental rivalry, need to be removed in order for TQM to operate successfully. Teams or new systems which concentrate on improving cross-functional integration can help to achieve this.

5. Organisational Structure

a) Organisational Structure Description (No. of Sites)

TQM is generally easier to implement within one site than in a number of sites. The larger the number of sites the greater the difficulty of controlling its implementation and developing an integrated approach to TQM (if required). The greater the number of sites the more likely they will differ with regards to QCOCs and quality development.

It is important that organisation's develop a TQM approach which complements their organisational structure. For instance, an organisation consisting of a number of sites needs to decide whether to implement a fragmented approach (allowing each site to develop its own approach independently) or an integrated approach. Both approaches have advantages and disadvantages.

A fragmented approach encourages sites to pursue and tailor TQM to their own needs. With such an approach TQM is likely to progress at different rates on each site and the corporate/divisional boards control is likely to diminish. In contrast, an integrated approach provides a greater structure and control over each site for the corporate/divisional board. The advantage of this approach is that an imposed structure reduces the likelihood of poor implementations occurring by ensuring there is a similar level of management commitment at each site. The main difficulty of this approach is to develop a cohesive strategy which considers the specific needs of each site whilst maintaining a similar rate of progress across all sites.

b) Stability of Organisational Structure

If the organisational structure is stable then TQM will be easier to implement. An unstable organisational structure can threaten the implementation of TQM. Changes in organisational structure, such as the merging of two sites, will attack the structural elements of TQM already in place, like delegated teams. The departure of committed TQM personnel, particulary members of the site board, can threaten the impetus and drive for TQM.

c) Geographically Integrated

Organisations implementing TQM into sites geographically distanced from each other may find it more difficult to implement an integrated TQM approach. The physical distance between sites may hinder the transfer of information and weaken the effect the corporate boards leadership style and approach has on each site. In addition sites geographically distanced are likely to have different QCOCs due to the effect of the local environment on the organisation's employees.

6. No. of Employees

Generally the smaller the number of employees the easier it is to implement TQM. At smaller sites the steerers of TQM (usually the management board) are more visible and have less employees to manage and involve in TQM. This may mean a less detailed and sophisticated implementation structure is required to ensure employee participation and to improve business performance.

7. Industrial Relations

Organisations with poor industrial relations are likely to find it more difficult to implement TQM. Trade unions will be suspicious of TQM and the changes that may occur. This suspicion can be overcome by involving trade unions from the start either in the appraisal or planning of TQM. The involvement of trade unions will help in the acceptance of TQM by all employees.

Quality Development

Organisations with a high level of quality development are likely to be enthusiastic towards TQM. These organisations will understand the need for quality improvement and are therefore less likely to require as much training and education. They will be able to implement TQM more quickly.

It is important that Quality Activities presently being used are integrated within the TQM approach. This will ensure they do not become isolated with regards to the allocation of resources and can still operate successfully.

CONCLUSIONS

The most common factors affecting the implementation of TQM have been identified. It is recommended that organisations analyse themselves in terms of these QCOCs before implementing TQM. The information from such an analysis can help in determining which implementation approach to use and how quickly it should be implemented.

The findings have shown that there is a complex relationships between organisational factors and Quality Activities. The organisational factors which are critical to a Quality Activities success may:

- change with time;

- vary for each Quality Activity;
- vary dependent on the stage of Quality Activity development.

It is hoped that, in the future, research will concentrate on exploring these relationships in greater detail and:

- identify the most common 'quality critical' organisational factors for each Quality Activity;
- evaluate the level of criticality of each of these factors;
- and investigate the relationships between changes in criticality with changes in an organisation's level of quality development.

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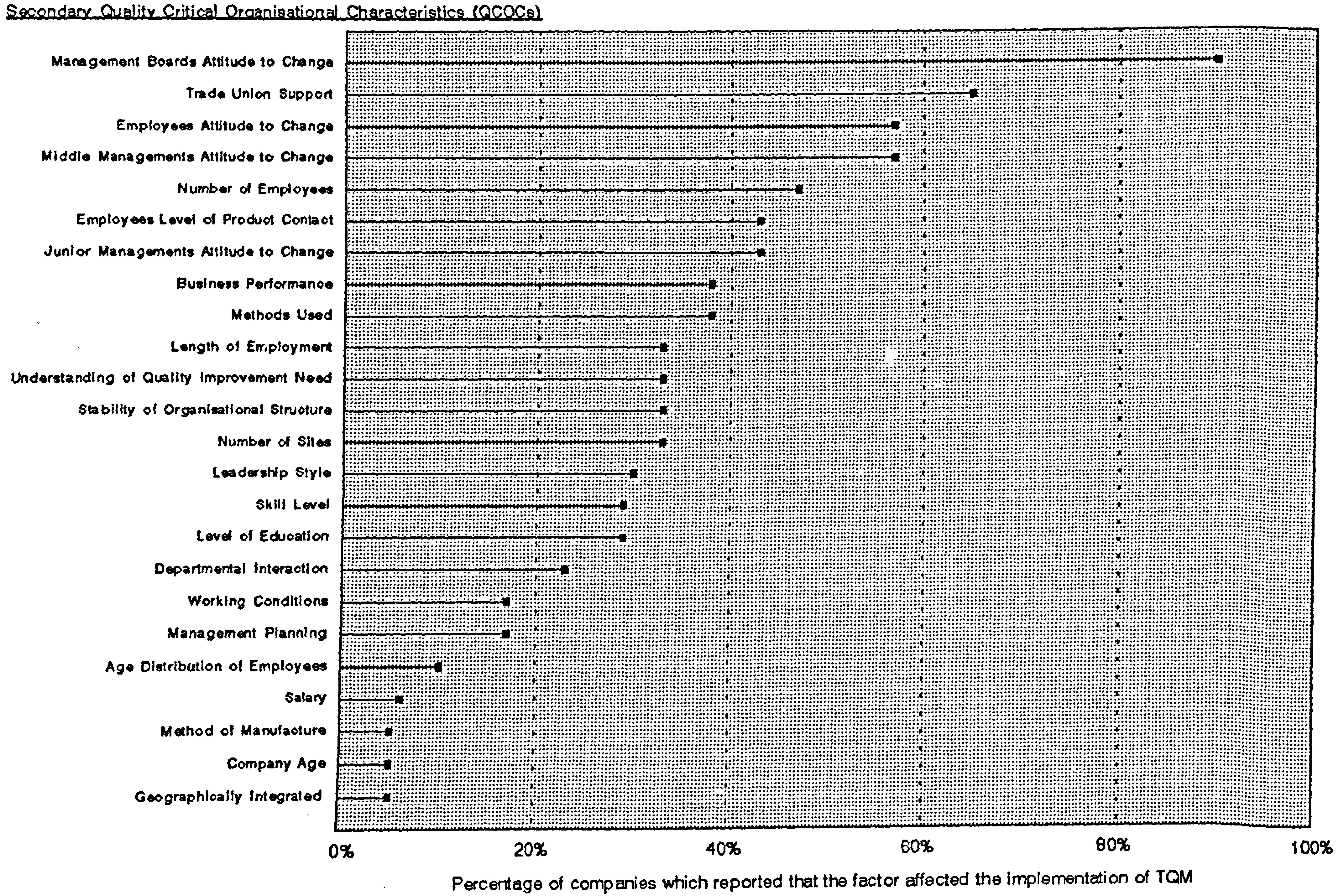
Figure 1 - The QCOCs Affecting the Implementation Stage of TQM.

Quality Critical Organisational Characteristics	
Primary QCOCs	**Secondary QCOCs**
I. Process Factors	1. Method of Manufacture
II. Type of Employees	2. Skill Level 3. Level of Education 4. Length of Employment 5. Age Distribution of Employees 6. Employees Level of Product Contact
III. Shared Values	7. Employees Attitude to Change 8. Business Performance 9. Organisation's Age 10. Methods Used 11. Understanding of Quality Improvement Need 12. Salary 13. Working Conditions
IV) Management Style	14. Management Boards Attitude to Change 15. Middle Managements Attitude to Change 16. Junior Managements Attitude to Change 17. Leadership Style 18. Management Planning 19. Departmental Interaction
V. Organisational Structure	20. Organisational Structure Description (No. of Sites). 21. Stability of Organisational Structure 22. Geographically Integrated
VI. Number of Employees	23. Number of Employees
VII. Industrial Relations	24. Industrial Relations

Figure 1 - Secondary QCOCs Affecting the Implementation Stage of TQM



Note. 21 companies were interviewed.

Figure 3 - Primary QCOCs Affecting the Implementation of TQM

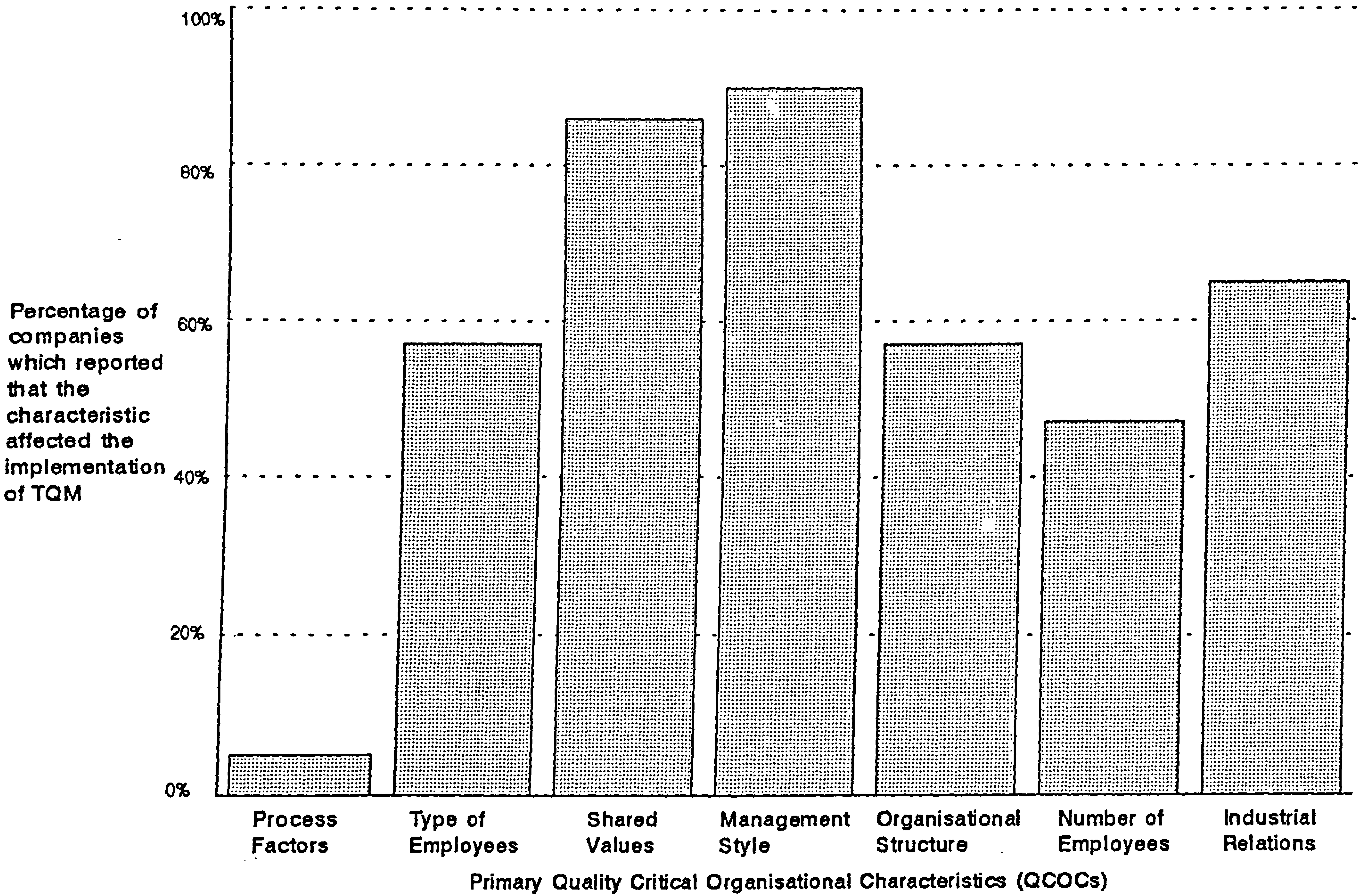


Figure 4 - The Expected Difficulty of Implementing TQM with regards to QCOCs and Quality Development.

	LOW<--------Expected difficulty of implementing TQM--------->HIGH	
1. PROCESS FACTORS		
a) Method of Manufacture	- flexible, low level of job specialisation	not flexible, high level of job specialisation
2. TYPE OF EMPLOYEES		
a) Skill Level	- high	low
b) Level of Education	- high	low
c) Length of Employment	- short	long
d) Age Distribution of Employees	- young (18-30yrs old)	old (50-65yrs old)
e) Employees Level of Product Contact	- high	low
3. SHARED VALUES		
a) Employees Attitude to Change	- positive	negative
b) Business Performance	- excellent	poor
c) Organisation's Age	- new organisation	established organisation
d) Methods Used	- new technology	traditional
e) Understanding of Quality Improvement Need	- high	low
f) Salary	- high	low
g) Working Conditions	- excellent	poor
4. MANAGEMENT STYLE		
a) Management Boards Attitude to Change	- positive	negative
b) Middle Managements Attitude to Change	- positive	negative
c) Junior Managements Attitude to Change	- positive	negative
d) Leadership Style	- participative	authoritative
e) Management Planning	- long term	short term
f) Departmental Interaction	- excellent (no barriers)	poor (barriers)
5. ORGANISATIONAL STRUCTURE		
a) Organisational Structure Type	- one site	high number of sites
b) Stability of Organisational Structure	- stable	unstable
c) Geographically Integrated	- integrated	fragmented
6. NUMBER OF EMPLOYEES		
a) Number of Employees	- small	large
7. INDUSTRIAL RELATIONS		
a) Industrial Relations	- excellent	poor
QUALITY DEVELOPMENT		
a) Level of Quality Development	- high	low
b) Quality Activities	- many	none
c) Integration of Quality Activities	- integrated	fragmented

PART 1 - A SYSTEM FOR THE MEASUREMENT OF QUALITY POSITION IN UK MANUFACTURING INDUSTRIES

(1) Introduction

The importance of Total Quality Management (TQM) is recognised worldwide. There have been numerous articles and books on TQM, written mostly by experienced Quality practitioners. Many of these describe how quality should be implemented and managed in the organisation. Saraph et al (1989) and Mann (1992), after a thorough review of the literature, had identified a set of key elements which make up the TQM body. One of the elements identified by both authors is that of the need for a quality measurement system.

A number of quality measurement systems are already in use. These can be grouped into several categories - the 'Award' measurement system, the 'Supplier Assessment' measurement system, the 'Statistical Data' system, the 'Conventional Performance Measurement' system, and 'Benchmarking'. The 'Award' measurement system includes the Malcolm Baldrige Award, the Deming Prize, and the European Quality Award, while an example of the 'Supplier Assessment' measurement system is the ISO 9000 quality system standard. A more elaborate account of these can be found in Mohd Zain (1993).

After a review of these systems have been made, it was found that while they function satisfactorily to the organisations which use them, they have several shortcomings when used strictly in the quality position measurement sense. Hence, an alternate system is required to be used in conjunction with the systems. This alternate system should ideally:

- be a self-assessment assessment mechanism,
- uses the performance of the industry as its basis of comparison,
- have a strong statistical correlation with business performance,
- retain industry relevance (ie. it has an industry *sector* dimension to it), and,
- possess a developmental orientation (ie. it can be used again over time).

Hence, research was undertaken to:

- develop a system which meets the above criteria, and,
- collect and analyse data to validate the proposed system

The new system proposed is called the Quality Measurement System (QMS). It will be seen that the QMS complements the systems which are already available so that when used side by side, a more complete potrayal of the overall quality position of the organisation can be determined.

A lengthy preparation was involved in the development of the QMS. This paper is the first of a 2-part report which describes to some detail the QMS system and its developmental procedure. In this paper, the QMS is described in 3 parts - the *elements,* the *instrument,* and the *final product.* These entail the overall make-up of the QMS. In each of these parts, the developmental process is briefly explained.

(2) The Elements of the QMS

Because the elements were to become the quality indices which would be used to measure the quality position of the organisation, their proper selection was of extreme importance. According to Juran (1983), "Quality features must serve a wide spectrum of quality needs : technological, departmental, managerial, and so on." He categorised the "species of units of measures" as *technological, product performance, errors and failures, functional department performance measures, upper management level,* and *evaluation of managers' performance on quality-related activities.* Juran felt that these indices should fulfil as many of the following requirements as possible:

- they provide "an agreed basis for decision making",
- they are understandable (ie. they should not lack 'standardised meaning'),
- they are to be applied across various functions,
- they are "susceptible to uniform interpretation",
- they are "economic to apply", and,
- they are "compatible with the existing designs of sensors".

Using the above as a basis, the initial selection of the elements adhered to the specifications outlined below:

The elements:

- should be related to the basic manufacturing organisation's functional structure,
- should consist of indices which were able to be extracted from information which were, as far as possible, readily available, and,
- should be consistent with the current quality thinking.

The selection of the elements was based primarily on extensive discussions with members of both the industry as well as the academia, and a review of the literature. After the selection, the elements were then subjected to a series of validation exercises. Figure 1 shows the basic building blocks which assisted in the development of these elements. The elements are broadly grouped into Areas, which consist of:

(1) General Quality Orientation,
(2) Quality Costing,
(3) Operations,
(4) Customer,
(5) Research and Development,
(6) Human Resources, and,
(7) Supplier.

In many respect, these Areas match with the areas addressed in the other measuring systems stated previously. In Figure 2, a comparison of the elements in the QMS and the Malcolm Baldrige Award is made.

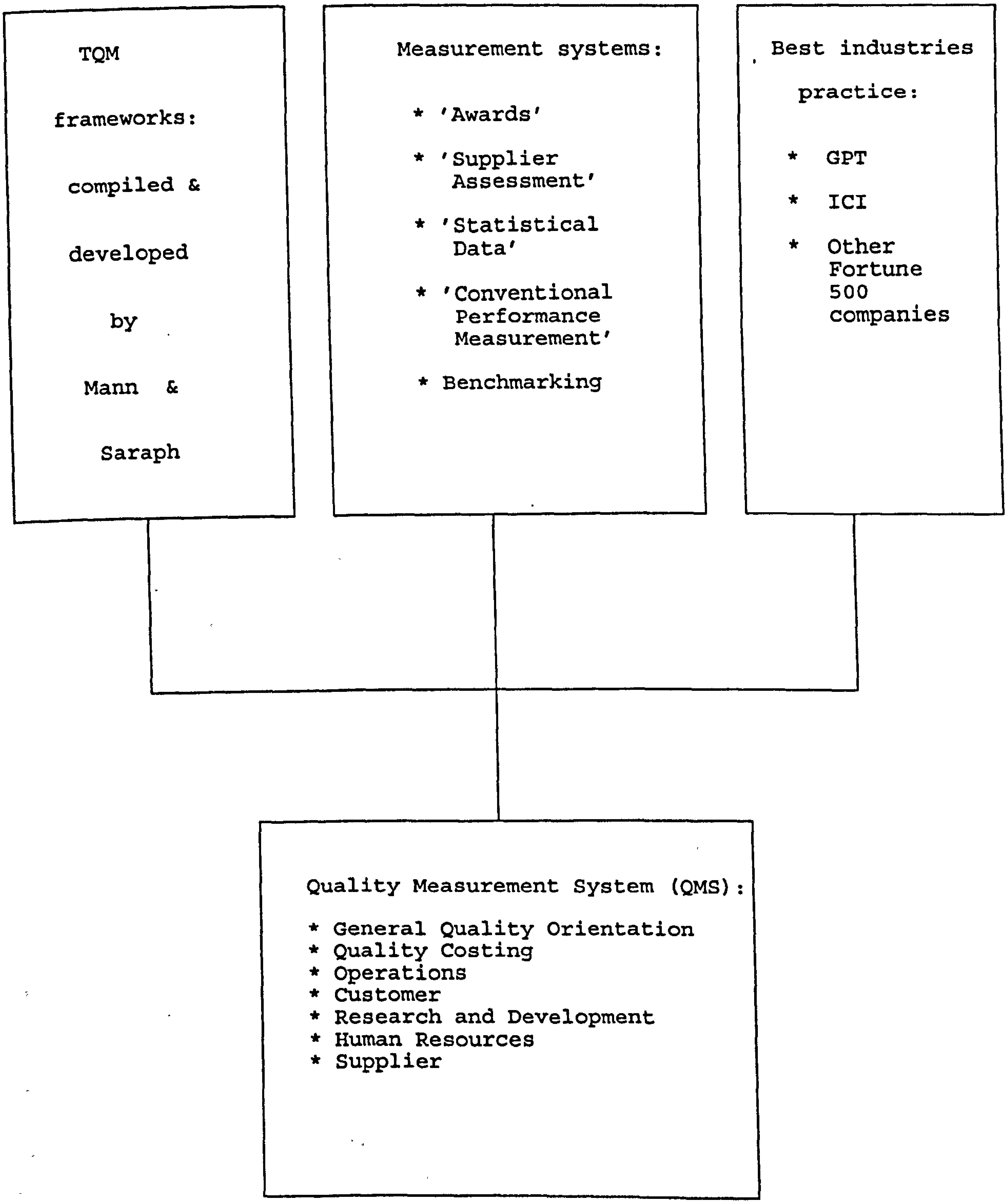


Figure 1 - The basic building blocks which assisted in the development of the Elements in the QMS

(3) The Instrument

The "instrument" is defined as the *tool* used to extract the information specified by the elements. It was recognised that without a "proper" tool, the information regarding the elements would be of little use. "Proper" is defined as being "valid" . The instrument for the extraction of information is the *questionnaire*. Figure 3 lists the elements of the QMS, taken from the questionnaire.

(4) The Final Product

The "final product" is defined as the resultant System, in its ready-to-use state. This consists of the instrument in the form of a questionnaire, a specified method of analysis, a specified method of presentation, and the Revisional Cycle Programme (RCP) which looks into further improving the overall Quality Measurement System. Descriptions of the method of analysis, the method of presentation, and the Revisional Cycle Programme are given below.

(4.1) The Method of Analysis

The questionnaire consists of all the elements, grouped into their respective Areas. For example, the element "number of quality performance indicators used at corporate level" is question no. 5, and it belongs to the Area "General Quality Orientation". Respondents would appropriately answer this question based on the number of quality performance indicators used in their organisation. As part of the Revisional Cycle Programme, the questionnaire is to be continually improved as more data and experience are accumulated in time.

The method of analysis is a scoring system which is based on the "Averaging Technique". This technique uses the average data in the particular industry as the mid-point between the highest score of 10, and the lowest score of 1. If, for example, the average number of quality performance indicators used in the Food industry is 4, then, a Food company which uses 4 quality performance indicators will awarded the average mark, which is 5 (taken as the mid-point between 10 and 1). On the other hand, if a company uses 11 quality performance indicators, and this happens to be the highest number of indicators used in the Food industry, then this company will be awarded 10 marks, which is the maximum score. If a company uses 6 quality performance indicators, then the mark that will be awarded to this company is 6.43. This is based on a calculation which assumes a simple linear relationship between "quality position" (ie. the score) and the number of quality performance indicators used. A detailed description of this technique can be found in Mohd Zain (1993).

After the award of marks utilising the averaging technique, the scores will then be further processed. Before this treatment is described, some background information to the basis of this treatment is in order.

As mentioned previously, the elements in the QMS are grouped into 7 broad Areas, the Areas being related to the basic manufacturing organisation's functional structure. Within each Area, the elements can be subgrouped into two - activities which constitute "effort", and activities which constitute "results". "Effort" refers to quality *initiatives* put in, while "results", the tangible *results seen*. This subgrouping was initially incorporated to study the correlation between quality efforts put in, and the tangible outcome. In the course of the investigation, unfortunately, it was found that this correlation study was too huge a task to carry out within the limited framework of the research programme. However, the "effort/result" structure was maintained.

Going back to the further treatment of the scores, each element in the QMS is firstly weighted according to its impact on the overall quality status of the organisation. This uses the assumption that certain quality activities contribute more towards the overall organisational quality status than other activities. The smallest quality activity contributor is given Classification X, while the largest contributor, Classification Z. Classification Y is given to the quality activities which give an impact between that of the ones in Classifications X and Z. Figure 4 denotes the classifications of all the elements. 'ARUBS' and 'Mini-Questionnaire' form part of the Validation Process which is further elaborated in Part 2 of this paper.

Utilising the classification described above, every element can now be put into its respective X, Y, or Z groupings, each being either in its "effort" or "results" categories. In other words, there are two groupings involved here -- the first is whether the element is in the "effort" or "results" categories, and the second being in the X, Y, or Z classifications. It has to be noted that the broad divisions of the 7 Areas described above is still maintained, as it will be, throughout the analysis of the scores.

Once all the elements are put into their respective groupings and subgroupings, the scores of each element is then added, and this summation is then multiplied by a factor of 1 (for Classification X), 2 (for Classification Y), and 3 (for Classification Z). An addition between the various Classifications in the same Area is then performed.

An illustration of this procedure should clarify this lengthy explanation. For this purpose, the Area of Research & Development is looked into. The elements in this Area are "number of R & D researchers" (designated "TN04"), "number of design techniques used" ("TDEST"), "efficiency of the design process" ("TCEK"), "guarantee period" ("TGUA"), "frequency of new product introduction into the market place" ("TCEK"), "number of major changes made" ("TCHA"), and "timelapse between design release and product release to customer" ("TDESC"). The elements are now grouped into their respective categories of "efforts"/ "results". Those which belong to the same Classification (X, Y, or Z) are added first, and then multiplied with their respective factors.

- R&D Effort - Y Classification : (TN04 + TDEST) * 2
- R&D Results - X Classification : (TCEK) * 1
- R&D Results - Y Classification : (TGUA + TNEW + TCHA) * 2
- R&D Results - Z Classification : (TDESC) * 3

This is then followed by addition between various Classifications in the same Area:

- R&D Effort : (TN04 + TDEST) * 2 (no change from above)
- R&D Results : [(TCEK) * 1] + [(TGUA + TNEW + TCHA) * 2] + [(TDESC) * 3]

Part 1 - General Quality Orientation

Q1a Does your company have a quality policy?
* yes, but not in writing
* yes, in writing
* no quality policy

Q1b If yes, in what year was the policy introduced?

Q3 Do you keep yourself up-to-date with matters relating to quality appreciation (attending quality seminars, membership with quality related bodies, etc)?

Q4 Has the company been listed for BS5750/ISO 9000? Yes/No

Q4a If yes, in what year was the company first awarded the above?

Q5 Which of the following internal quality performance indicators are formally monitored at corporate level on a regular basis?
* reject level
* first time pass rate
* rework time
* other, please specify

Q6a-c Are there any interactions between these personnel during the following processes? (Personnel = R&D, Production, Marketing, Quality, Sales, Buying, Customer, Supplier; Process = design, choice of supplier, supplier audit).

Q7 Does the topmost manager (the highest in the organisation) have a personal involvement in quality-related affairs (eg. quality goal settings, etc)? Yes/No

Q8 Does the company perform any kind of benchmarking? Yes/No

Q9 Does the company practice any form of self-evaluation of the effectiveness of its quality approaches? Yes/No

Part 2 - Quality Costing

Q10 Are you aware of BS 6143, the British standard for a quality cost system? Yes/No

Q11 Does the company collect and report the cost of quality?
* yes, it is collected but not formally reported
* yes, it is collected and reported but not on a regular basis
* yes, it is collected and reported on a regular basis
* no, quality cost is not collected

Q12 In what year was the cost information first monitored?

Q13 The quality cost information is deployed to....
* middle management
* lower level management
* shopfloor operators
* not deployed at all

Q14 Is the cost information presented in the company's annual summary report? Yes/No

Q15 Is quality cost expressed as a percentage of:
* sales
* value added
* operational cost
* others, please specify

Q16 Not including Customer Service Department, does your company employ workers with 70% or more of their time involved in rectifying mistakes? Yes/No

Q16a If yes, how many are there on site?

Figure 3 - the elements of the QMS

Part 3 - Operations

Q17 With regards to your main process on the shopfloor, what can be said about its state (ie the process spread) more than 80% of the time?

* the spread is often beyond the specifications tolerance
* the spread is within the specifications tolerance, but is not narrow
* the spread is narrow and well within the specifications tolerance

Q18a-c If process capability is monitored,

* the process capability index (Cp) is... above 1? below 1? equals 1?
* the Cpk is... equal to Cp? unequal to Cp?
* in what year was the process spread first monitored?

Q19 Does the shopfloor use these techniques regularly in running daily operations? (Techniques = SPC, statistical sampling, process capability studies, process failure mode effect analysis, poka yoke, quality improvement teams, quality circles, quality awareness programs, internal audits)

Q20 Taking the last 3 months' typical main process data, what is the first time pass rate?

Q21 Looking at the process as a whole, what is the production capacity?

Q22 Are there employees in the manufacturing division who spend more than 70% of their time in process improvement? Yes/No

Q22a If yes, how many are there on site?

Part 4 - Customer Affairs

Q23 What is the average time lapse (lead time) between customer order to delivery of product?

Q24 What is the percentage of times the delivery target, as specified by the customer, is met?

Q25 What is the average time lapse between customer complaint and satisfactory changes initiated by the complaint?

Q26 What approximate percentage of products are returned within 3 months of delivery due to whatever failure mode?

Q27 Are customers contacted... On a regular basis? Only when there's problem?

Q29 Excluding administrative personnel, what is the approximate number of people employed in R&D?

Q30 What is the guarantee period of your major product?

Q31 How many times do you introduce products which are new or upgraded (ie. with more than 40% of the features & characteristics different from that of existing ones)?

Q32 What is the efficiency of your design process?

Q33 What is the approximate time lapse between design release before manufacturing start-up, and product release to customers?

Q34 What is the approximate number of major changes made to the design between design release before manufacturing start-up, and product release to customers?

Q35 Which of the following techniques are used during the design process? (Techniques = project planning & control, QFD, experimental designs, Taguchi methods, DFMEA, benchmarking, design review meetings, product life cycle costing, reliability improvement programs, field trials/product clinics, human factor analysis, value engineering, other - please specify)

Q36 Is 'customer satisfaction' data acquired in any way?

Q37 Is there any special training given to employees at customer-contact ends? Yes/No

Q40i Do you give any of these training to managers? (Training types = Technical, Business, Personal Skills, Quality Appreciation, SPC)

Q40ii What are the duration of the training courses?

Q42 Is there any program of company-wide award for employee performance? Yes/No

Q43a-b Does the company have any program.... for supplier award/recognition? ...of help/training/networkingwith the supplier?

Figure 3 - continued.

(4.2) The Method of Presentation

After all the data have been processed appropriately, each participating organisation (ie. the companies which fill in the questionnaire) will receive a custom-drawn profile of its performance. In addition, the performance of the industry average is also given, so that comparison with others in the same industry sector can be made by the organisation concerned. This *quality position profile* is based on the scores obtained using the method of analysis presented above.

Figure 5 is an example of the quality position profile of a typical organisation in the Chemical industry.

(4.3) The Revisional Cycle Program

As its name implies, the Revisional Cycle Program (RCP) is basically a program which revises the 'goodness' of the QMS. It repeats itself after the questionnaire mailshot has completed its cycle every year. The RCP would provide the foundation for further research into this area.

The RCP would look into 3 areas of improvement. They are:

- the measuring instrument (for example, the wording and presentation of the questionnaire)
- the quality measurement model (for example, the questionnaire content and scoring system)
- the expansion of database (ie. the database of responses from the questionnaire)

(5) Summary

Research into the formulation of an alternative system to measure the quality position of an organisation has been undertaken. This consists of the development of the elements, the collection of data, and the analysis of the collected data. The new proposed system is called the Quality Measurement System (QMS). In this paper, an overall depiction of the QMS is presented. The validation of the QMS is presented in Part 2 of the report.

Question (element)	ARUBS		Mini-questionnaire		Total	Class.
	raw	conver'd	raw	conver'd		
1a	95	38	-	-	-	Z
1b	95	38	50	30	68	Y
3	100	40	-	-	-	Z
4	-	-	100	60	-	Z
4a	-	-	50	30	-	Y
5	95	38	100	60	98	Z
6a	90	36	100	60	96	Z
6b	90	36	75	45	81	Z
6c	90	36	75	45	81	Z
7	-	-	100	60	-	Z
8	-	-	-	-	-	Y
9	-	-	-	-	-	Y
10	-	-	-	-	-	Y
11	95	38	100	60	98	Z
12	-	-	50	30	-	Y
13	90	36	-	-	-	Z
14	-	-	100	60	-	Z
15	100	40	25	15	55	Y
16	80	32	-	-	-	Z
16a	80	32	-	-	-	Z
17	80	32	70	42	74	Y
18a	50	20	55	33	53	Y

Figure 4 - the XYZ Classifications of the elements in the QMS. 'ARUBS' and 'Mini-Questionnaire' form part of the Validation Process

Question	ARUBS		Mini-questionnaire		Total	Class.
	raw	conver'd	raw	conver'd		
18b	50	20	40	24	44	Y
18c	50	20	25	15	35	X
19	-	-	100	60	-	Z
20	70	28	100	60	88	Z
21	80	32	75	45	77	Y
22	-	-	75	45	-	Y
22a	-	-	100	60	-	Z
23	80	32	-	-	-	Z
24	80	32	100	60	92	Z
25	70	28	100	60	88	Z
26	95	38	100	60	98	Z
27	90	36	100	60	96	Z
29	70	28	-	-	-	Y
30	75	30	90	45	75	Y
31	70	28	60	36	64	Y
32	65	26	5	3	29	X
33	70	28	100	60	88	Z
34	20	8	75	45	53	Y
35	-	-	50	30	-	Y
36	-	-	100	60	-	Z
37	-	-	100	60	-	Z
40i	95	38	75	45	83	Z
40ii	-	-	50	30	-	Y
42	-	-	50	30	-	Y
43a	-	-	-	-	-	Y
43b	-	-	-	-	-	Y

Figure 4 - continued

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PART 2 - THE VALIDATION AND PRESENTATION OF A PROPOSED QUALITY MEASUREMENT SYSTEM

Abstract

This paper describes a programme which was developed to validate the Quality Measurement System (QMS) described in Part 1 of the report. The QMS is a system proposed to be used alongside other 'quality measurement systems' already in use in the marketplace. A description of the need for a rigorous validation exercise, and some aspects of validation are presented. Then, the design of the validation programme undertaken is outlined. The validation process consists of several sections - each of which is then described in some detail.

(1) Introduction & Background

The need for a quality measurement system in the execution of Total Quality Management has been recognised by many (see for instance Saraph et al (1989) and Mann (1992)). After a review of the literature, it was found that there exist several systems which are capable of 'measuring' the quality positions of organisations. However, a further investigation into these systems show that an alternate quality measurement system, to be used in conjunction with the ones already available, is needed (Mohd Zain, 1993).

An alternate system of measurement, called the Quality Measurement System, was proposed by Mohd Zain (1993). An overview of this system can be found in Part 1 of the paper. In this article, the validation programme, which intended to assure the validity and integrity of the Quality Measurement System, is presented. An overview of some of the results of the validation exercise is also given.

(2) The Quality Measurement System in Brief

Before the validation programme is described in some detail, a brief description of the Quality Measurement System (QMS) is called for. For a more comprehensive description, see Part 1 of the paper.

The QMS comprises of 3 components:

- o the elements. These are indices which are believed to represent the overall organisational quality position, and hence can be used to measure the quality position itself
- o the instrument. This is the tool to extract information from the industry; in the QMS, this tool is an industrial questionnaire

- the final product. This is the resultant System, in its ready-to-use state. This consists of the industrial questionnaire, a specified method of analysis, a specified method of presentation, and the Revisional Cycle Programme which looks into improving the QMS.

(3) The Validation Programme

The need to validate the research became increasingly important as work progressed. Considerable study has been undertaken elsewhere in this area (for example ---------) where validation using this approach becomes critical.

In this project, since the final outcome of the research was a system (the QMS) which would utilise a data extraction instrument (the industrial questionnaire) and scoring system -- all of which were new and had not been tested elsewhere -- every stage of the work had to be validated.

Many authors have offered methodologies for testing validity (see for example Parten (1950) and Easterby-Smith et al (1991)). The authors felt that the suggestions put forth by Easterby-Smith et al is more relevant for use in this study. Easterby-Smith defined validity as "a question of how far we can be sure that a test or instrument measures the attribute which it is supposed to measure". He then listed 3 ways of estimating validity, which was taken from Patchen (1965). They were:

- face validity - whether the instrument or its items are plausible,
- convergent validity - confirmation by comparing the instrument with other independent measurement procedures, and,
- validation by known group - comparing groups otherwise known to differ on the factor in question.

The face validation of this research can, to a large extent, be determined from the intensity of rigour imposed at every stage of the work. The author had attempted to justify all action items with reasonable support. For example, the selection of the elements in the QMS had to go through several iterations to ensure that all predefined specifications were met. The predefined specifications were formulated based on extensive discussions with various parties as well as survey of the literature.

Convergent validity was achieved utilising the 'ARUBS programme', 'scoring mode selection', and 'sensitivity analysis', all presented in the following paragraphs. Validation by known group was performed by the identification of industry-specific characteristics, which is part of the scoring mode selection and sensitivity analysis procedures.

After a thorough study of all validation routes, a programme was designed. The programme was dealt with in 2 aspects, namely:

i the elements and scoring system. Each element carries a certain weighting. This weighting was assigned in accordance to a certain scoring system. Both the validation of the selection of the elements, and the validation for the scoring system used, was also dealt with,

ii the measuring instrument. As stated above, this is the industrial questionnaire. Even if the elements and scoring system used was taken to be valid, the data collected and analysed in accordance to the QMS model could still not be considered valid unless the measuring instrument used to extract the data was.

An elaboration of the above is given below.

(3.1) The Elements and Scoring System

The initial selection of the elements was mainly influenced by discussions the author had with members of both the academia and industry. This was then backed by literature search. It was realised that in order to establish the justification for the selection of the elements, this alone was not adequate. However, if it could be shown that:

- there exists some form of correlation between quality position and business performance,
- each industry sector exhibits its own industry-specific characteristics of quality position profiles, and,
- when used before and after a certain interval of time in an organisation, the quality position profile has shifted, in accordance to the changes in the organisation,

then, justification for the selection of elements (hence, validation) could be achieved.

In addition,

- if the assumptions used in the scoring method can be shown to have some credence when tested on a sample of data,
- if the trends which emerged following data analysis were consistent when another scoring method was used, and,
- if the weighting assigned on the importance of each element could be verified by practising industrialists as acceptable,

then, the validity of the scoring system could be established.

(3.2) The Measuring Instrument

It was decided that the measuring instrument could be regarded as valid if it was capable of extracting 'absolute' responses. An 'absolute' response is one which satisfies the requirements below:

i it is **accurate** in terms of the question interpretation, based on a specified 'Accuracy Glossary' which was simultaneously developed,

ii it is **uniform** with regards to other respondents' interpretation,

iii it is **reliable** and **credible** in terms of the source of the information,

iv it is in the form not **simplified** to an extent where the accuracy of the contents may be jeapordised, and,

v it does not contain any **bias** due to any special circumstances the respondent is in.

Items (i) and (ii) above relate to the respondents' **interpretation** of the questions while items (iii), (iv), and (v) relate to the **provision of data** supplied by the respondent.

As can be envisioned, this exercise required more than what has already been outlined above. Based on the criteria above, a programme called ARUBS (Accuracy, Reliability, Uniformity, presence of Bias, and tendency for Simplification) was developed. Section (4) below describes the programme in more detail.

(4) The ARUBS Programme

The ARUBS programme consists of 5 elements, namely:

i A - the **accuracy** of the interpretation of the question,

ii R - the **reliability** of the information supplied by the respondent,

iii U - the **uniformity** of the accuracy of the question interpretation,

iv B - the presence of **bias** in the information supplied, and,

v S - the tendency for **simplification** of the information supplied.

With the above information,

a the measuring instrument could be modified appropriately (for example, a change in its wordings),

b the data supplied could be treated accordingly (for example, perhaps in assigning a 'correction factor'), and,

c the weighting of the elements could be assigned utilising sound research evidence.

Item (b) above can be used to highlight the differences between industry sectors, and the problems of acquiring a standardised benchmark base.

Each and every element in the QMS had to go through the ARUBS criteria before a certain score was given. This score constituted 40% of the final score of the element. The other 60% would come from another programme that was developed, called the 'mini-questionnaire programme', which is detailed in section (5) below.

(5) The Mini-Questionnaire Programme

The mini-questionnaire programme aimed at supporting the criteria for the selection of elements in the QMS, thus validating the model. While the chosen elements adhered to the predefined requirements as described in the literature (see for example Juran's (1983) criteria for the selection of performance indicators), research to verify that the requirements are indeed appropriate have not been performed. In addition, further validation was required to ensure that the list of elements was both comprehensive and precise. A Delphi-type expert review, such as the one used in this study, was deemed suitable.

The elements from the industrial questionnaire were put forth in the form of a mini-questionnaire. Respondents were then asked a series of questions on their opinion of the elements. The questions were:

- how **useful** was the data extracted by the element,
- how **accurate** was the data,
- how **easily extracted** was the data,
- how **timely** could the data be extracted, and,
- should the data be **included** in the QMS.

For example, one of the elements in the QMS is the 'first time pass rate'. Respondents were asked on the usefulness, accuracy, ease of extraction, and timeliness of this data. Finally, the respondents were asked if this element should indeed be incorporated into the QMS at all.

As stated earlier, the elements were processed through the mini-questionnaire programme before a certain score was given. This score constitute 60% of the final score given to the element in question. (The other 40% came from the ARUBS programme, presented above.)

(6) The Resultant XYZ Classification

This research used the assumption that certain quality activities contribute more towards the overall organisational quality status than other activities. The smallest quality activity contributor was given Classification X, while the largest contributor, Classification Z. Classification Y was given to the quality activities which give an impact between that of the ones in Classifications X and Z.

The determination of the classification each element belonged to was based on both the ARUBS programme score (40%), and the mini-questionnaire programme (60%). From here,

Question (element)	ARUBS		Mini-questionnaire		Total	Class.
	raw	conver'd	raw	conver'd		
1a	95	38	-	-	-	Z
1b	95	38	50	30	68	Y
3	100	40	-	-	-	Z
4	-	-	100	60	-	Z
4a	-	-	50	30	-	Y
5	95	38	100	60	98	Z
6a	90	36	100	60	96	Z
6b	90	36	75	45	81	Z
6c	90	36	75	45	81	Z
7	-	-	100	60	-	Z
8	-	-	-	-	-	Y
9	-	-	-	-	-	Y
10	-	-	-	-	-	Y
11	95	38	100	60	98	Z
12	-	-	50	30	-	Y
13	90	36	-	-	-	Z
14	-	-	100	60	-	Z
15	100	40	25	15	55	Y
16	80	32	-	-	-	Z
16a	80	32	-	-	-	Z
17	80	32	70	42	74	Y
18a	50	20	55	33	53	Y

Figure 1 - the XYZ Classifications of the elements in the QMS. These Classifications are obtained after going through the 'ARUBS' and the 'Mini-Questionnaire' programmes.

Question (element)	ARUBS		Mini-questionnaire		Total	Class.
	raw	conver'd	raw	conver'd		
18b	50	20	40	24	44	Y
18c	50	20	25	15	35	X
19	-	-	100	60	-	Z
20	70	28	100	60	88	Z
21	80	32	75	45	77	Y
22	-	-	75	45	-	Y
22a	-	-	100	60	-	Z
23	80	32	-	-	-	Z
24	80	32	100	60	92	Z
25	70	28	100	60	88	Z
26	95	38	100	60	98	Z
27	90	36	100	60	96	Z
29	70	28	-	-	-	Y
30	75	30	90	45	75	Y
31	70	28	60	36	64	Y
32	65	26	5	3	29	X
33	70	28	100	60	88	Z
34	20	8	75	45	53	Y
35	-	-	50	30	-	Y
36	-	-	100	60	-	Z
37	-	-	100	60	-	Z
40i	95	38	75	45	83	Z
40ii	-	-	50	30	-	Y
42	-	-	50	30	-	Y
43a	-	-	-	-	-	Y
43b	-	-	-	-	-	Y

Figure 1 - continued

- score 0 - 40 was given Classification X,
- score 41 - 79 was given Classification Y, and,
- score 80 - 100 was given Classification Z.

Figure 1 lists the XYZ Classification of the elements in the QMS, while appendix 1 lists the elements of the QMS, taken from the questionnaire.

With each element now classified in either X, Y, or Z classifications, the marks awarded to each participant of the industrial questionnaire could now be processed through a certain method of analysis. This method of analysis has been presented in some detail in Part 1 of this paper, while the validation of this method of analysis is given below.

(7) Selection of the Scoring Mode

The validation of the method of analysis involved validating the selection of the scoring mode used in the QMS. Here, the *sensitivity* (ie. the extent of dependence of the quality position profile on the scoring method) of the scoring mode was studied. This can be investigated by acquiring the quality position profile using several scoring modes.

A series of scoring systems (referred to as 'modes') was first developed and reviewed in terms of their *industry-specific characteristics* and *correlation with business performance* of the figures generated. Based on several considerations, by the process of elimination, the 'best' scoring mode was identified. This 'best' scoring mode was then used as the 'scoring system' to finally gauge the quality position of any participating organisation.

The factors which were considered when designing the scoring system consisted of whether the raw data should be:

- weighted vs. not weighted,

- (if weighted), factored according to the XYZ classification vs. factored using the original factoring assignment (ie. the overall score after being processed through ARUBS and the mini-questionnaire programme), and,

- added vs. multiplied against one another.

Weighting acknowledged the differing level of contributions of the various QMS elements towards the overall organisational success. If weighting was adopted, the raw data was either multiplied according to the XYZ classification described in section (6) above, or multiplied to the combination of the original factoring assignment of ARUBS and the mini-questionnaire programme.

After the elements have been arranged in their appropriate sub-areas (details of which can be found in Part 1 of the paper), they (the elements) were then either added or multiplied. In addition, weighting also brought about the question of whether the data, once either multiplied by the XYZ classification factors or the original factoring assignments, should then be added *or* multiplied to one another. In other words, the question of addition vs. multiplication was applied in 2 situations - firstly, prior to the weighting vs. non-weighting decision, and secondly, if weighting was decided upon.

The addition vs. multiplication and weighting vs. non-weighting alternatives were investigated to study the combinational effects of the various interactions. This would simultaneously give an insight as to whether the effects were complementary to each other, or that certain combinations would result in different characteristics. An example would be that of whether quality activities would give an *additive* or a *multiplicative* effect.

Using various combinations based on the above factors, 6 scoring modes were considered, namely:

- o no weighting, addition,
- o no weighting, multiplication,
- o weighting, factor XYZ, multiplication,
- o weighting, factor XYZ, addition,
- o weighting, factor original, addition, and,
- o weighting, factor original, multiplication.

After processing the raw data using all 6 scoring modes above, the primary data generated was analysed for their *data range, industry-specific characteristics*, and *correlation with business performance*. The less 'favourable' modes found within this analytical framework were marked, while the more 'favourable' ones were further analysed. This was essentially a filtering process, whereby the most 'favourable' scoring mode was eventually identified.

(7.1) Data Range Analysis

The analysis based on data range was basically that of the examination of how large was the range between the highest and the lowest score of the various sub-areas. If the range was very large, then the presentation of quality profile of the organisation would prove impractical, and may be inaccurate and misleading.

(7.2) Industry-Specific Characteristics

For the study of industry-specific characteristics, 4 techniques were employed:

- o studying the visual appearance of charts of the various scoring modes using the average values of all the sub-areas,

- o studying the 'clustering characteristics' of the various scoring modes. In order to justify the use of this technique, the shape of distribution of some of the data was examined. It was found that the curves were close to that of the normal, bell-shaped distribution. Tables of skewness were also constructed, and was found that more than 81% of the data sets had the skewness value of less than 1. Hence, the 'clustering characteristic' analysis was thought to be justified. In this technique, calculations of the percentage of the standard deviation to average ratios of the individual sectors

( ) were done, and these were then compared to the same ratios of the entire population. A smaller figure of ( ) of the individual industry sector gave better 'clustering characteristic'.

o studying the average value of the ( ) ratios above. A bigger figure of % meant that the standard deviation, when compared to the mean value, was high. This implied that the company-to-company data was widely distributed around its mean. Similarly, a smaller figure of % implied a tighter distribution of company-to-company data. This sub-technique also essentially looked into the 'clustering characteristic' described above.

(7.3) Correlation with Business Performance

After going through the analysis described in sections (7.1) and (7.2) above, the 'best' scoring mode was identified. To further support this decision, an additional investigation into the correlation of the quality profiles with business performance was performed. Data on business performance was obtained from the second part of the industrial questionnaire which inquired the participants' business situation. The objective of this investigation was twofold - (i) to see if there was any correlation between quality position and business performance; this complements research by Mann & Kehoe (1994) on the identification of quality activities which most directly affect business performance, and (ii) to see if the same trend would appear when used in conjunction with the other scoring modes, hence, determining the extent of sensitivity of the selected scoring mode against the others.

(7.4) Summary of the Validation Process of the Method of Analysis

With initially 6 scoring modes to choose from, utilising the process of elimination, all the modes were investigated. At some levels, the modes were investigated in pairs, and the disadvantaged ones marked for eventual disposal. Often, the disadvantaged modes were marked more than once before being discarded. Finally, it appeared that the favourable criteria for a scoring mode would consist of *weighting, factor XYZ, and addition*. This scoring mode was selected to be used in the QMS.

A more detailed and in-depth elaboration of this lengthy selection process can be found in Mohd Zain (1993).

(8) Summary

An alternate system to measure the quality position of an organisation, apart from the systems already available in the marketplace, has been developed. This new system is named the Quality Measurement System (QMS). As the QMS is an entirely new system, much effort was put into the validation of the model. In this paper, the design of the validation programme was first explained. Then, the process of validation itself was described in some detail. This process can be broadly categorised into 2 aspects - the validation of the elements and scoring system, and the validation of the measuring instrument.

It has been shown that this exercise produced encouraging results. Hence, the QMS, described extensively in Part 1 of the report, was therefore validated.

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Appendix 1 - elements of the QMS, taken from the questionnaire

Part 1 - General Quality Orientation

Q1a Does your company have a quality policy?
* yes, but not in writing
* yes, in writing
* no quality policy

Q1b If yes, in what year was the policy introduced?

Q3 Do you keep yourself up-to-date with matters relating to quality appreciation (attending quality seminars, membership with quality related bodies, etc)?

Q4 Has the company been listed for BS5750/ISO 9000? Yes/No

Q4a If yes, in what year was the company first awarded the above?

Q5 Which of the following internal quality performance indicators are formally monitored at corporate level on a regular basis?
* reject level
* first time pass rate
* rework time
* other, please specify

Q6a-c Are there any interactions between these personnel during the following processes? (Personnel = R&D, Production, Marketing, Quality, Sales, Buying, Customer, Supplier; Process = design, choice of supplier, supplier audit).

Q7 Does the topmost manager (the highest in the organisation) have a personal involvement in quality-related affairs (eg. quality goal settings, etc)? Yes/No

Q8 Does the company perform any kind of benchmarking? Yes/No

Q9 Does the company practice any form of self-evaluation of the effectiveness of its quality approaches? Yes/No

Part 2 - Quality Costing

Q10 Are you aware of BS 6143, the British standard for a quality cost system? Yes/No

Q11 Does the company collect and report the cost of quality?
* yes, it is collected but not formally reported
* yes, it is collected and reported but not on a regular basis
* yes, it is collected and reported on a regular basis
* no, quality cost is not collected

Q12 In what year was the cost information first monitored?

Q13 The quality cost information is deployed to....
* middle management
* lower level management
* shop floor operators
* not deployed at all

Q14 Is the cost information presented in the company's annual summary report? Yes/No

Q15 Is quality cost expressed as a percentage of:
* sales
* value added
* operational cost
* others, please specify

Q16 Not including Customer Service Department, does your company employ workers with 70% or more of their time involved in rectifying mistakes? Yes/No

Q16a If yes, how many are there on site?

Part 3 - Operations

Q17 With regards to your main process on the shop floor, what can be said about its state (ie the process spread) more than 80% of the time?
* the spread is often beyond the specifications tolerance
* the spread is within the specifications tolerance, but is not narrow
* the spread is narrow and well within the specifications tolerance

Q18a-c If process capability is monitored,
* the process capability index (Cp) is... above 1? below 1? equals 1?
* the Cpk is... equal to Cp? unequal to Cp?
* in what year was the process spread first monitored?

Q19 Does the shop floor use these techniques regularly in running daily operations? (Techniques = SPC, statistical sampling, process capability studies, process failure mode effect analysis, poka yoke, quality improvement teams, quality circles, quality awareness programs, internal audits)

Q20 Taking the last 3 months' typical main process data, what is the first time pass rate?

Q21 Looking at the process as a whole, what is the production capacity?

Q22 Are there employees in the manufacturing division who spend more than 70% of their time in process improvement? Yes/No

Q22a If yes, how many are there on site?

Part 4 - Customer Affairs

Q23 What is the average time lapse (lead time) between customer order to delivery of product?

Q24 What is the percentage of times the delivery target, as specified by the customer, is met?

Q25 What is the average time lapse between customer complaint and satisfactory changes initiated by the complaint?

Q26 What approximate percentage of products are returned within 3 months of delivery due to whatever failure mode?

Q27 Are customers contacted... On a regular basis? Only when there's problem?

Part 5 - Research and Development

Q29 Excluding administrative personnel, what is the approximate number of people employed in R&D?

Q30 What is the guarantee period of your major product?

Q31 How many times do you introduce products which are new or upgraded (ie. with more than 40% of the features & characteristics different from that of existing ones)?

Q32 What is the efficiency of your design process?

Q33 What is the approximate time lapse between design release before manufacturing start-up, and product release to customers?

Q34 What is the approximate number of major changes made to the design between design release before manufacturing start-up, and product release to customers?

Q35 Which of the following techniques are used during the design process?
(Techniques = project planning & control, QFD, experimental designs, Taguchi methods, DFMEA, benchmarking, design review meetings, product life cycle costing, reliability improvement programs, field trials/product clinics, human factor analysis, value engineering, other - please specify)

Q36 Is 'customer satisfaction' data acquired in any way?

Q37 Is there any special training given to employees at customer-contact ends? Yes/No

Part 6 - Human Resources

Q40i Do you give any of these training to managers?
(Training types = Technical, Business, Personal Skills, Quality Appreciation, SPC)

Q40ii What are the duration of the training courses?

Q42 Is there any program of company-wide award for employee performance? Yes/No

Part 7 - Suppliers

Q43a-b Does the company have any program.... for supplier award/recognition? ...of help/training/networking with the supplier?

Appendix 2 - the analysis of the 'clustering characteristic' of the scoring mode. The mode examined here is mode B which did not take into consideration the weighting of the elements. The figures in the boxes are the scores of the Areas of all the industry sectors.

Mode : B (no weighting, addition)

	Chem	Oil	Misc	Food	Elect	Eng'g	Text	E.P.
A1E	20	23	38	24	18	27	26	20
A1R	83	0	83	133	57	0	57	57
A2E	59	72	31	46	54	40	55	54
A2R	133	0	0	100	100	43	78	17
A3E	47	32	58	58	59	50	53	100
A3R	43	60	57	50	60	67	43	50
A4E	50	67	70	63	56	50	56	57
A4R	58	45	83	60	50	42	50	16
A5E	35	31	45	33	30	35	24	30
A5R	37	23	27	33	32	30	33	30
A6E	56	61	71	44	67	50	73	54
A7E	58	62	50	56	50	100	88	64
#≤EP	6	6	4	4	8	5	6	

- Σ#≤EP = 39; 39/7 industries = 5.6

  ∴ 5.6 of the 12 sub-areas (ie. 46%) have better or similar clustering characteristic (Column A, Table 10.1) (ie. $\sigma:\chi$), compared to E.P.

- Σ all = 4271

  ∴ Average = 4271/84 = 51 (Column B, Table 10.1)

Appendix 2 - continued

Mode : J (no weighting, multiplication)

	Chem	Oil	Misc	Food	Elect	Eng'g	Text	E.P.
A1E								
A1R	83	0	100	133	57	0	57	57
A2E	302	207	29	283	194	186	164	267
A2R	40	0	0	150	230	150	138	106
A3E	191	118	653	188	226	196	149	215
A3R	256	213	97	100	233	187	74	259
A4E	94	145	103	140	105	111	91	100
A4R	199	117	222	145	247	130	188	153
A5E	75	77	72	70	95	73	75	74
A5R	127	109	123	109	150	160	130	127
A6E	56	61	71	44	67	50	73	54
A7E	115	116	94	186	126	140	194	134
#≤EP	8	8	7	5	4	7	7	

- $\Sigma\# \leq$ EP = 46; 46/7 industries = 6.6

  ∴ 6.6 of the 12 sub-areas (ie. 55%) have better or similar clustering characteristic (Column A, Table 10.1) (ie. $\sigma:\chi$), compared to E.P.

- Σ all = 10259

  ∴ Average = 10259/77 = 133 (Column B, Table 10.1)

Mode : E (weighting, multiplication, factor XYZ)

	Chem	Oil	Misc	Food	Elect	Eng'g	Text	E.P.
A1E	44	40	63	40	35	57	50	38
A1R	74	0	88	133	59	0	65	65
A2E	110	119	49	79	84	82	79	87
A2R	133	0	0	100	94	43	85	14
A3E	178	119	144	100	180	188	213	172
A3R	65	110	84	66	75	73	52	69
A4E	47	67	70	53	50	53	53	47
A4R	131	117	176	117	131	114	125	79
A5E	37	31	45	32	31	37	22	31
A5R	38	21	29	32	34	28	32	31
A6E	87	84	109	83	97	74	118	83
A7E	65	58	54	61	48	94	81	67
#≤EP	4	8	5	7	5	3	5	

- $\Sigma \# \leq EP = 37$; 37/7 industries = 5.3

  ∴ 5.3 of the 12 sub-areas (ie. 44%) have better or similar clustering characteristic (Column A, Table 10.1) (ie. $\sigma{:}\chi$), compared to E.P.

- Σ all = 6318

  ∴ Average = 6318/84 = 75 (Column B, Table 10.1)

Appendix 3 - part of the correlation with business performance analysis of the scoring modes. Column 1 indicates the groups which the participating organisations belong to in terms of their business performance (there are 6 groups altogether). Column 2 indicates the scoring modes.

			A1E	A1R	A2E	A2R	A3E	A3R
Gp 1	B	S	68.0	6.1	25.3	11.3	12.6	6.3
		U	63.5	8.5	33.6	11.6	17.7	5.3
		∇	1.1	0.7	0.8	1.0	0.7	1.2
	F	S	181.3	18.2	61.5	34.0	28.2	67.2
		U	167.1	25.5	80.8	34.7	36.5	56.0
		∇	1.1	0.7	0.8	1.0	0.8	1.2
	J	S	6.8E8	6.1	22286.1	13.4	98.0	6500.5
		U	4.6E8	8.5	41348.6	16.6	259.6	2954.2
		∇	1.5	0.7	0.5	0.9	0.4	2.2
	H	S	5752.2	606.3	1791.6	907.4	1026.9	2137.8
		U	5315.1	850.0	2328.7	924.9	1337.1	1735.3
		∇	1.1	0.7	0.8	1.0	0.8	1.2
Gp 2	B	S	68.0	6.1	25.3	11.3	12.6	6.3
		U	66.7	6.2	26.5	11.7	14.3	5.5
		∇	1.0	1.0	1.0	1.0	0.9	1.2
	F	S	181.3	18.2	61.5	34.0	28.2	67.2
		U	177.2	18.7	64.6	35.0	32.2	61.0
		∇	1.0	1.0	1.0	1.0	0.9	1.1
	J	S	6.8E8	6.1	22286.1	13.4	97.97	6500.5
		U	5.3E8	6.2	26793.4	17.0	184.0	4349.9
		∇	1.3	1.0	0.8	0.8	0.5	1.5
	H	S	5752.1	606.3	1791.6	907.4	1027.0	2137.8
		U	5620.0	622.6	1869.9	932.7	1183.7	1937.4
		∇	1.0	1.0	1.0	1.0	0.9	1.1

Notes: 'S' = 'upper range'; 'U' = 'lower range'; ∇ = gradient

			A1E	A1R	A2E	A2R	A3E	A3R
Gp 3	B	S	66.7	6.2	26.5	11.7	14.3	5.5
		U	63.5	8.5	33.6	11.6	17.7	5.3
		∇	1.1	0.7	0.8	1.0	0.8	1.0
	F	S	177.2	18.7	64.6	35.0	32.2	61.0
		U	167.1	25.5	80.8	34.7	36.5	56.0
		∇	1.1	0.7	0.8	1.0	0.9	1.1
	J	S	5.3E8	6.2	26793.4	16.6	184.0	4349.9
		U	4.6E8	8.5	41348.6	15.6	259.6	2954.1
		∇	1.1	0.7	0.7	1.1	0.7	1.5
	H	S	5620.0	622.6	1870.0	932.7	1183.7	1937.4
		U	5315.1	850.0	2328.7	924.9	1337.1	1735.3
		∇	1.0	0.7	0.8	1.0	0.9	1.1
Gp 4	B	S	66.5	7.0	34.4	11.7	16.4	5.7
		U	43.0	1.0	28.5	11.5	10.8	6.7
		∇	1.5	7.0	1.2	1.0	1.5	0.9
	F	S	175.7	21.0	84.0	35.1	35.9	62.2
		U	116.5	3.0	70.8	34.6	21.8	60.3
		∇	1.5	7.0	1.2	1.0	1.6	1.0
	J	S	4.6E8	7.0	64006.9	17.2	147.4	3726.4
		U	1.2E7	1.0	35191.5	15.3	31.4	2187.5
		∇	40.0	7.0	1.8	1.1	4.7	1.7
	H	S	5580.8	700.0	2413.8	937.2	1330.5	1975.9
		U	3738.9	100.0	1995.8	922.7	805.9	1882.5
		∇	1.5	7.0	1.2	1.0	1.7	1.1

Appendix 3 - continued

			A1E	A1R	A2E	A2R	A3E	A3R
Gp 5	B	S	66.5	7.0	34.4	11.7	16.4	5.7
		U	67.7	7.1	30.7	11.8	15.0	6.0
		∇	1.0	1.0	1.1	1.0	1.1	1.0
	F	S	175.7	21.0	84.0	35.1	35.9	62.2
		U	178.5	21.2	75.4	35.4	32.9	61.8
		∇	1.0	1.0	1.1	1.0	1.1	1.0
	J	S	4.6E8	7.0	64006.9	17.2	147.4	3726.4
		U	5.2E8	7.1	39674.0	'7.9	193.4	4333.8
		∇	0.9	1.0	1.6	1.0	0.8	0.9
	H	S	5580.9	700.0	2413.8	937.2	1330.5	1976.0
		U	5680.6	705.8	2163.7	942.9	1210.8	1949.0
		∇	1.0	1.0	1.1	1.0	1.1	1.0
Gp 6	B	S	67.7	7.1	30.7	11.8	15.0	6.0
		U	43.0	1.0	28.5	11.5	10.8	6.7
		∇	1.6	7.1	1.1	1.0	1.4	0.9
	F	S	178.5	21.2	75.4	35.4	32.9	61.8
		U	116.5	3.0	70.8	34.6	21.8	60.3
		∇	1.5	7.1	1.1	1.0	1.5	1.0
	J	S	5.2E8	7.1	39674.0	17.9	193.4	4333.8
		U	11605839	1.0	35191.5	15.3	31.4	2187.5
		∇	45.0	7.1	1.1	1.2	6.2	2.0
	H	S	5680.6	705.8	2163.7	942.9	1210.8	1949.0
		U	3738.9	100.0	1995.8	922.7	805.9	1882.5
		∇	1.5	7.1	1.1	1.0	1.5	1.0

Appendix 3 - continued

QUALITY IMPROVEMENT TEAMS AND FACILITATION

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SUMMARY

■ Paper identifies research issues in the driving of culture change through Teamwork Strategies.

■ Current approaches do not tune.

- Process
- Teamwork
- Facilitation

Issues to organisational needs

■ Illustrate through industrial case studies, how these issues arise and need for improved understanding of the relationships necessary for successful T.Q.

1. The Key Elements of Total Quality

Total Quality is a strategic approach to producing the best product and service possible - through constant innovation$_{(1)}$. It is a journey rather than an identifiable end.

There are many brands of presentation of the Total Quality philosophy and its implementation path. Most emanate from the quality gurus but all encompass a body of common elements.

<u>**Common Elements in Total Quality Strategies**</u>

* Proof of Need.

* Top Management commitment - Mission Statement.

* Improvement orientation.

* Prevention orientation - do it right first time.

* People Matter - improving employee motivation
  - better communication

* Harnessing employee creativity - Education & Training
  - Quality Improvement Teams

*	Customer Orientation	-	research external customer needs
		-	concept of "internal customer"
*	Culture Change	-	3 to 5 years minimum
*	Teamwork		

The strategic approach, whether Kaizan, BPR or whatever requires teamwork and culture change. Unlike in other areas of Quality where the tools and techniques are readily available and improvement measurable, the methods and measures for teamwork and culture change are <u>not</u> required.

2. Driving Total Quality through Teamwork

The road to Total Quality is littered with failures (1). It is not the Total Quality philosophy which is at fault, but the driving process which has failed. There are of course many and varied reasons.

Tailoring the Total Quality drive to the prevailing culture of the company or enterprise is a very real problem. Within this tailoring process, problems can be identified at the various stages:

* Developing the front-end framework as 'proof of need' becomes evident; how the top management embrace and express their commitment; the development of a new mission statement highlighting the way ahead; the specification of the Total Quality programme.

* Choosing appropriate education and training for top management and subsequently all employees.

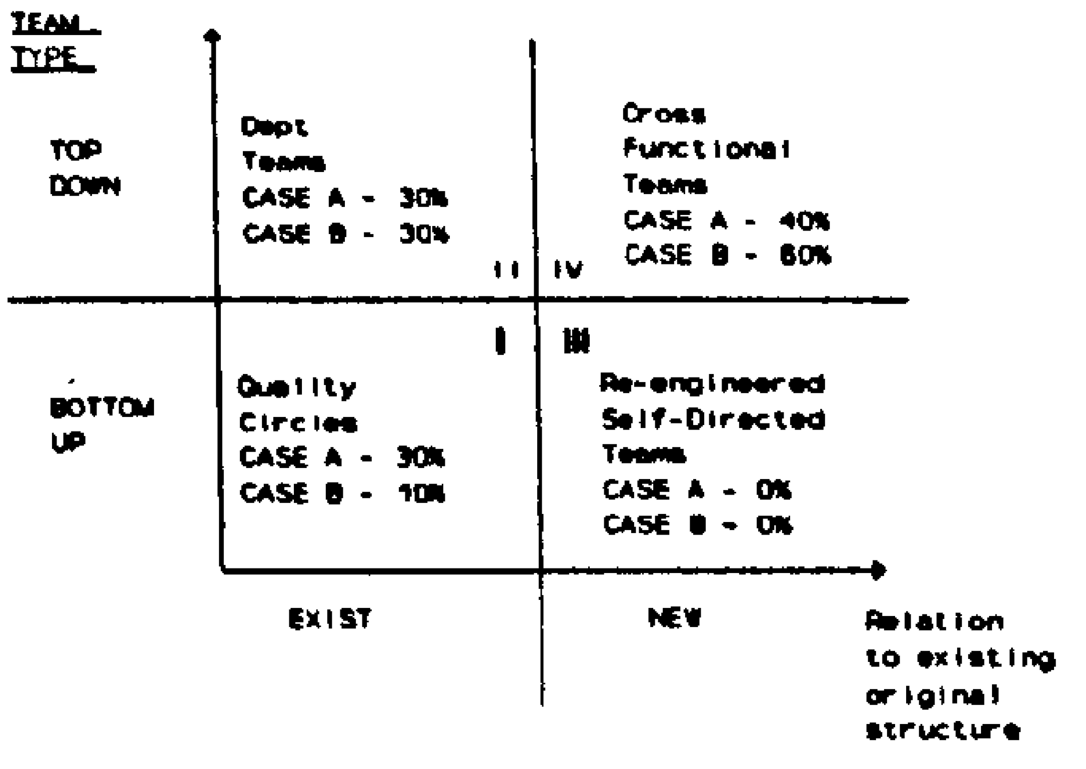
* Setting up and facilitating a teamwork strategy.

* Sustaining the "managed in" elements of Total Quality.

'Culture Change' is often seen as a driver in the implementation process. The culture incorporates the set of values, behaviours, modes of operation underlying all activity in the enterprise. Teamwork is usually considered central to the culture change strategy because it can promote interdependence rather than independence (2), expand the individuals' abilities to solve problems and make decisions, and create an atmosphere of belonging. It fosters the belief that everyone has a vital role to play in satisfying the customer. For real attitude change to become adopted by the workforce, a critical mass of people changing 'the way they do things' is necessary. There lies the key influence that a properly tailored and extensive teamwork strategy can bring.

Various authors have pointed out the danger of believing that TQM is merely training employees, setting up Quality Improvement Teams and problem solving, e.g. (3). This is clearly not the case. However, this paper intentionally focuses on the teamwork contribution to TQM.

In particular the way in which teams are used, composed and facilitated are key issues. These dimensions need to be understood in the context of the business needs to ensure successful operation. In particular the Facilitation issue is the mechanism for tuning the operation of our improvement teams as shown.



Case study research presented in this paper examines some of the issues associated with each of these dimensions and attempts to quantify the tuning parameters.

3. Improvement Teams

Developing a teamwork strategy has some key issues associated with organisational structuring, the team types, and their facilitation at all levels.

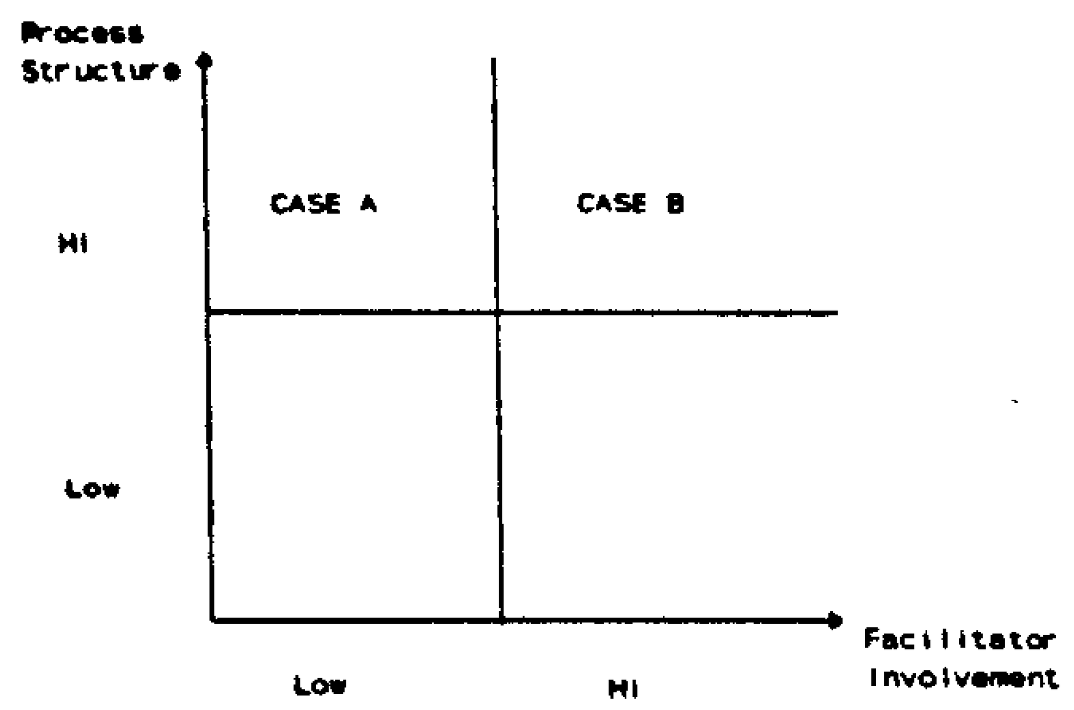
Improvement is the purpose of most types of team, but the focus for improvement takes very different forms. The 'top-down' 'deployed objectives' approach to teamwork identifies the bigger improvements which are being pursued at the strategic business objectives level and traces improvement specifications down to more tactical levels where concrete improvements can be determined, implemented and monitored. This often leads to the formation of an ad-hoc team with a *cross-functional* membership set up to see through the improvements before disbanding. These are often new types of structure for an organisation.

In contrast, a 'top-down' deployment of objectives to a *departmental* context, where there are existing functional channels and collaboration, enables improvement teams to be set up within the existing structure of the company. These can then exist on a semi-permanent basis to pursue a succession of improvement project.

The 'bottom-up' approach is well documented from successes in Japan. *Quality Circles* rely on utilising, in a voluntary manner, the creative insights that a function group who work together can generate to produce local improvements. Given the right condition-setting, these improvements arise more through "spontaneous combustion" than directed kindling of ideas. The more tactical nature of the team's focus generally leads to improvements of a local nature, but the philosophy promotes a significant incremental improvements through harnessing a multitude of small improvements.

The research case studies identified Q.I. teams as the critical activity in driving T.Q. implementation. The companies studied were mature, traditionally structured, multi-site organisations building T.Q. upon established (ISO 9000) Q.M.S.

In terms of the types of teams and the relationship to existing organisational measures shown in Fig ?



This research identifies a predominance for teams based in Quadrant IV which from a culture viewpoint is the least sustainable domain.

In terms of the *team role profile*, this was assessed using a simple Belbin analysis of team roles. Whilst the Belbin profiling was a rather limited tool, it provided an important measure of the prevailing team role culture within the study companies. In both organisations the people were reasonably purposeful in operational terms and helpful in attitude, but all activity was enmeshed in a fire-fighting environment. Training was spasmodic and blame was always elsewhere.

The distribution of team roles shown in Fig ? illustrates the predominance of 3 specific groups. This represents an important cultural measure in terms of our ability to function as a team-based organisation as Belbin's original research identified a clear need for team balance.

The data is a measure of both the style of management in place before the adoption of T.Q. and the way in which people were behaving.

There is no doubt that the heightened perception of self and others in the 'team role' labels provides a heightened awareness of team building and team operation dynamics in practice, and this in turn provides positive attitudes to teamwork activities.

Again the research illustrates the inability of organisations to analyse effectively the teambuilding requirements and the lack of measures of (improved) performance.

The research has identified a number of activities critical to the effective operation of teamwork which the facilitators need to address:

- team formation and selection
- team operation and dynamics
- team activities and methods

Again the case study companies lacked both the tools and techniques for addressing these issues and also appropriate measures of their performance in providing effective facilitation.

In terms of *team formation* for both organisations, this involved *team operation Facilitation* in teamwork activity which is well documented. The facilitator's role can be summarised in terms of:

- helping the team to be effective
- providing the orchestration of team processes

but with specific duties:

- Maintain team focus
- Supportively deal with problems
- Encourage everyones participation
- Provide direction and consulting
- Suggest consensus alternatives

The issue of what type of Belbin profile would suggest an aptitude for operating as a facilitator was discussed at length. Clearly it could only provide an indication. Two team roles seemed to stand out in terms of characteristics that a facilitator must have:

Team Worker:	Socially orientated; Ability to respond to people and situations and promote team spirit; Cohesive influence.
Monitor Evaluator:	Good on judgement and discretion; Having a certain hard-headedness.

The Team Worker role seems to match the interpersonal skills and encouraging nature required. The Monitor Evaluator role seems to match the provision of a guiding influence which is naturally focusing and reviewing. The single role Team Worker and single role Monitor Evaluator are very different types of people who do not appear to have overlapping characteristics. The adoption of characteristics in tension with each other may be necessary and could explain partially why good facilitators are rare.

Some organisations have preferred to train all leaders to be facilitators. This seems a useful approach to ensure facilitation is taken seriously and is always present to a degree. However, the dual role of leader and facilitator is difficult in various team situations where:

- the team is large
- the project is complex and cross-functional
- the leader has vested interests
- there is conflict or very strong personalities
- there is a strong political element

A separate facilitator can bring improved effectiveness to many such team situations.

The cost effectiveness is, however, a different question. Some companies, e.g. Kodak, have been convinced that full time facilitators so enable teams to be effective that they produce improvements whose commercial benefits outweigh the facilitators' salaries.

7. Team Activity Facilitation

The essential nature of team activity is problem solving. Whilst problem solving is endemic in the Quality Movement, it has been popularised by Deming and Juran. More specific problem solving approaches can be specified in a form tailored to the organisational culture and the team type. In some cases, a cook-book company version, tuned to the organisation, can provide a basis for steering team activity whilst maintaining a clear direction and promoting a high level of ownership of the methods.

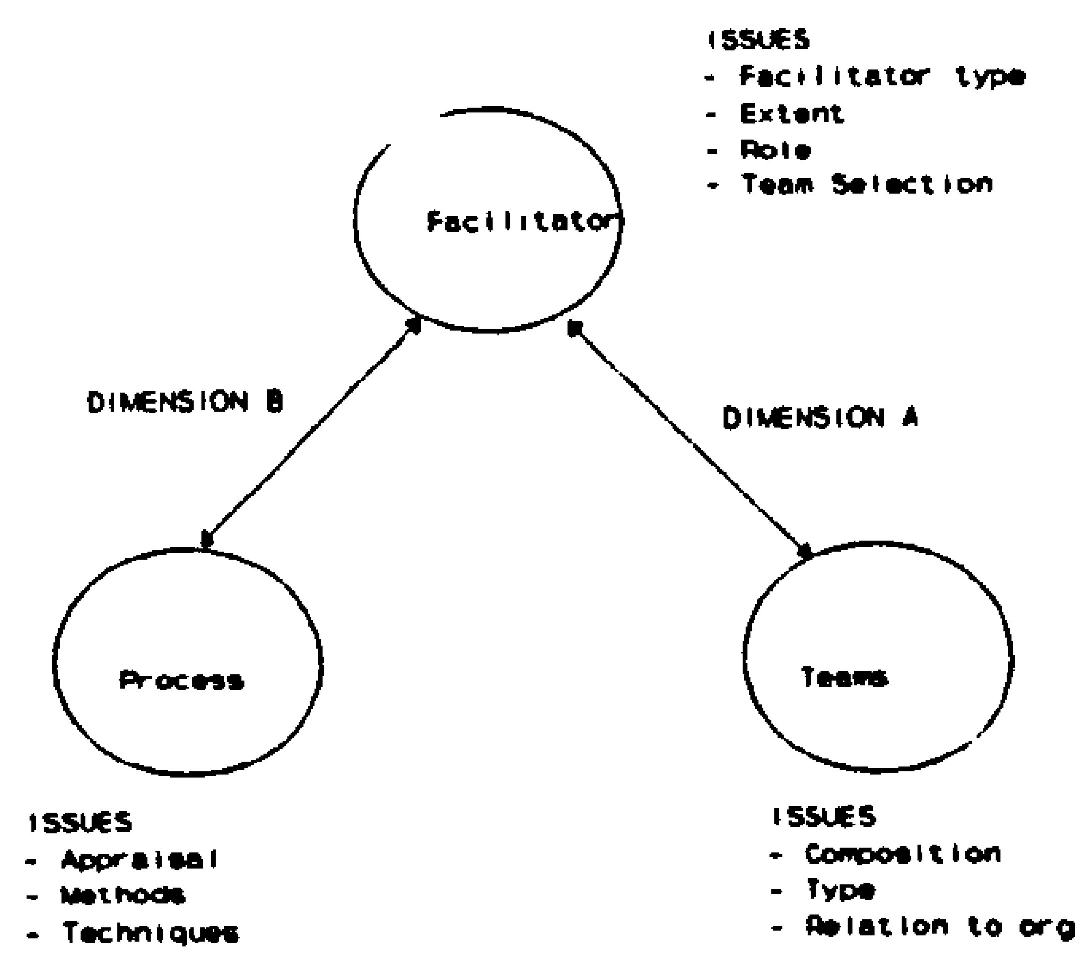
The company had no team culture but was determined that the whole improvement team initiative would work. Although there was a large proportion of Team Workers and Company Workers as employees, who could contribute purposively to team activity, the company felt that deployed projects required a clear focus and direction which would be sustained throughout the duration of each project.

The approach taken was to provide a problem solving methodology in a sequential and fairly rigorous form to provide activity facilitation. In addition, it was thought that the monitoring aspect of facilitation would be best served by producing project reporting in parallel with the activity progression. This was attempted in two forms, 'ABC Solve' and 'ABC Team-Solve', using language appropriate to the two type of team, one for the quality circle departmental teams and one for the project teams. In addition, a (desperate!) attempt was made to keep the chart simple enough to be used in practice without losing the richness, creativity and flexibility (including iterations) of the problem solving approach. One of the charts, ABC Team-Solve, is given in Figure 4 at the end of the paper as an example.

The in-house cook-book approach ensured an emphasis on methods development and their use in a comprehensive problem solving methodology. The specified reporting stages encouraged good practice in project management terms as each project progressed down the various stages. The other clear intention was to foster the feeling of ownership of the particular company approach as improvement teams developed familiarity with it on their projects.

Facilitators are often seen in terms of providing consulting in the use of methods for improvement teams. In the company, facilitators were seen as the 'keepers' of the problem solving approach and instrumental in promoting the effective use of the charts and the related problem solving methods.

A basic framework for understanding the role of the facilitator was missing in the case study organisations. They understood the importance of facilitation but did not possess the insights into how to effectively tune the balance between team operation (dynamics) and team activity (process). The approaches adopted by the case study companies is shown in Fig



but no account was taken of the team type or original relationship (Fig) and hence the success of teams was variable.

Conclusion

The culture of an organisation will benefit from a teamwork approach only if it delivery intrinsic improvement in employees outlook creating a greater willingness to problem solving and communications along with other skills and willingness. Facilitation of the team processes and activity is crucial in this process, but there are no clear guidelines to tune such facilitation to an organisation's current status.